SMITHSONIAN MISCELLANEOUS COLLECTIONS
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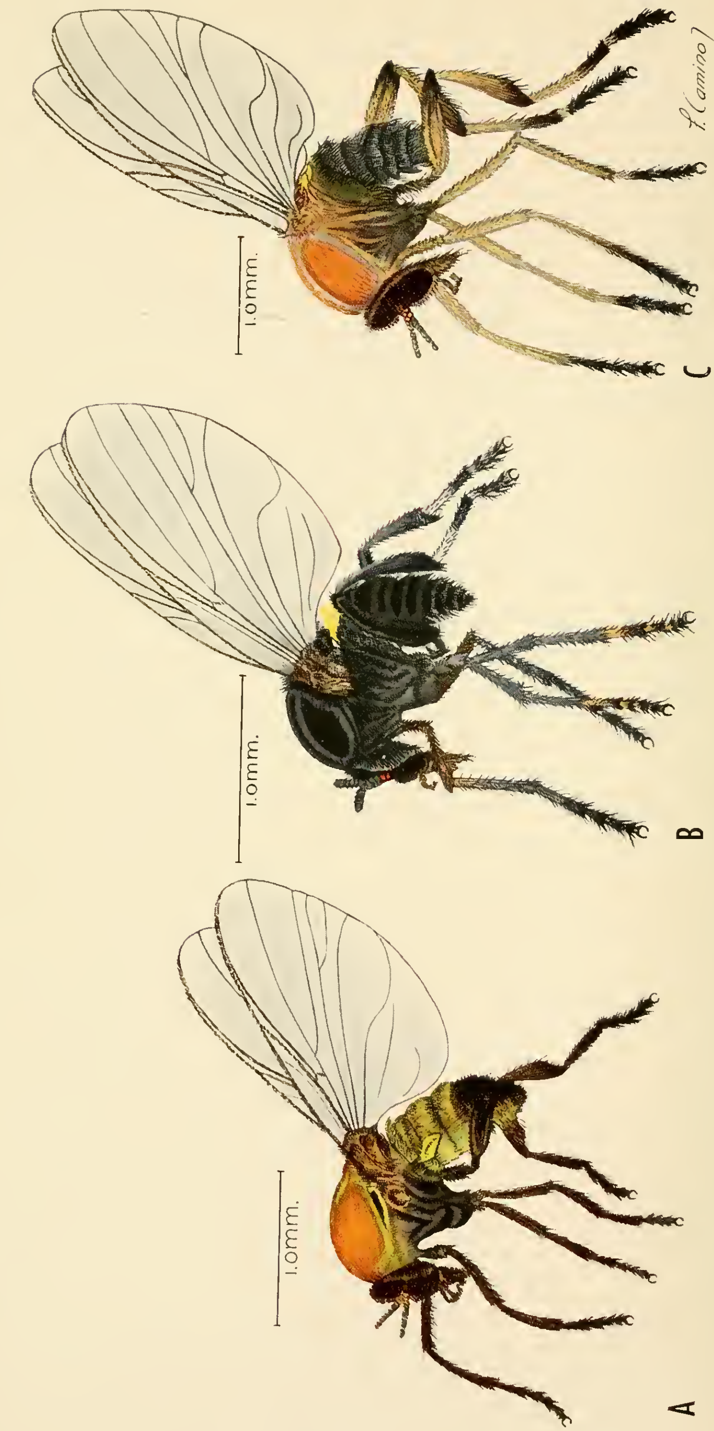
THE BLACK FLIES (DIPTERA, SIMULIIDAE) OF GUATEMALA AND THEIR ROLE AS VECTORS OF ONCHOCERCIASIS

(With 44 Plates)

By
HERBERT T. DALMAT
Laboratory of Tropical Diseases
National Institutes of Health

(Publication 4173)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
APRIL 5, 1955



The three principal vectors of onchocerciasis in Guatemala: A, *Simulium* (*S.*) *ochraceum* Walker; B, *Simulium* (*S.*) *metallicum* Bellardi; C, *Simulium* (*Lanea*) *callidum* (Dyar and Shannon).

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CONTENTS

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To the owners and managers of the following plantations or organizations who permitted me to carry out field studies on their property, and some of whom also supplied meteorological and other data used in this presentation:

In San Pedro Yepocapa

Amparo
La Argentina
La Cabaña
Candelaria
La Ceiba
La Conchita
Miraflores
Montellano
Montevideo
Morelia
Niágara
Nimayá
Palo Verde
Panajabal
Peña Plata
Recreo
Recuerdo
Rosario Chuarramos
San Antonio Sumatán
San Lucas Miramar
San Rafael Sumatán
Sta. Cristina
Sta. Emilia
Sta. Rosa Sumatán
Sta. Sofía
Sta. Teresa
Sibajá
La Trinidad
La Victoria

In San Bernabé Acatenango

Armenia
El Carmen
Chalabal
Chantunjay
Concepción
Las Delicias
La Esmeralda
La Española
Esperanza Pérez
Esperanza Ramos
Hacienda Vieja
El Naranjo
Nueva Providencia
Paraiso
El Platanar
La Providencia
El Rincón
San Diego
San José Miramar
San Rafael Pacún
San Vicente Pacún
Sta. Felisa
Sta. Margarita
Tajancarón
Tehuyá
La Torre
La Unión

In Pochuta, Chimaltenango

Barberena
California
Ceilán
La Chácara
Costa Rica
Florencia
Mirandilla
Nueva Concepción
El Pacayal
El Pacayalito
Pancúm
El Paraiso
El Recuerdo
El Salvador
San Bernardino
San Carlos
San Francisco
San Jorge
Sta. Emilia
Sta. Rita
La Torre
Venecia

In other regions

Mocá, Suchitepéquez
El Naranjo, Suchitepéquez
Monte de Oro, Sololá
Montequina, Sololá
Olas de Mocá, Sololá
Santa Cruz Quixayá, Sololá
La Helvetia, Retalhuleu
El Llano, Escuintla
San Luis Buena Vista, Escuintla
United Fruit Co., Tiquisate, Escuintla
El Zapote, Escuintla
La Paz, San Marcos
United Fruit Co., Bananera, Izabal
Experiment Station of the Instituto Agropecuario, Quezaltenango

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* Now chief of the Instituto de Investigaciones Científicas, University of San Carlos.

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H. T. D.

THE BLACK FLIES (DIPTERA, SIMULIIDAE) OF GUATEMALA AND THEIR ROLE AS VECTORS OF ONCHOCERCIASIS *

By Herbert T. Dalmat

Laboratory of Tropical Diseases
National Institutes of Health

(With 44 Plates)

INTRODUCTION

In 1893 Manson[1] referred to a worm occurring in subcutaneous nodules of the head and chest of three natives of the Gold Coast in Equatorial West Africa. This parasite, now known as *Onchocerca volvulus* (Leuckart, 1893) Railliet and Henry, 1910, is the cause of human onchocerciasis. The developing filariid larvae move about in the subcutaneous tissues. Wherever they come to rest they cause an inflammatory reaction resulting in the formation of a fibrous nodule or cyst. These are usually palpable but at times are buried so deep in the tissues that they escape discovery. Adult male and female worms are found in these nodules, while their young, the microfilariae, migrate throughout the subcutaneous tissue, only very rarely entering the circulating blood. Should only male or female worms be present in a nodule, to the exclusion of the opposite sex, no microfilariae will be produced and the infection will eventually die out. It is the microfilarial stage that produces the disease symptoms. When the appropriate species of flies of the family Simuliidae bite an infected person, they ingest microfilariae, which then develop in the thoracic muscles of the flies, passing through several morphological changes. The final, or infective, larvae are then inoculated into another human being by the bite of the infected flies (fig. 1). The developmental forms and the exact path of migration of the filariid larvae in the human host

* Result of a study jointly supported by the Laboratory of Tropical Diseases of the National Institutes of Health, Public Health Service, and the Pan American Sanitary Bureau in cooperation with the Dirección General de Sanidad Pública of the Republic of Guatemala. The project was aided by a research grant from the National Institutes of Health, Bethesda, Md.

[1] Specimens and a short description of the parasite were sent to Manson by R. Leuckart, who has since been credited with the species. (See Leuckart, 1893, in Literature Cited.)

are still unknown. In Mexico and Guatemala the nodules are found preponderantly in the region of the head and shoulders of infected individuals, while in Africa the nodules are more prevalent around the waist. Ocular involvement, including blindness, is an important manifestation of the disease.

Although early workers speculated a good deal concerning the transmission of the parasite from one person to another, it was the discovery of the presence of the disease in Guatemala by Robles in 1915 (Calderón, 1917; Robles, 1919) that actually stimulated extensive investigations of onchocerciasis and its transmission. The disease is now known to be endemic in large areas of central Africa (Puyuelo and Holstein, 1950), in Guatemala, Central America (Strong et al., 1934), Mexico (Puig Solanes et al., 1948), and in Venezuela, South America (Potenza et al., 1948). A single case, diagnosed as probably being onchocerciasis, was reported by Hartz (1950) from Surinam, Dutch Guiana. The recent discovery of the presence of the disease in Venezuela (Potenza, Cordero, and Anduze, 1948) suggests the possibility of still wider distribution of onchocerciasis than is known at the present time. Although accurate statistics concerning the incidence of the disease are not available, it is believed that almost a million people in these various areas are infected. The estimate given for Mexico is about 35,000, and for Guatemala about 25,000. The number of cases in Venezuela still has not been determined, although it is believed to be low in comparison to the figures for Guatemala or Mexico. The degree of infection in the endemic zones of Guatemala varies greatly from one locality to another. On some fincas (plantations) as few as 5 percent of the population is infected, while on others, not very distant, nearly 100 percent is infected. From the statistics made available by the Department of Public Health of Guatemala, it appears that a general average of about 35 percent of the population in the disease zones is infected. Ocular involvement is manifest in more than half of the persons infected, and blindness (pl. 1, fig. 1), the most serious sequela, occurs in approximately 5 percent.

Robles (1919; see also Calderón, 1917), after discovering the presence of onchocerciasis in Guatemala and after making preliminary epidemiological studies, was inclined to believe the vector [2] was a day-biting insect, probably two anthropophilic species of *Simulium* flies he found in the endemic region. It remained for Blacklock (1926a,b), working in Africa, to be the first to infect *Simulium* adults with the microfilariae of *Onchocerca volvulus* and to trace subsequent develop-

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[2] Throughout this paper the word "vector" is used interchangeably with "intermediate host."

ment of the parasites in the flies. His investigations, as well as later ones of Strong (1931a,b,c), Hoffmann (1930a,b,c,d,e; 1931a), De León (1940a,b), and Vargas (1948), clearly indicated that *Simulium*

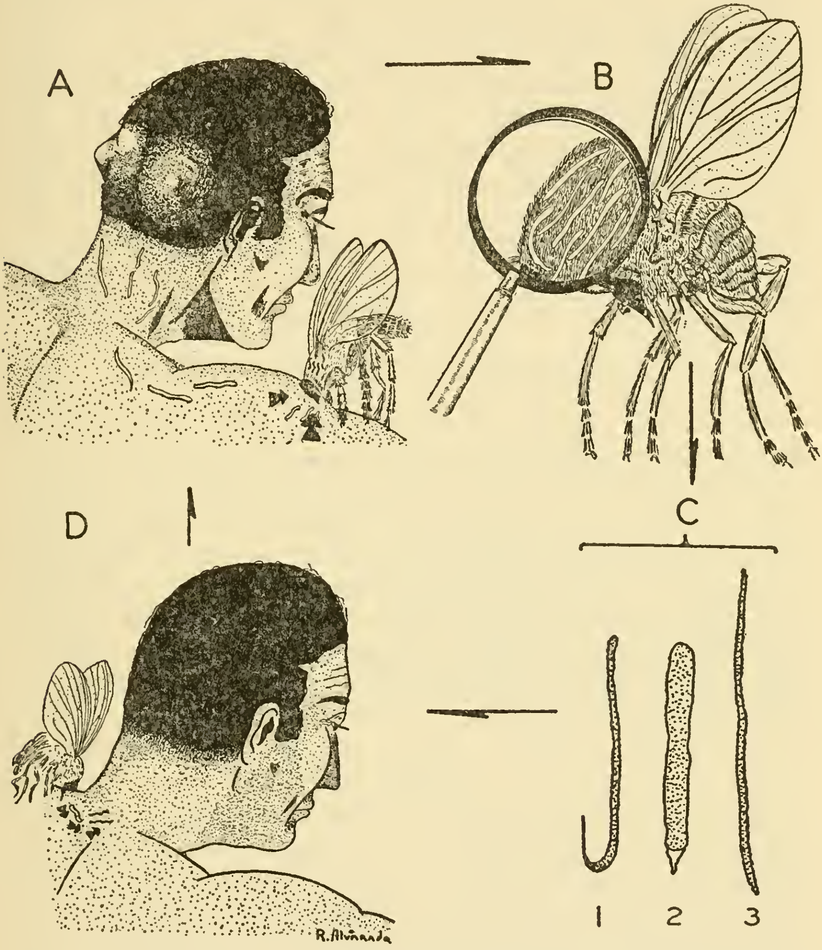


FIG. 1.—Diagrammatic representation of the transmission of human onchocerciasis: *A,* Uninfected *Simulium* fly biting the infected individual and ingesting microfilariae from subcutaneous tissues. *B,* Infected fly, showing developmental forms of larval filaria in the thorax. *C,* Developmental form of larval filaria as found in the fly: *1,* microfilaria; *2,* "sausage" stage; *3,* infective larva. *D,* Fly with infective larvae infecting a man by his bite. This man will eventually develop nodules, as shown in *A,* in which adult *Onchocerca volvulus* are found.

species probably transmit onchocerciasis. This will be discussed in more detail under reservoirs and vectors in the section on "Animal Associations."

It is the purpose of the present study to give as complete an account as possible of the Simuliidae of Guatemala, so that their role in the transmission of onchocerciasis can more easily be appreciated. It has been felt advisable to give first a general discussion of the importance of this group of flies, and to present epidemiological factors in Guatemala that may be involved in the transmission of the disease. Then follows the body of the paper, which includes the taxonomy, ecology, and distribution of all species of black flies that have been collected in Guatemala, with special reference to the principal anthropophilic species. The biting habits, resting places, flight range, longevity, and attempts to colonize those species that most commonly attack human beings are discussed in detail. It is hoped that this information will serve as a firm foundation upon which can be developed an efficient program of control of the vectors of onchocerciasis.

IMPORTANCE OF THE SIMULIIDAE

The flies belonging to the family Simuliidae affect man and animals both by their bites and as intermediate hosts of parasites. For years they have been recognized as serious pests of domestic and wild animals. In the literature can be found numerous references to heavy animal losses sustained along the river basins of northern and southeastern Germany, along the Danube, in the forested sections of Siberia, in Australia, Canada, the United States, and in parts of South America due to the attack of these flies. Animals listed as having been affected include mules, horses, cattle, hogs, sheep, dogs, cats, deer, foxes, rabbits, turkeys, chickens, ducks, and other fowl.

PESTS

Ciurea and Dinuflescu (1924) describe the destructive outbreaks of the goloubatz fly (*Simulium colombaschensis* (Fabricius)) in parts of Rumania in 1923. Tremendous numbers of wild and domestic animals were affected, and more than 16,000 domestic animals were reported killed. The flies also attacked man, biting voraciously, but did not cause human deaths. In the Western Hemisphere, Riley (1887) gives a lucid account of the outbreaks of *Cnephia pecuarum* (Riley), the buffalo or turkey gnat, in the lower Mississippi Valley of the United States, with the loss of large numbers of mules, horses, turkeys, hens, and hogs. Numerous cattle, sheep, dogs, and cats also suffered severely. Rempel and Arnason (1947) describe the heavy outbreaks of *Simulium arcticum* Malloch in central Saskatchewan, Canada, during the years 1944, 1945, and 1946. The flies were wind-borne, carried from 20 to 90 miles from the breeding places. Although the animals affected included cattle, horses, sheep, hogs, and others, more than 80 percent of the 800 animals killed were cattle. At times the animals started dying within 4 hours after attack by the flies. In the few outbreaks mentioned above and in others described in accounts of various authors (Webster, 1904; Wilhelmi, 1920; Bradley, 1935), it appears that deaths usually occur as a consequence of an acute toxemia, caused by the vast number of bites of black flies, or as a result of anaphylactic shock. Debility, due to a heavy loss of blood, and suffocation brought about by inhalation of myriad flies may also be contributing factors.

Black flies are not only pests of domestic and wild animals in the Western Hemisphere, but their attack on man has prevented the normal exploitation of highly desirable areas in the United States and Canada. With the application of modern control techniques, it has been found economically feasible to develop some of these regions into resort areas, as well as to construct strategic roads and bases (e.g., Alaska Highway).

In Guatemala, the Merck & Co. quinine plantation, Finca Montequina (Municipality of Atitlán, Department of Sololá), was so badly infested by anthropophilic species of black flies during February 1948 that workers were threatening to leave the finca employ. The flies were a pest not only in the fields but in the buildings as well. Many of the workers were suffering from edema, pruritus, lymphangitis, and fever brought on by the bites. Several had developed secondary infections from scratching bites that caused intense itching. The author was consulted for help in alleviating the plague. Finca Montequina, comprising 564 acres, is situated on the southwest slope (facing the Pacific Ocean) of the Volcano Atitlán, at an altitude of 3,200 feet. That part of the plantation on which the workers were especially exposed to the ravages of the fly population is situated on one of the ridges exposed to the Pacific winds. After an unsuccessful attempt to find probable breeding areas of the flies in the vicinity of the finca, it was determined that they had been carried into the region by monsoons prevailing at that season of the year. With the application of DDT to the region infested and to the dwellings therein situated, and with the fortunate cessation of the winds, the fly problem was markedly reduced.

Another finca, Santa Emilia, located at 3,560 feet in the Municipality of San Pedro Yepocapa, Department of Chimaltenango, is situated on the Pacific slopes of the Volcanoes Fuego and Acatenango. The flies were so numerous, and the biting so constant during January and February 1948, that the members of the family of the plantation owner bound their arms and legs with gauze in an attempt to keep the swellings down and to prevent further secondary infections. Their faces were so swollen that their eyes were almost completely obscured. They finally had to leave the plantation until the fly population subsided. In this case the flies were breeding on the finca. Since the homes of the affected individuals were surrounded by hills that formed a natural bowl, the winds, instead of carrying flies into the area, were preventing their exit from the hollow. Because at that time no insecticides were available, it was finally necessary for the people to leave the plantation until the fly population subsided naturally.

TRANSMISSION OF DISEASE

The Simuliidae are important not only because of their effect, as pests, upon man and other animals, but also as vectors or intermediate hosts of pathogenic organisms. *Simulium* species have been shown to transmit *Leucocytozoon smithi* of turkeys (Skidmore, 1932; Johnson, Underhill, Cox, and Threlkeld, 1938), *Leucocytozoon anatis* of ducks (O'Roke, 1934), *Onchocerca gutturosa* of cattle (Steward, 1937), and *Onchocerca volvulus* of man (Blacklock, 1926a,b). Members of this family have also been incriminated in the transmission of *Setaria equina* of horses, and Parker (1934) was able to transmit tularemia by the interrupted feedings of *Simulium decorum katmai* Dyar and Shannon. As stated in the introduction, human onchocerciasis, transmitted by several species of Simuliidae, is now known to be endemic throughout extensive regions of Equatorial Africa and in South America (Venezuela), Central America (Guatemala), and southern Mexico. The present study of the Simuliidae has been made in an attempt to help establish their role in the transmission of human onchocerciasis in Guatemala and to obtain sufficient data concerning their biology and ecology to permit the establishment of an efficient control program against them.

EPIDEMIOLOGY

Presence and spread of onchocerciasis in Guatemala and Mexico.—Various investigators have postulated that onchocerciasis was introduced into Guatemala and Mexico by infected Negro slaves brought in from Africa; also that the disease spread from Guatemala to Mexico owing to large movements of population such as religious pilgrimages and migrations of field workers. These assumptions have been based primarily on the fact that the disease was recognized in Guatemala (1915) prior to its discovery in Mexico (Fülleborn, 1923).

Certainly the disease was already well established in Guatemala when Robles (1919) discovered its presence in 1915. Federico Polá de Torroella (1947), a cartographer with the Pan American Sanitary Bureau when the author began his work in Guatemala, was afforded the opportunity of examining many old titles and other documents relating to land holdings, while in the process of preparing maps. In the title to a coffee plantation in Oaxaca, Mexico, Torroella found mention of the fact that Negroes and Indians working on that plantation in the fifteenth century were infected with the disease, characterized by nodules on the head and trunk regions, which often led to blindness. Supposedly a Spanish physician was sent from Spain to study the disease. Torroella has been attempting to obtain copies of documents in the Spanish archives to substantiate these statements.

Whether the disease was introduced from Africa to the Americas, or whether it spread from Guatemala to Mexico, is of academic importance only. The fact remains that onchocerciasis, at present, does exist in the Americas (Mexico, Guatemala, and Venezuela). Since it appears to be endemic only in certain circumscribed areas (map 1), factors that probably contribute to this phenomenon should be discussed. Some of these are geography, climate, occupation of the people, the people themselves, and environmental factors such as plant associations, animal populations, and streams.

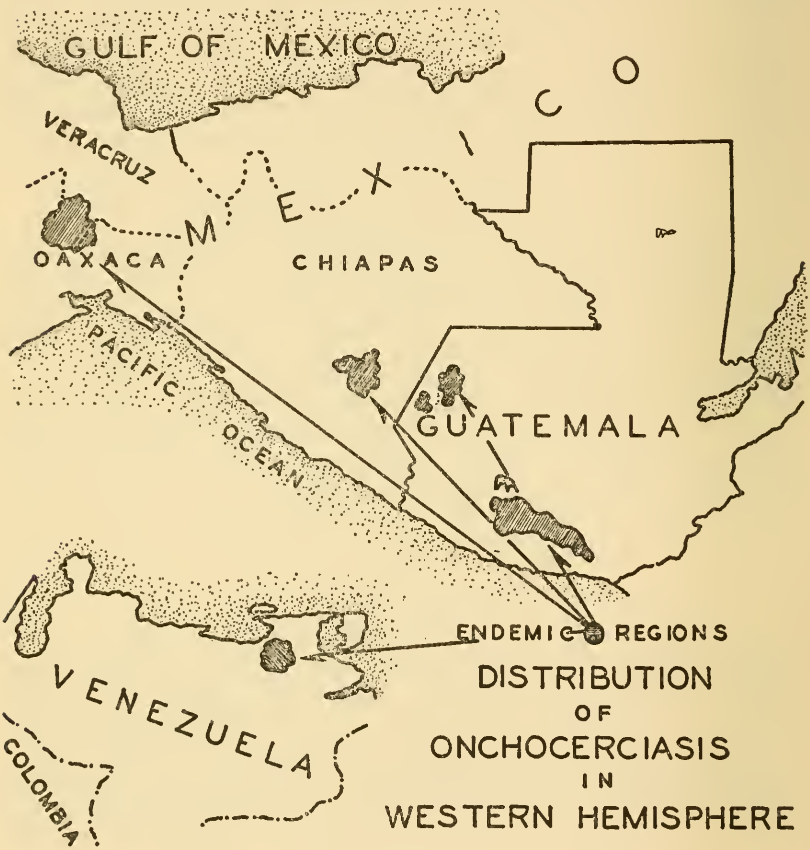
GEOGRAPHY AND CLIMATE[3]

GUATEMALA

Guatemala is situated between latitude 13°46′ and 17°58′ N. and longitude 88°13′ and 92°12′ W. Its land mass, approximately 42,300 square miles, faunistically forms a transition between the Neotropical and Holarctic regions. Griscom (1932) recognizes three life zones in Guatemala: The Tropical Zone, from sea level to 3,000-4,500 feet; the Subtropical Zone, 3,000-6,000 feet and locally much higher; and the Temperate Zone, 5,000-13,000 feet. It has often been said that Guatemala has more variation in altitude in proportion to surface area, as well as greater diversity of climate, than any other portion of the earth. Moving inland from the Pacific Ocean, certain geographical areas can be distinguished (map 2): (1) Bordering on the ocean, *the coastal plain* appears as a 30-50-mile-wide band rising uniformly to an elevation of 1,000-2,000 feet; (2) *the foothills* of the Sierra Madre, which continue to rise from the coastal plain more rapidly and irregularly to about 5,000-6,000 feet; (3) *the volcanic mountains*

[3] Shelford, 1926; Griscom, 1932; author's personal observations and data.

(principal branch of the Sierra Madre), which rise to heights approaching 14,000 feet (pl. 2, fig. 1); (4) *the plateau region* (Los Altos), which is composed of innumerable ridges and slopes, the majority between 6,000-8,000 feet, a number of rather extensive areas above 10,000 feet, with occasional drops to 5,000 feet, and a few iso-

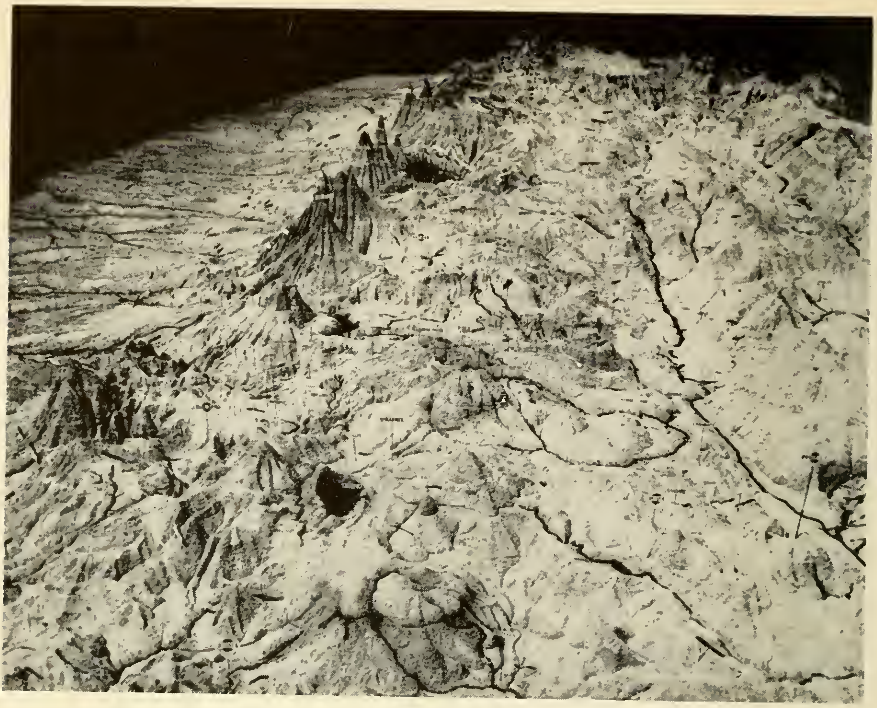


MAP 1.

lated ridges above 11,000 feet; (5) *the Verapaz region* with its low mountains, luxuriant rain forest, abundant streams, and almost daily rains (only the southern band of Baja Verapaz is extremely dry); (6) *the semi-arid valley of the Motagua River,* which typifies the arid tropical zone of Guatemala, the northern limit of which extends to the slopes of the Sierra de las Minas (this area usually receives only a few inches of rainfall a year); and (7) *the moist lowlands* of the Atlantic coast, including the Plain of the Petén, which comprises about

1. Men blinded by onchocerciasis. San Pedro Yepocapa, Chimaltenango.

2. Weaving straw sleeping mats (petates) from local reeds. San Pedro Yepocapa.



1. Relief map of Guatemala, showing the Pacific Cordillera of the Sierra Madre. Hipódromo, Guatemala City.

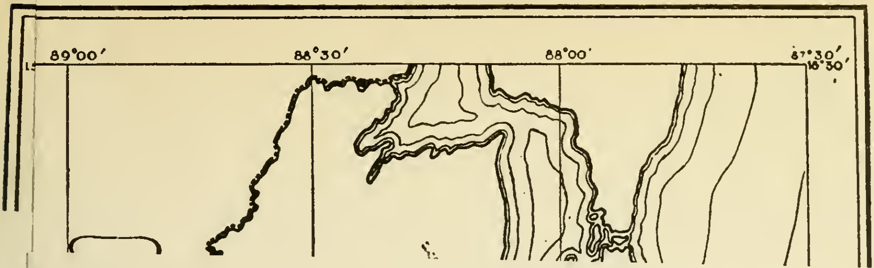
2. Aerial view of the principal zone of onchocerciasis along the Pacific versant of the Sierra Madre.

1. San Pedro Yepocapa, with the volcanoes Acatenango and Fuego in the background.

2. San Pedro Yepocapa, with the Pacific plain in the background.

1. Indian woman weaving cotton cloth with hand loom.

2. Spreading coffee on cement patios to permit necessary drying.


89°00′
88°30′
88°00′
87°30′
16°30′


MOIST LOWLANDS
LOS ALTOS
SIERRA MADRE
FOOTHILLS
COASTAL PLAIN
VERAPAZ REGION
MOTAGUA VALLEY
Dpto EL PETEN
FLORES
BELICE
HONDURAS
EL SALVADOR
OCÉANO PACÍFICO
Dpto. HUEHUETENANGO
Dpto. EL QUICHE
Dpto. ALTA VERAPAZ
Dpto. IZABAL
Dpto. BAJA VERAPAZ
Dpto. SAN MARCOS
TOTONICAPAN
Dpto. SOLOLA
CHIMALTENANGO
Dpto. QUETZALTENANGO
Dpto. GUATEMALA
Dpto. JALAPA
Dpto. CHIQUIMULA
Dpto. RETALHULEU
SUCHITEPEQUEZ
Dpto. JUTIAPA
Dpto. SANTA ROSA
LEGEND
0 - 800 FEET
800 - 1,600 ,,
1,600 - 4,900 ,,
4,900 - 8,100 ,,
8,100 - 9,700 ,,
9,700 - 11,400 ,,
OVER - 11,400 ,,
TOPOGRAPHIC MAP OF GUATEMALA

Map 2.

one-third of the entire area of Guatemala but is very sparsely populated. The Sierra Madre, as it crosses the boundary between Mexico and Guatemala, has branching from it a large secondary chain of mountains which extends to the north. The principal cordillera, considered by some to be a continuation of the Andes, forms the volcanic mountains (23 volcanoes included) mentioned above, which extend across the southern part of Guatemala in a general southeasterly direction, dividing the country more or less into two parts; the northern branch of mountains, which runs in a general west to east direction, is comprised of the Sierra de los Cuchumatanes, Sierra de Chuacus, Sierra de las Minas, and the Montaña del Mico. Also branching from the northern group are the Sierra de la Cruz, which passes to the north of Lake Izabal, somewhat paralleling the Montaña del Mico, and the Sierra de Chama, which runs northward from the Sierra de Chuacus. The Sierra del Merendón, another small secondary range that branches from the volcanic cordillera, runs along the eastern limit of Guatemala, bordering Honduras.

Guatemala, with its complex topography and great range of altitudes has, as would be expected, a correspondingly great diversity in climate, and the changes are often very abrupt. The country is sufficiently far north of the Equator for the temperature to show some seasonal variation at any given altitude. During the winter months of the north temperate regions, the average monthly temperature in Guatemala also drops. This is best exemplified by a small but noticeable drop in minimum temperature in the highlands of Guatemala during December, January, and February. This fall in temperature, however, is hardly perceptible in the lowlands. Because of these slight variations, the seasons in Guatemala are often referred to as the "hot season" (March to October) and the "cool season" (November to February). Actually, however, in any one area the average daily temperature varies but little throughout the year, and the daily maxima and minima do not significantly vary from the mean daily temperatures. The well-marked variations in temperature really arise between zones of different altitudes. These zones have been termed "tierra caliente" (hot region) for the coastal plain (sea level to 2,000 feet); "tierra templada" (temperate region) for the foothills (2,000 to 6,500 feet); and "tierra fría" (cold region) for the mountains (6,500 feet and above).

It will be seen from table 1 that as the altitude increases the mean annual temperature decreases, and the difference between the mean annual maximum and minimum increases.

With the exception of relatively slight variations in temperature throughout the year in any one area, seasonal change is primarily a question of rainfall, and the distribution of rain is largely a matter of topography. On the Caribbean slope of Guatemala, which receives the moisture-laden tradewinds from the northeast more or less regularly throughout the year, there is no real dry season. On this versant 120 to 200 inches of rain are recorded annually, falling on as many as 250 days distributed throughout the 12 months. As would be expected, to the south of the northern mountain ranges there is a region that is very dry, often with desert conditions. Thus, in Chiquimula, in the Department of the same name, the average annual rainfall during a 7-year period was less than 16 inches, falling on 21 days distributed over only 5 months of the year. In the Motagua River

TABLE 1.—*Relation of temperature to altitude in Guatemala*

Station	Altitude (*feet*)	Number of years included in data	Mean annual temperatures (*Fahrenheit*) Maximum	Minimum	Mean	Difference between maximum and minimum
Puerto San José, Escuintla	3	3	88.7	75.4	83.8	13.3
Finca Morelia, Chimaltenango	3150	4	87.4	61.3	70.9	26.1
Guatemala City, Guatemala	4900	24	82.0	51.6	64.8	30.4
Quezaltenango, Quezaltenango	7735	11	77.9	35.6	58.5	42.3

valley there may be as little as 6 inches of rain recorded annually. As one progresses south and west to the region of Los Altos and to the northeastern slopes of the Sierra Madre, the rainfall increases with altitude. On the Pacific slope of the Sierra Madre, which rises out of the coastal plain like a solid wall, there is a pronounced dry and wet season, the latter being caused primarily by the more local south-southwest winds from the Pacific, which blow somewhat irregularly from May through October. Those areas along the slopes of the mountains above 1,500 feet receive large amounts of rainfall, primarily during the 6-month rainy season. The heaviest rainfall occurs during the period between the "Canícula de San Juan" (cessation of rain in the middle of July) and the beginning of the dry season, usually in the month of September. At various stations in the Departments of Retalhuleu and San Marcos more than 190 inches of rain are recorded. At one station in the Municipality of Malacatán, Department of San Marcos (southwestern Guatemala), almost 390 inches of rain were recorded falling on 160 days over the 12 months of 1945. This

1. Typical clothing worn by the inhabitants of the principal onchocerciasis zone.

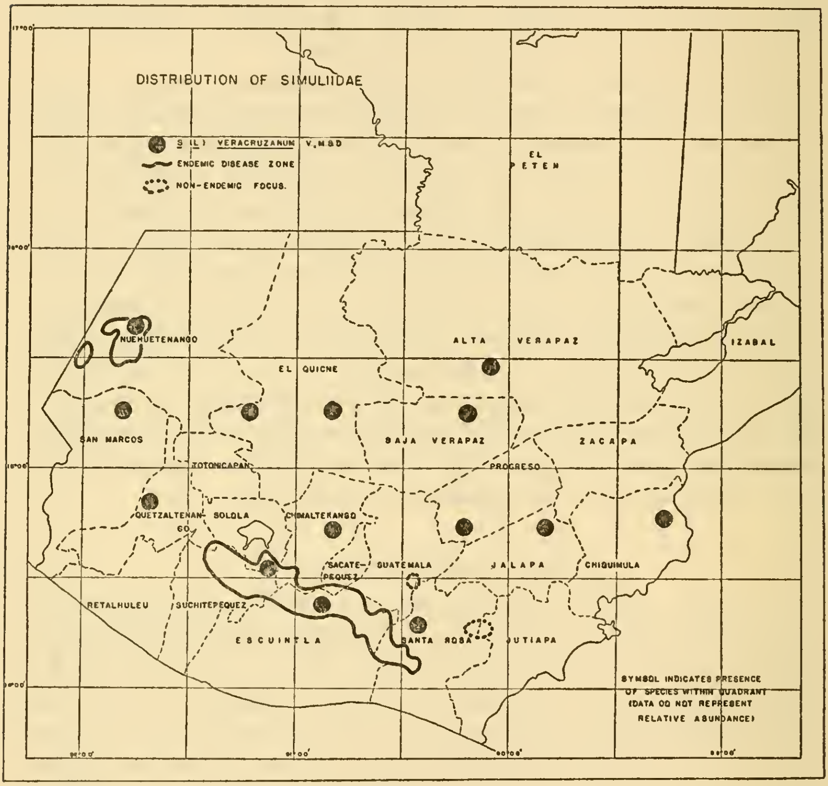
2. Vegetation on Finca Santa Emilia, Municipality of Yepocapa. This is typical of the onchocerciasis region.

extreme local condition is brought about by the unique location of the area, situated so that it receives the northeast tradewinds, the southwest winds from the Pacific, and additional moisture-carrying air currents from Mexico. Every variation within these extremes can be found in Guatemala. The seasons, more properly perhaps, can be divided into the "rainy season" (May to October) which almost coincides with the "hot season," and the "dry season" (November to April) which almost parallels the "cool season."

Within any one region, and at great proximity, may be found startling variations in climatic conditions due to the particular location of the area, the direction of the slope, or the degree of exposure to prevailing winds. Thus, en route to our laboratory, in passing from the northeastern side of the Volcano Acatenango (exposed to the tradewinds) to the southwestern side (exposed to the Pacific winds) at the highest point reached by the road (over 8,500 feet), the same climatic conditions are rarely encountered. It may be perfectly clear on the northeastern exposure, with a blue sky and cumulus clouds, while on the southwestern side, reached in a matter of seconds by merely following a turn in the road, it will be drizzling or raining and the clouds will so enshroud the road that foglights become a necessity. Within less than 13 miles on the same road, one also tends to put on and remove warmer outer garments at least twice.

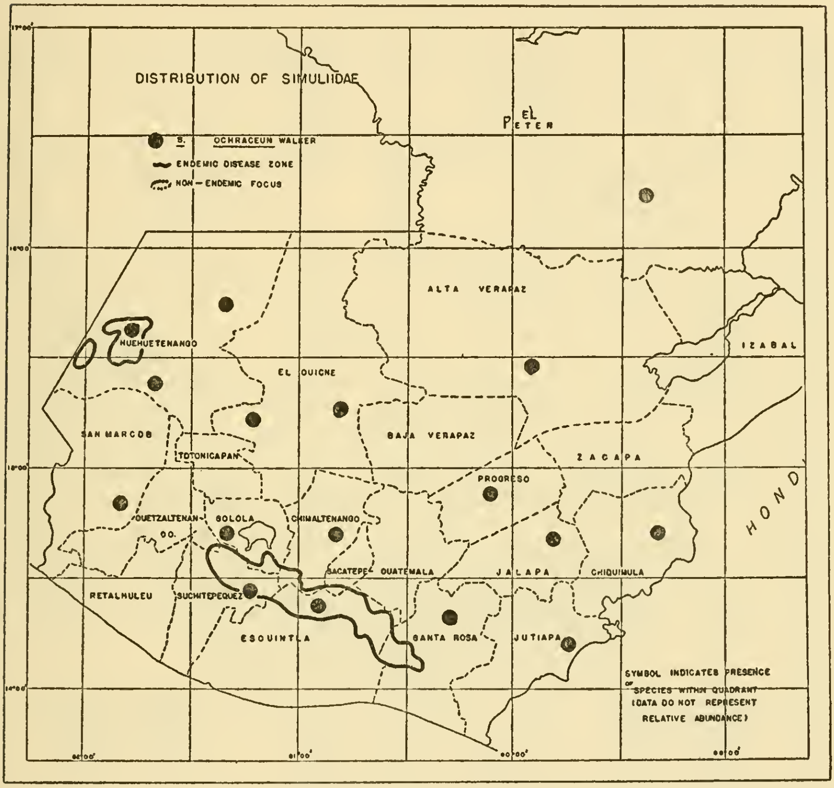
THE ONCHOCERCIASIS ZONES

The present study is primarily concerned with the principal onchocerciasis zone, which is situated in the foothills region, extending as a 75-mile-long band (500 square miles) along the Pacific slope of the Sierra Madre (maps 3-14 and pl. 2, fig. 2) from the Volcano San Pedro in the west to Tecuamburro in the east. This zone, 1,500 feet to 4,800 feet in altitude, experiences a pronounced dry and wet season, as does the entire Pacific slope. The high volcanoes are the center of local areas of precipitation, and these have their effect on the surrounding country. With the western slopes of the volcanoes all facing the Pacific, and the eastern slopes, at the higher altitudes, intercepting the northeast tradewinds, there is almost daily precipitation somewhere on their summits. This onchocerciasis zone was formerly considered as two zones: one encompassing parts of the Departments of Escuintla and Santa Rosa and the other including parts of Escuintla, Chimaltenango, Sololá, and Suchitepéquez. The finca El Zapote and its contiguous annexes lie, geographically, directly between the two zones as previously constituted. A survey, by the author, of the blackfly population in this intermediate region yielded all three species usually incriminated as being the principal transmitters of the disease. The ecological and meteorological conditions seemed identical for this region and the adjoining onchocerciasis zones. To further justify joining the two zones, a questionnaire was presented to those workers on the finca and annexes who were found to have onchocerciasis, in an



Map 3.

attempt to determine in which regions they most probably contracted the disease. More than half of the infected group were born in regions considered to be outside the disease zones, and of this number several were born on the finca El Zapote, never having left it; of the other 40 percent questioned, one-third had been born in an onchocerciasis zone but left it when still infants and had since that time resided on the finca El Zapote. Nodules did not begin to appear on these individuals until they had reached maturity. The remaining persons had actually lived in a known infected zone where they had contracted the disease. Other fincas in the same region as Zapote, also formerly considered to be located between the two main zones, have workers infected with *Onchocerca volvulus,* but no investigation has been made to determine whether or not the disease is autocthonous to those areas. The above data appear sufficient to warrant the union of the two former zones into one larger zone. The population of this principal

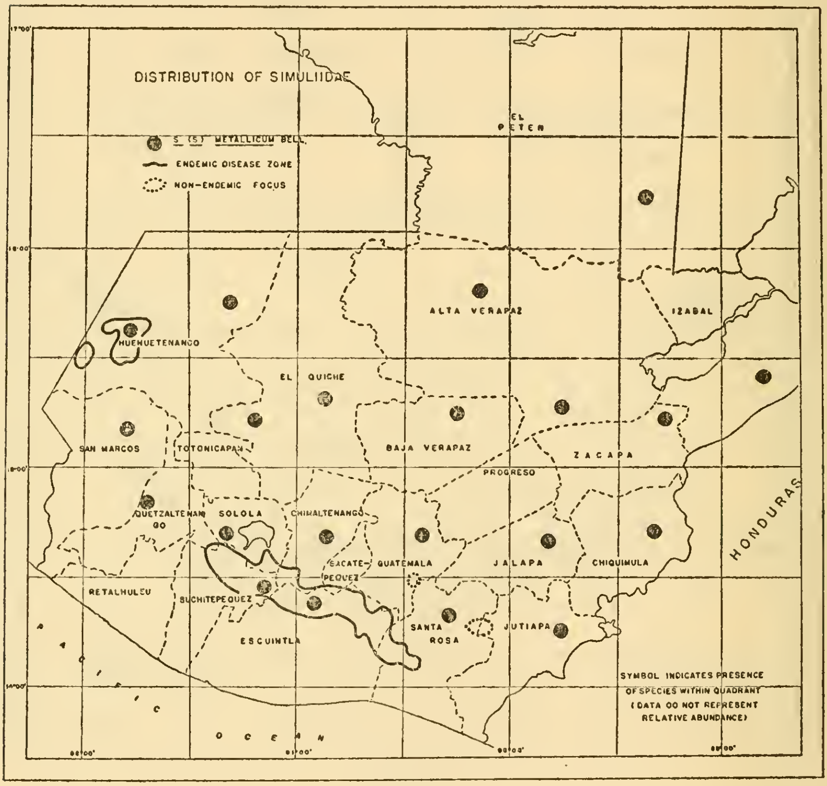


Map 4.

zone has been conservatively estimated as 60,000 persons, of whom 30 percent are infected with onchocerciasis.

In addition, there are two smaller disease zones (further study will probably prove them to be really only one zone) in the western Department of Huehuetenango (total of 85 square miles), near the Mexican border. This endemic region, like the Mexican disease zone, is situated in the eastern part of the "Valley of Chiapas," between two branches of the Andean chain, rather than on the Pacific slope of the more southern branch. There is also a suspected focus at La Carretera near San José Acatempa, located between Cuilapa and Jutiapa in the eastern Department of Jutiapa. The population of the Huehuetenango disease zone has been estimated as 3,500, of which almost 40 percent are infected with onchocerciasis. Undoubtedly there are still other onchocerciasis zones in Guatemala yet to be discovered.

Yepocapa onchocerciasis zone.—For the sake of convenience the principal onchocerciasis zone will hereafter be referred to as the Yepo-

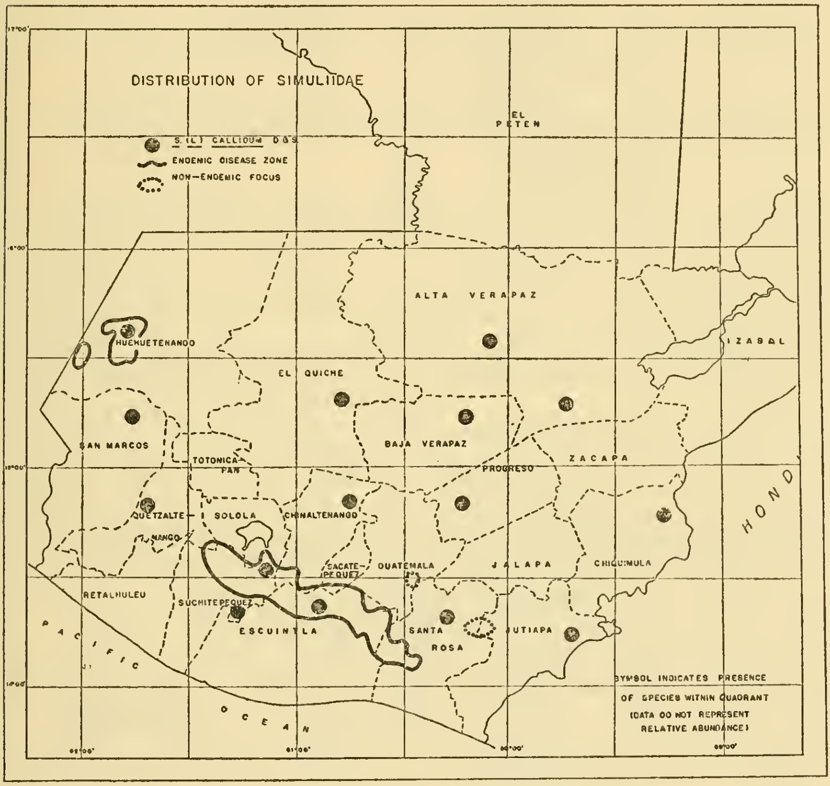


Map 5.

capa Zone, since it is at San Pedro Yepocapa (approximately 91° W. longitude and 14° 30′ N. latitude), Department of Chimaltenango, that the center of investigations was established. The town itself is situated at the highest elevation at which the disease is found, approximately midway between the western and eastern limits of the disease zone. Yepocapa was chosen as a desirable center of activity because of its proximity to the infected regions and because it can be reached from Guatemala City on a vehicular road. A substation was also in operation at San Bernabé Acatenango, 18 road miles from Yepocapa, from

1947 to 1951, for the purpose of obtaining additional collections and data.

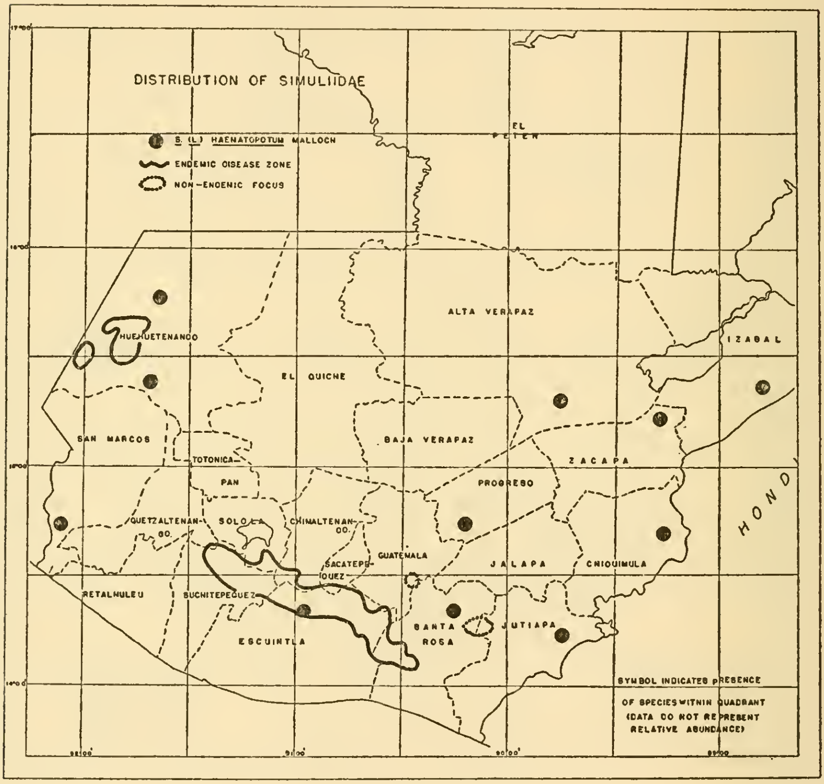
There are 2,200 inhabitants of the town of Yepocapa. Including the people living on, and employed by, the coffee fincas (plantations) within the entire Municipality of Yepocapa, there are 8,200 inhabitants, of which 74 percent are Mayan Indians. The town is situated



Map 6.

on the western slopes of the Volcanoes Acatenango (12,992 feet) and Fuego (12,730 feet) at an elevation of 4,850 feet (pl. 3, fig. 1). From the town, looking southward, can be seen gradually descending chains of foothills, and the Pacific Ocean can barely be distinguished at the horizon (pl. 3, fig. 2), some 40 miles away. The location of Yepocapa is rather unique in that it is fully exposed to the moisture-laden winds of the Pacific, to the more local conditions effectuated by the overlooking eastern volcanoes which serve as a barrier, and to the downwinds that cross over these volcanoes from the northeast. The interaction of these factors results in isolated conditions of precipitation, temperature, and winds.

The weather of the Yepocapa region can most easily be appreciated from an examination of the meteorological data (Yepocapa and Acatenango stations) collected over a 5-year period, from August 1, 1947, through July 31, 1952, which have been summarized in tables 2 and 3.



Map 7.

It will be noted that the mean monthly maximum temperature varies slightly throughout the year and that the mean monthly minimum also varies little, although there is a slight reduction in temperature during December, January, and February. The reduction in minimum temperature is reflected in the slight seasonal drop in the mean monthly temperature during the same months. This is the middle of the "cool" or "dry" season, as discussed above under Guatemala. Also, as would be expected, there is a corresponding drop in precipitation and relative humidity, which is more noticeable, and extends over a longer period

Table 2.—*Meteorological data—San Pedro Yepocapa, Chimaltenango, Guatemala*

(August 1, 1947—July 31, 1952)

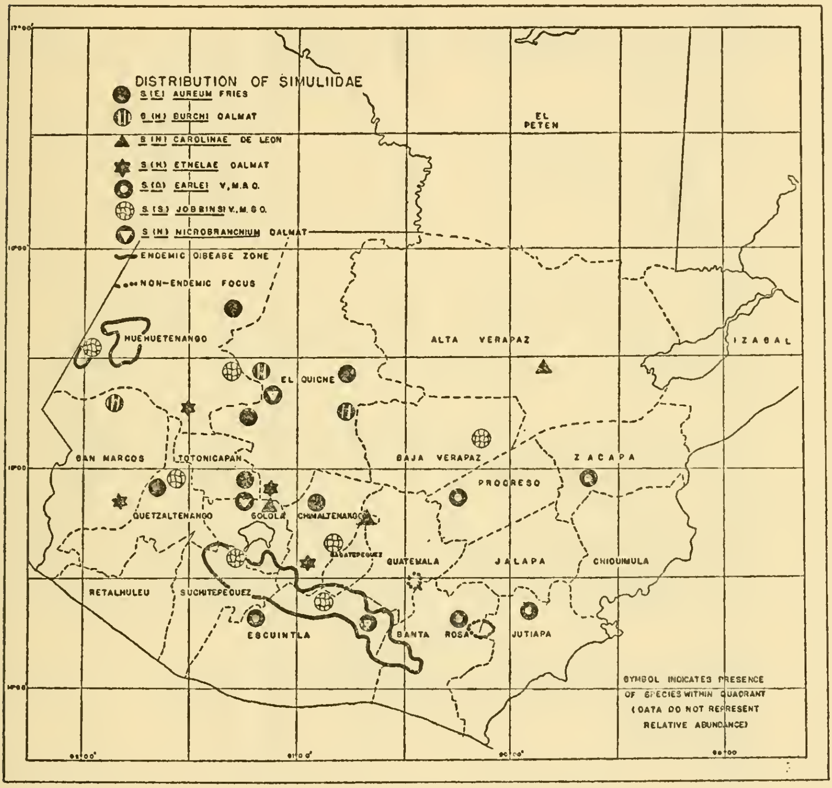
Meteorological factors		Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Annual averages	Averages (5 years)
Mean monthly maximum temperature (°F.)		1947–48	75.2	77.0	76.6	77.7	78.4	78.4	81.1	81.5	81.9	82.0	80.4	79.2	79.1	78.7
		1948–49	79.4	77.5	78.1	78.6	77.4	76.1	77.9	79.0	78.3	80.4	78.1	81.5	78.5	
		1949–50	81.0	77.7	75.6	76.4	79.4	79.0	79.2	78.3	80.6	79.9	78.6	79.4	78.8	
		1950–51	78.3	77.7	76.1	78.8	75.7	78.4	77.2	79.5	81.1	78.8	78.6	79.0	78.3	
		1951–52	80.6	76.8	79.3	80.4	79.0	79.0	78.3	77.5	78.4	79.5	76.0	79.0	78.8	
Mean monthly minimum temperature (°F.)		1947–48	57.8	55.8	56.5	53.5	52.6	52.0	54.0	52.8	54.6	55.8	55.5	55.5	54.7	54.1
		1948–49	55.1	52.4	54.4	54.6	54.8	53.7	52.4	54.6	54.0	54.3	55.3	55.1	54.2	
		1949–50	54.9	53.8	53.7	52.8	53.5	53.9	45.8	54.2	56.0	55.7	54.4	56.0	53.7	
		1950–51	56.7	54.7	54.4	54.6	52.0	51.3	49.5	51.9	54.2	55.3	55.8	55.3	53.8	
		1951–52	55.3	53.8	54.2	54.4	53.3	53.3	51.3	53.8	54.9	55.6	55.8	55.5	54.2	
Mean monthly temperature (°F.)		1947–48	66.5	66.4	66.6	65.6	65.5	65.2	67.6	67.1	68.3	68.9	68.0	67.4	66.9	66.4
		1948–49	67.3	65.0	66.3	66.6	66.1	64.9	65.2	66.8	66.2	67.4	66.7	68.3	66.4	
		1949–50	67.9	65.7	64.6	64.6	66.4	66.4	62.5	66.2	68.3	67.8	66.5	67.7	66.2	
		1950–51	67.5	66.2	65.3	66.7	63.8	64.8	63.4	65.7	67.7	67.1	67.2	67.2	66.1	
		1951–52	67.9	65.3	66.8	67.4	66.1	66.2	64.8	65.7	66.7	67.6	65.9	67.3	66.5	
Mean relative humidity		1947–48	83	88	90	96	90	82	81	82	81	91	93	79	86	85
		1948–49	94	93	82	88	87	89	88	85	87	88	92	90	89	
		1949–50	90	94	88	86	80	82	85	84	84	87	92	88	87	
		1950–51	88	90	92	85	82	75	75	75	76	83	83	80	82	
		1951–52	83	87	90	88	79	77	71	70	72	82	86	79	80	
Precipitation [Total inches (days)]		1947–48	9.9(13)	25.7(24)	18.3(20)	10.6(11)	2.9(5)	0(0)	1.0(1)	2.0(3)	7.3(7)	18.8(18)	18.8(18)	14.8(21)	130.1(141)	126.7 (139)
		1948–49	16.4(17)	18.5(22)	8.4(14)	4.4(7)	0(0)	0(0)	0(0)	0(0)	8.8(9)	13.2(16)	19.7(24)	10.4(19)	99.8(128)	
		1949–50	19.4(19)	49.3(28)	32.8(13)	0.8(2)	0(0)	1.3(2)	1.9(4)	8.7(8)	1.6(6)	13.3(24)	28.8(23)	19.0(15)	176.9(144)	
		1950–51	21.6(17)	26.3(23)	25.6(20)	0.3(1)	0(0)	0.3(2)	0.2(2)	0.4(3)	2.7(9)	9.0(15)	11.2(20)	21.0(26)	118.6(138)	
		1951–52	11.9(20)	26.3(24)	9.4(17)	1.7(4)	0(0)	0.7(1)	0.1(1)	1.8(3)	2.6(8)	19.1(25)	20.7(23)	13.1(16)	107.4(142)	
Winds (percent)	1947 1948	Strong	6	0	6	22	38	30	22	8	15	19	3	19	16	
		Slight	86	91	81	69	62	67	70	81	70	61	79	73	74	
		None	8	9	13	9	0	3	8	11	15	20	18	8	10	
	1948 1949	Strong	3	4	7	23	32	26	25	13	3	0	0	23	13	Strong 18
		Slight	3	90	74	60	68	68	67	87	94	83	90	74	71	
		None	94	6	19	17	0	6	8	0	3	17	10	3	16	
	1949 1950	Strong	11	0	26	33	50	33	39	10	7	0	0	0	17	Slight 75
		Slight	82	80	70	63	50	67	61	87	90	100	100	100	79	
		None	7	20	4	4	0	0	0	3	3	0	0	0	4	
	1950 1951	Strong	9	10	23	53	32	32	43	3	0	10	10	10	20	None 7
		Slight	71	90	77	47	68	68	57	97	100	90	90	90	79	
		None	20	0	0	0	0	0	0	0	0	0	0	0	1	
	1951 1952	Strong	0	94	29	60	60	42	14	0	7	0	0	0	26	
		Slight	100	3	71	40	40	55	86	100	90	100	100	100	73	
		None	0	3	0	0	0	3	0	0	3	0	0	0	1	

TABLE 3.—*Meteorological data—San Bernabé Acatenango, Chimaltenango, Guatemala*

(August 1, 1947—July 31, 1951)

Meteorological factors	Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Annual averages	Averages (4 years)
Mean monthly maximum temperature (°F.)	1947–48	77.5	76.7	78.2	79.1	78.9	82.0	79.3	79.4	80.5	78.9	76.4	81.6	79.0	80.2
	1948–49	82.0	79.8	78.5	80.2	81.2	82.9	82.0	80.2	81.1	81.8	79.6	82.3	81.0	
	1949–50	81.8	75.5	78.7	83.7	84.3	83.2	80.9	79.8	79.6	78.7	79.1	81.1	80.5	
	1950–51	79.8	78.3	76.7	82.3	82.3	82.1	81.2	81.4	82.3	79.8	79.8	81.4	80.6	
Mean monthly minimum temperature (°F.)	1947–48	54.2	52.5	53.6	53.3	53.3	48.9	52.7	52.0	56.0	56.3	55.6	57.2	53.8	52.0
	1948–49	54.2	53.4	53.8	52.9	51.6	51.1	47.9	49.7	51.8	52.9	54.0	53.4	52.2	
	1949–50	45.7	53.4	53.4	50.6	48.0	49.7	47.3	50.4	51.6	52.5	52.4	51.3	50.5	
	1950–51	54.1	53.6	52.0	50.7	47.9	48.0	47.3	50.0	53.1	54.3	54.3	54.3	51.6	
Mean monthly temperature (°F.)	1947–48	65.8	64.6	65.9	66.2	66.1	65.4	66.0	65.7	68.2	67.6	66.0	69.4	66.4	66.1
	1948–49	68.1	66.6	66.2	66.6	66.4	67.0	65.0	65.0	66.5	67.4	66.8	67.9	66.6	
	1949–50	63.7	64.4	66.0	67.1	66.1	66.4	64.1	65.1	65.6	65.6	65.7	66.2	65.5	
	1950–51	66.9	65.9	64.3	66.5	65.1	65.0	64.2	65.7	67.7	67.0	67.0	67.8	66.0	
Mean relative humidity	1947–48	84	89	87	83	79	74	74	75	76	85	86	84	81	73
	1948–49	77	74	78	73	70	61	66	66	68	76	78	70	71	
	1949–50	71	80	76	66	61	60	61	68	70	81	78	74	70	
	1950–51	74	80	82	63	62	63	56	65	69	76	79	73	70	
Precipitation [Total inches (days)]	1947–48	21.7(19)	22.3(27)	17.0(16)	10.0(9)	1.5(2)	0(0)	0.4(1)	1.0(4)	4.2(7)	18.5(16)	14.0(19)	18.0(20)	128.6(140)	114.4 (114)
	1948–49	10.3(15)	10.5(14)	5.7(10)	4.8(5)	0(0)	0(0)	0.5(2)	0.3(1)	8.8(7)	18.8(12)	18.3(17)	8.2(17)	86.2(100)	
	1949–50	15.6(18)	30.4(23)	43.6(14)	0.1(2)	0(0)	1.2(3)	0(0)	2.2(4)	1.4(3)	14.7(19)	20.0(18)	9.8(15)	139.0(119)	
	1950–51	11.6(13)	28.4(23)	25.2(15)	1.2(2)	0(0)	0.1(1)	0.1(1)	0.1(1)	1.5(2)	6.9(10)	13.2(15)	15.4(13)	103.7(96)	
Winds (percent) 1947 1948	Strong	11	2	10	33	43	61	48	3	2	0	33	56	25	
	Slight	89	96	90	67	57	39	52	97	97	95	67	44	74	
	None	0	2	0	0	0	0	0	0	1	5	0	0	1	
1948 1949	Strong	22	13	48	50	39	52	43	32	13	6	10	39	31	Strong 25
	Slight	70	87	49	47	35	38	25	39	87	68	80	35	55	
	None	8	0	3	3	26	10	32	29	0	26	10	26	14	
1949 1950	Strong	16	13	42	47	44	45	36	36	0	3	7	16	25	Slight 60
	Slight	58	74	45	23	20	42	25	61	100	94	80	61	57	
	None	16	13	13	30	36	13	39	13	0	3	13	23	18	
1950 1951	Strong	19	43	13	37	40	11	34	12	7	0	7	13	30	None 15
	Slight	45	50	70	16	47	51	27	53	79	84	83	62	55	
	None	36	7	17	47	13	38	39	35	14	16	10	25	25	

than does the reduction in temperature. Beginning usually in October or November, a period of stronger winds is also recorded, this being caused by the winter tradewinds blowing from the northeast. It can be seen that the general climate of the Yepocapa region is mild and rather constant, the only radical changes being in rainfall and, therefore, in relative humidity.



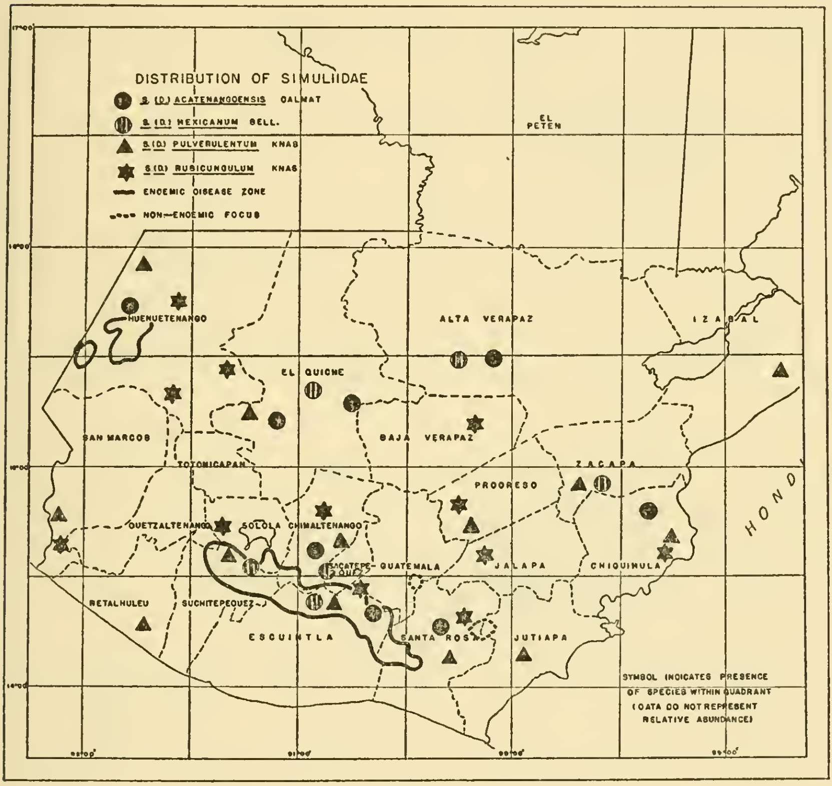
Map 8.

In table 4 comparative annual data are given for six areas within the onchocerciasis zones (Yepocapa, Acatenango, Finca Mocá, Finca El Naranjo, Finca El Zapote, and Finca San Luis Buena Vista), for two areas that are not within the disease zones (Acultzingo and Beliz, sections of Finca La Helvetia), although with conditions apparently identical to those within the zones, and for two coastal areas which have ecological conditions quite different from those in the zones. It will be noted that, except for Tiquisate and Bananera, conditions reported from all the other regions are somewhat similar. Certain gen-

TABLE 4.—*Meteorological data—Comparison of areas in the onchocerciasis zone with those outside of it*

Stations:	Acatenango	Yepocapa	El Naranjo	Mocá	El Zapote	San Luis Buena Vista	Acultzingo	Beliz	Tiquisate	Bananera
Altitude (feet)	5,320	4,850	3,850	3,000	2,500	1,610	4,500	2,950	220	198
Average annual temperature (°F.)	66.1	66.4	68.2	71.7	72.3	74.8	65.6	69.8	80.1	75.7
Average annual maximum (°F.)	80.2	78.7	79.8	81.4	82.6	83.9	76.9	79.8	90.5	87.6
Average annual minimum (°F.)	52.0	54.1	56.6	62.5	61.9	65.7	54.3	59.8	69.6	69.2
Difference between maximum and minimum (°F.)	28.2	24.6	23.2	19.1	20.5	18.2	22.6	20.0	20.9	18.4
Average relative humidity	73	86	—	87	—	—	—	76	68	69
Month with register of highest average temperature	July	May	April	April	May	May	August	May	April	April
Month with register of lowest average temperature	February	February	January	January	January	January	January	January	January	January
Total annual rainfall (inches)	114.4	126.6	186.5	172.4	153.5	171.5	135.5	176.8	89.4	92.3
Month with register of highest rainfall	September	September	September	September	September	September	September	September	September	September
Month with register of lowest rainfall	December	December	January	January	January	January	January	January	February	April
Average number of days during which rain fell per year	114	139	209	201	185	167	214	203	139	268
Length of period reported (years)	4	5	2	12 (rain, 33 yrs.)	2	2	2	2	14 (rain, 2 yrs.)	10

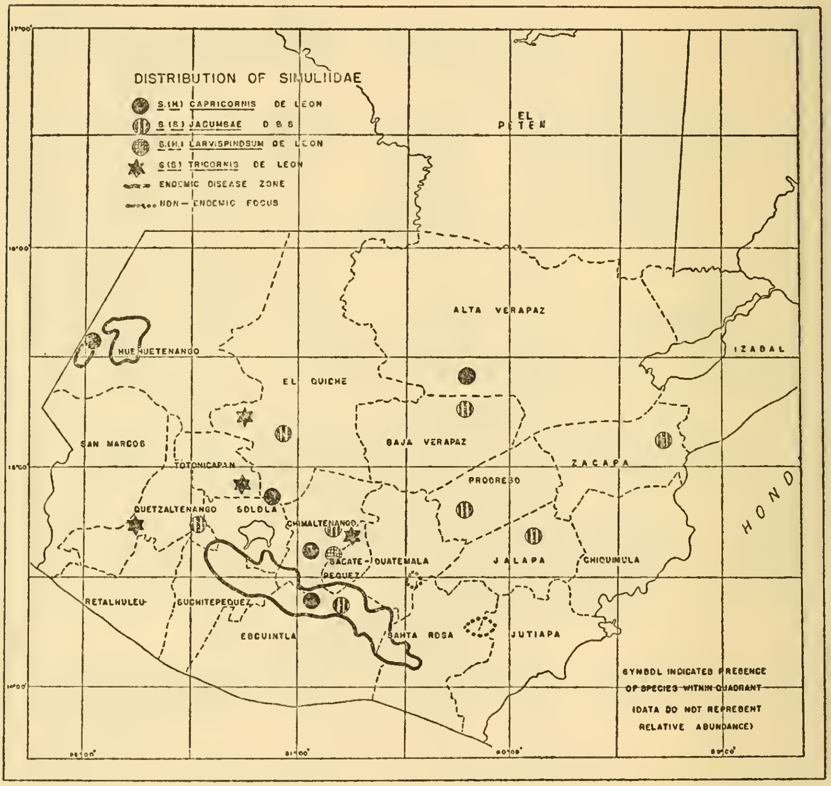
eral trends can be indicated. The average annual temperature descends as the altitude ascends. The rainfall is greatest in those areas between 1,500 feet and 4,000 feet where the great wall of volcanic mountains serves as a barrier to the moisture-laden air currents. In all cases the heaviest rainfall is reported in September, the second heaviest rain usually being recorded in June. All the areas for which data are given



MAP 9.

are on the Pacific versant except Bananera, which is near the Gulf of Honduras. Bananera, exposed to the tradewinds, receives much heavier rainfall than Tiquisate.

The similarities of conditions in areas within the onchocerciasis zones and outside of them would tend to show that the meteorological factors are not in themselves sufficient to explain the presence or absence of onchocerciasis. However, they do have a marked effect. Thus, in regions as high as Quezaltenango (table 1), it is quite possible that the great variation between mean maximum and mean minimum temperatures throughout the year may, to some degree, affect the rate and character of black-fly development. Only few *Simulium ochraceum* were found in areas much above 5,000 feet. At the other extreme, the relatively high mean temperature at San José (table 1), Tiquisate, and Bananera (table 4) may so affect the streams by lowering the dissolved-oxygen content that the principal vectors of oncho-



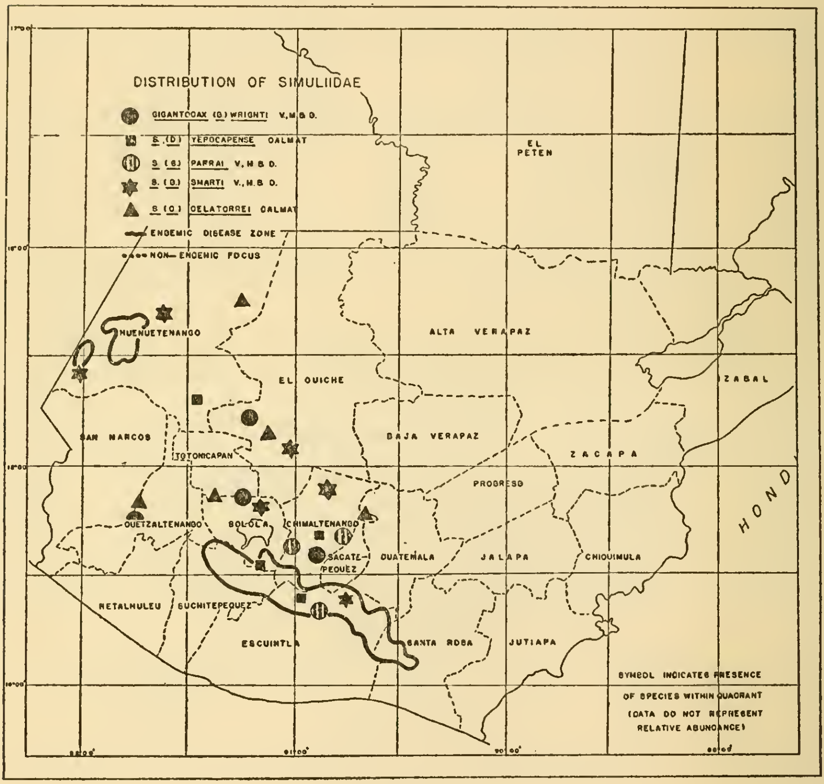
Map 10.

cerciasis are not able to breed in them. Certainly *Simulium ochraceum* has never been found in streams situated below 500 feet altitude. This may be due to the lack in the true coastal area of the proper stream type (see section on "Streams") for breeding of the principal anthropophilic species, as well as to the effect of the high mean temperature.

In the Pacific coastal belt between 1,500 and 5,000 feet, the fluctuation from the mean daily temperature is relatively slight in any 24-hour period, and the mean daily temperature is relatively constant throughout the year. Thus, insect development should be able to continue at approximately an equal rate. However, onchocerciasis, as well as its principal simuliid vectors, are not prevalent in all parts of this belt. It may be that the amount and extreme seasonal fluctuation of rains may play important roles as limiting factors in certain regions. Certainly, the size of the black-fly population in a particular area can be

MAP II.

correlated with the seasonal variation in the rainfall. During the rainy season, from May to October, the number of adult flies of the principal anthropophilic species is definitely reduced, although numerous larvae may be found. After heavy rain, it is invariably found that large numbers of larvae have been washed downstream, many being killed by the action of sand and stones. The rains may also destroy large numbers of adults. However, a small adult population is always maintained. From the middle of October or the beginning of November, when the dry season commences, through February the adult population builds up to a high level. These months coincide with the period when the workers on the coffee plantations are most active and, therefore, most exposed to infection. This is discussed more fully in the section entitled "The Inhabitants, Their Occupations and Customs." Toward the end of the dry season, in March and April, the small streams that serve as breeding places primarily for *S. ochraceum* (see



MAP 12.

section entitled "Classification of Permanent Streams by Morphological Age") dry up, partially or completely, and there is a definite reduction trend in the population of the species (see the section on ecology). It can be seen that in areas where there are extreme dry and wet seasons, the breeding of simuliids, especially the anthropophilic species that attach to floating vegetation rather than to rocks, may be markedly affected.

At plantations Acultzingo and Beliz (table 4), where all conditions appear equal to those in the onchocerciasis zones, it is believed that the

1. General view of the terrain in the Yepocapa onchocerciasis zone.

2. Finca Montevideo, Yepocapa. Note how the hacienda area has been cut out of the semitropical rain forest.

1. Construction of native dwelling (ranchito). Usually the roof must be replaced every 5 years. Neighbors often cooperate in accomplishing this task.

2. Laborers' homes (ranchería) on Finca Recreo, Yepocapa.

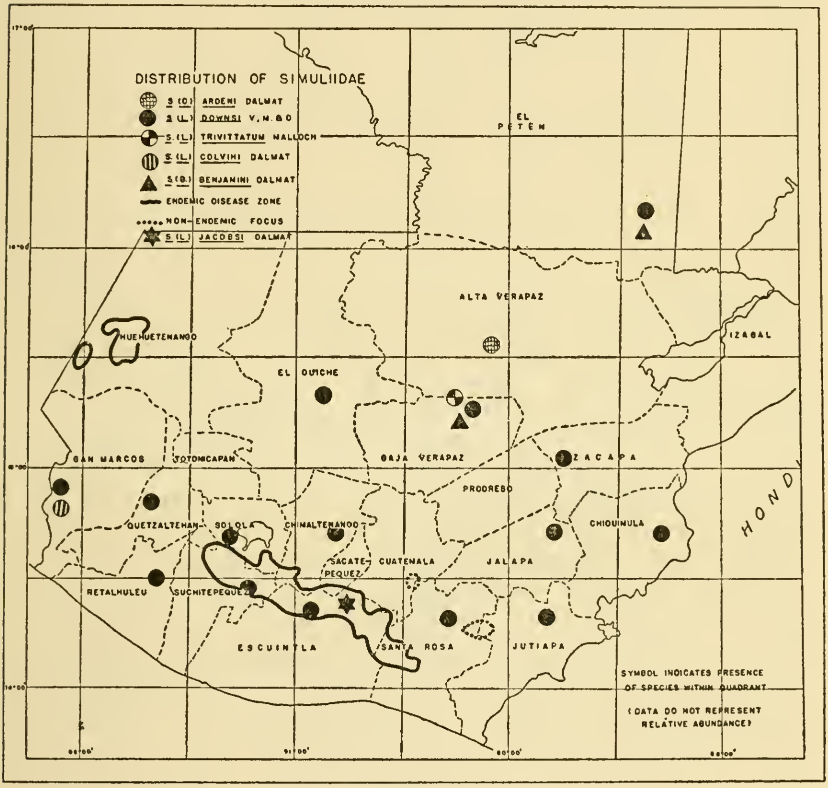
1. Man-made water channel (toma) that conducts water to the finca area from a near-by stream. These channels serve as good breeding grounds for *S. metallicum* and other species of black flies.

2. Flash stream, Quisaché, Chimaltenango. No black-fly breeding occurs in this type of temporary water source.

1. Itinerant salesmen (cargadores) who will set up shop in the San Pedro Yepocapa market compound for 2 or 3 days.

2. Seepage from large area of wet-faced wall, from which streams originate.

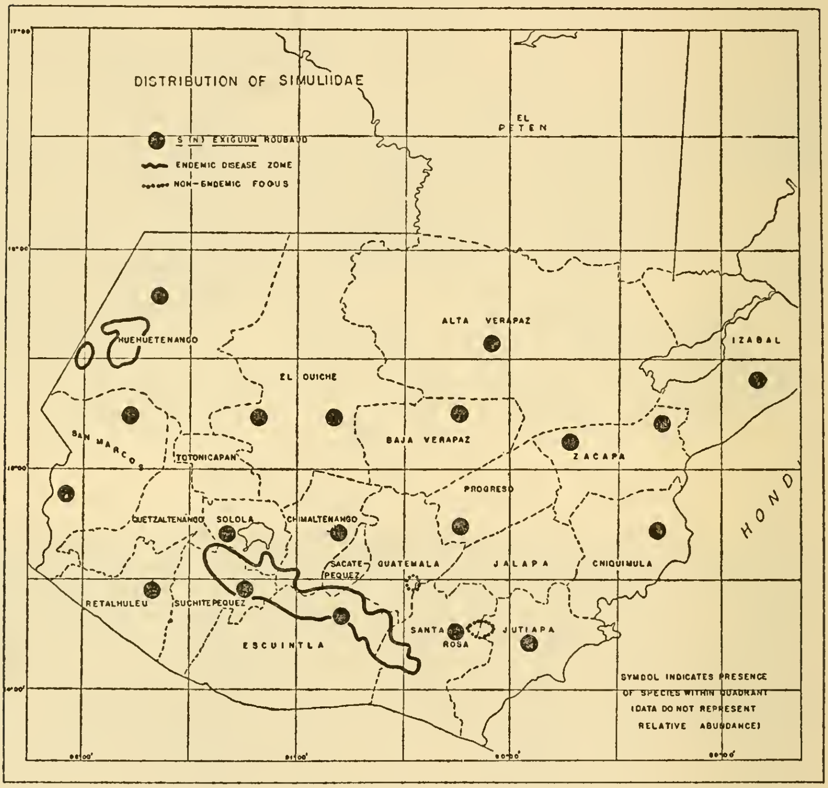
disease could become endemic. Surveys of these two plantations have shown that both *Simulium ochraceum* and *S. metallicum* are present in large numbers. Should a sufficiently large group of infected individuals be introduced into the region at one time, transmission may take place and the disease may then become established. Another region, in the north-central Department of El Quiché, is similar in



MAP 13.

altitude, meteorological conditions, crops, stream types, and species of *Simulium* to regions within the onchocerciasis zones. In addition, numerous residents of this large region migrate annually to the onchocerciasis region to work on the coffee plantations for about a 4-month period, especially during the harvest. Many of these transient workers have become infected, yet no endemic zone is believed to have become established in El Quiché. This may be explained by the social organization in this department, a subject which is discussed in the following section of this presentation.

It is believed that only a very careful study of the actual disease zones as they are presently constituted, followed by long-term investigations concerning the extension of the disease to new areas, will make it possible to demonstrate clearly the importance of the meteorological and other factors in relation to the endemicity of onchocerciasis.



Map 14.

THE INHABITANTS, THEIR OCCUPATIONS AND CUSTOMS

In a search for the explanation of the limited distribution of onchocerciasis in Guatemala many environmental factors must be studied. In the preceding section the geography and climate were discussed. It will now be appropriate to consider the inhabitants of the onchocerciasis regions and determine to what extent their occupations and customs may be responsible for the transmission of onchocerciasis, while still preventing it from spreading rapidly and extensively.

As previously stated ("Onchocerciasis Zones"), in the Municipality of Yepocapa, 6,000, or 74 percent, of the 8,200 inhabitants live or work outside of the town. Of this rural group approximately 95 percent are Mayan Indians. They live in small huts, usually made of cornstalks, with straw roofs. More recently somewhat better-constructed houses are being built on a few of the plantations. During most of the year the women usually remain at home, attending to such domestic chores as obtaining water from streams or centrally located water outlets, which they collect in large earthen receptacles (tinajas) carried gracefully on their heads; preparing the family's food, usually consisting of black beans, some vegetables, wild herbs, chirmol (a mixture of finely diced onion, tomato, and chilies), salt, tortillas, bananas, coffee, meat about once a week and, infrequently, rice; doing the family wash; making purchases and selling their excess produce (often things they do not use, like eggs, beets, carrots); making trips to the fields and streams to collect herbs for food, and reeds for making sleeping mats (petates) and native "umbrellas" (suyacales); cutting firewood in the nearby woodlands; caring for the children; and occasional weaving (pl. 4, fig. 1). This routine, of course, varies somewhat with different localities. In the highlands weaving may be a principal occupation of the women, while in Yepocapa very few weave their cloth, preferring to purchase it in the market place.

The work day of the woman begins at about 3 a.m. to 4 a.m. if the man must walk a distance to work, or at 5 a.m. if he does not have far to go. At this hour the woman grinds the corn, which was softened and removed from the husk by heating in lye water prepared from wood ashes the previous day. The ancient grinding-stone (metate) method is still used; but also, when possible, the corn is taken to the town's electric or hand-operated mill, where it is coarsely ground. The ground corn is made into dough (masa) for preparing the day's supply of tortillas and pixtones (thick, soft variety of tortilla used on travels). On market days, usually once or twice a week, the women congregate to buy and sell their wares and to exchange experiences. Wherever the women go, they usually carry with them their infants suspended in a large cloth (perraje) slung around the shoulders to form a cradle. During the coffee harvest almost all the women leave for the fields to help gather the coffee, the children accompanying them and the infants being carried in the manner just described. At this season of the year, when the fly population is at its peak, the women and children, as well as the men, who remain relatively stationary while picking the coffee, serve as particularly good targets for attacking *Simulium*.

The work of principal importance to the man is the cultivation of his cornfield (milpa). It is usually cleared from a piece of woodland owned by the Indian, rented from the owner for a one-third share of the crop, or lent to him by the finca that employs him. In the Yepocapa region, a man will usually cultivate two pieces of land, at different altitudes, in order to have his corn mature several months apart, thereby giving a more constant supply of grain. It can be stored only for relatively short periods under existent conditions because of the danger of damage by grain beetles. A person working on a finca, in addition to the 15 days he is allowed for clearing his land, will spend all possible spare time on his milpa and will request days of leave to give special attention to the corn at certain times of the year. Since tortillas are the staple in the diet of the Indian family, the significance of the cornfield is obvious. In the region of Yepocapa, the head of the family and his sons over 8 years of age will clear (roza) the piece of land, somewhat over 10,000 square yards, in November or December. In December or January they will burn the dry debris and turn it into the soil. From February 2d (Día de Santa Candelaria) to the 15th the corn grain is planted (siembra) in an 8,000-square-yard plot. (About 2,000 square yards will be planted with tomato and chili.) In April the terrain is weeded and soil is arranged into mounds (tamegua) around the young cornstalks; and in June the soil is again worked and moved to form rows (calza). In July or August, when the corn is well formed, the stalk is doubled over (dobla), permitting it to dry and harden, so that it will be ready for the harvest (tapizca) on the 8th of December (Día de Concepción). During each of these periods of special attention to the milpa, the workers are exposed to the bites of the black flies more than usual.

The majority of inhabitants in the municipality of Yepocapa live and work on the coffee fincas. Here the work day usually begins at 7 a.m. and lasts until 4 p.m., although up to 1947 it had been from 6 a.m. until 5 p.m. The cultivation of coffee requires much attention throughout the year, and therefore the workers are constantly exposed to the bite of *Simulium* flies. Permanent residents (rancheros) of the finca carry out the work during most of the year, but additional workers (cuadrilleros) are hired from other regions (outside of the onchocerciasis zones) to work during the harvesting and processing season. Young seedlings must be grown over a one- to two-year period and transplanted to the fields (in May or June); shade trees (*Inga leptoloba* Schlecht., "caspirol"; *Inga micheliana* Harms, "chalúm"; *Musa sapientum* L., banana in several varieties) and shrubs must be planted; numerous secondary branches that are sapping food from the primary branches must be pruned, and dead twigs removed (after the harvest);

branches must be bent (agobeo) to stimulate formation of new shoots, followed by selection of the most productive (in April or May and again in August) ; the coffee fields must be weeded periodically (end of harvest, May and September) and wild sprouts of coffee cut out; in July and August, a few months before the harvest, shade is removed (desombra) from those sections of the plantation where the coffee is retarded so that ripening can be hastened and the harvest will not be too extended; then, finally, comes the harvesting and processing (October-January) which requires an increased number of laborers.

To reach his work in the field a peon often has to walk 3 to 4 miles on narrow footpaths through dense rain forests. Flowing through these woodlands are numerous small, shallow streams, a few inches to a few feet in width, abounding in emergent and floating vegetation, which serve as breeding places for the anthropophilic species of black flies. Because of the usually long walk to and from the fields, the worker is exposed to bites during almost the entire period of activity of the flies.

During the harvest, if the worker is employed in the mill (beneficio) or on the drying patios, he is also well exposed to the simuliids. While working at the fermenting tanks or while shoveling coffee beans on the patios (pl. 4, fig. 2) the workers usually remove their shirts and roll up their trousers. It is a common sight to see these men with literally thousands of flies feeding on their backs, which are traversed by vertical stripes of blood. This period of greatest finca activity, when women and children as well as the men are in the fields, also corresponds to the season of greatest black-fly population. Because of the large concentration of persons, it is probable that infected flies can more readily transmit their parasites. Since the incubation period of onchocerciasis is not definitely known, it is not possible to draw definite conclusions as to when maximum transmission occurs. However, studies of seasonal variation of natural infection in *S. ochraceum, S. metallicum,* and *S. callidum* show that the percent of infection in the flies is approximately the same in the season of the harvest and during the remainder of the year (table 5). Thus it would seem that with the same rate of natural infection, with the tremendous increase in the number of flies, and with the concentrated human population during the period of the harvest, transmission should then reach its peak.

When his usual work in the fields is finished, the man engages in various chores. He may gather firewood for his home, sharpen his machete and azadón (giant hoe), which are his principal agricultural tools, or, commonly in Yepocapa, weave sleeping mats (petates) (pl. 1,

TABLE 5.—*Natural-infection rate of* S. ochraceum, S. metallicum, *and* S. callidum *on fincas in the Municipality of San Pedro Yepocapa, Chimaltenango, Guatemala*

(Data expressed as the number of infected flies over the total number of flies of each species collected per month, per finca. Each reading represents the total for one to four collecting periods, depending upon availability of flies.)

Month	Species	Fincas: Conchita	Santa Emilia	Monte-video	Buena Vista	Recreo	Recuerdo	Sibajá	Santa Rosa	Santa Teresa	Total	Percent infection
1952 August	*ochraceum*	0/102	0/ 48	0/ 60	0/120	3/132	2/120	0/ 5	0/ 6	0/ 9	5/ 602	0.83
	metallicum	1/ 27	0/121	0/ 80	0/ 56	1/101	1/ 73	1/244	0/161	1/130	5/ 993	0.5
	callidum	0/ 2	0/ 4	0/ 10	0/ 8	0/ 3	0/ 1	0/ 4	0/ 4	0/ 1	0/ 37	0.0
September	*ochraceum*	0/ 41	0/ 56	0/ 45	0/ 54	1/ 40	0/137	0/ 3	0/ 0	0/ 24	1/ 400	0.25
	metallicum	1/ 85	2/ 88	2/ 78	0/ 91	1/ 86	0/112	0/136	2/139	0/123	8/ 938	0.86
	callidum	0/ 4	0/ 0	0/ 4	0/ 7	0/ 1	0/ 5	0/ 10	0/ 9	0/ 7	0/ 47	0.0
October	*ochraceum*	0/ 46	0/116	3/109	1/108	3/ 88	6/110	0/ 0	0/ 9	0/ 21	12/ 607	2.0
	metallicum	0/ 99	0/ 42	1/ 41	0/ 30	0/108	1/ 24	0/153	0/122	0/119	2/ 738	0.27
	callidum	0/ 2	0/ 6	0/ 9	0/ 4	0/ 8	0/ 3	0/ 7	0/ 7	0/ 4	0/ 50	0.0
November	*ochraceum*	0/119	2/ 90	0/133	0/127	0/180	2/ 92	0/ 79	0/102	0/109	4/1031	0.4
	metallicum	0/ 32	0/ 80	0/ 45	0/ 14	1/ 27	0/ 25	0/ 56	1/ 36	0/ 42	2/ 357	0.56
	callidum	0/ 1	0/ 7	0/ 2	0/ 9	0/ 3	0/ 8	0/ 14	0/ 4	0/ 7	0/ 55	0.0
December	*ochraceum*	0/109	0/126	0/116	0/ 14	0/121	0/119	0/ 61	0/ 24	0/ 19	0/ 709	0.0
	metallicum	0/ 42	0/ 14	0/ 24	0/ 89	0/ 19	0/ 21	0/ 89	0/102	0/113	0/ 513	0.0
	callidum	0/ 2	0/ 8	0/ 3	0/ 14	0/ 6	0/ 13	0/ 8	0/ 11	0/ 14	0/ 79	0.0
1953 January	*ochraceum*	0/150	0/102	0/ 46	0/139	0/ 92	1/ 90	0/229	0/ 82	0/ 32	1/ 962	0.1
	metallicum	0/131	0/ 87	0/138	1/ 97	0/115	1/ 36	0/ 37	0/114	0/120	2/ 875	0.23
	callidum	0/ 23	0/ 11	0/ 11	0/ 29	0/103	0/144	0/ 45	0/ 96	0/ 14	0/ 476	0.0
February	*ochraceum*	0/278	0/217	2/227	0/169	2/168	0/152	0/174	1/ 73	0/190	5/1648	0.3
	metallicum	0/140	0/183	0/153	0/ 85	0/ 90	0/100	0/172	0/222	0/147	0/1292	0.0
	callidum	0/ 5	0/ 5	0/ 36	0/ 15	0/ 6	0/ 55	0/ 37	0/ 12	0/ 24	0/ 195	0.0
March	*ochraceum*	1/112	0/ 15	0/ 45	0/110	1/178	0/210	0/ 30	0/ 20	0/ 50	2/ 770	0.26
	metallicum	0/189	0/218	0/118	0/194	0/121	0/ 80	0/150	4/140	0/ 60	4/1270	0.32
	callidum	0/ 12	0/ 5	0/ 38	0/ 6	0/ 8	0/ 12	0/ 10	0/ 17	0/ 1	0/ 109	0.0
April	*ochraceum*	0/ 21	0/ 10	0/ 20	0/ 1	0/ 18	0/ 11	0/ 5	0/ 0	0/ 0	0/ 86	0.0
	metallicum	1/165	0/ 50	0/ 50	0/ 90	1/201	1/ 86	0/ 50	0/ 8	0/ 2	3/ 702	0.43
	callidum	0/ 6	0/ 1	0/ 0	0/ 0	0/ 3	0/ 0	0/ 5	0/ 0	0/ 0	0/ 15	0.0

fig. 2) or fans (sopladores) for ventilating the fires. These are made from the reeds (tul) that had been collected from the streams, dried, and stripped to remove the pithy heart. While carrying on any of these activities, or while just relaxing in front of his house, the worker is always subject to the bites of the flies. The simuliids are omnipresent on the finca, whether it be in the region of the ranchería (groups of native huts), at the beneficio or patios, in the woodlands, or on the coffee fields themselves.

Although the clothing worn by Indians of different regions varies in design and quantity, it usually follows a general pattern (pl. 5, fig. 1). The women wear a type of blouse (güipil) that fits loosely over the torso, leaving the neck and arms exposed, a skirt consisting of a $5\frac{1}{2}$-yard length of woven cloth (corte) wound tightly over the blouse and around the waist, and a waistband (banda) which keeps the skirt in place. The women sometimes use a cloth on their head or may intertwine strips of cloth with their braids, but they never wear footgear. The color and style of the güipil and the color and pattern of the skirt are distinct for almost every municipality.

The men generally wear a cotton shirt, cotton trousers, a hat made of palm straw, and sandals (caytes). Some use a black, sleeveless, woolen cape (gabán). During the cooler parts of the day they may also don a jacket. While working in the fields, many or all of the upper garments are often removed, and the trousers are turned up.

The children usually are dressed like their parents, although they may often be seen with little or no clothing, depending on the climate. In general, the type of clothes worn by the men, women, and children leaves them vulnerable to bites on the head, neck, arms, legs, and feet.

It is practically only to the coffee plantations that onchocerciasis in Guatemala is limited. Thus, in San Pedro Yepocapa those people who live and work in the town and do not work on, or visit regularly, the surrounding fincas are free of onchocerciasis. In an attempt to explain this, the makeup of a finca should be discussed.

The terrain of the finca is usually divided between gentle slopes, steep hills, and numerous ridges separated by deep valleys (barrancos). These areas are constantly being altered by extreme erosion, by deposition of volcanic ash and dust, and by earthquakes. Most fincas have several rapid-flowing streams and numerous rivulets crossing their terrain (pl. 5, fig. 2). However, there are several fincas, known as "dry fincas," which have no surface water other than the rain. Some fincas usually conduct the necessary water from the nearest river sources to the village (comprising all finca buildings) via metal or bamboo tubes, or transport it in barrels. Beneficios for coffee or sugarcane are usually situated along the rivers to supply the necessary water power. This lack of rivers, and therefore of fly-breeding areas on the "dry fincas," does not in itself preclude the possibility of black-fly prevalence or of endemicity of onchocerciasis. There are "dry fincas" in Guatemala that do, and others that do not, have the flies and the disease. This presence of flies in the absence of breeding areas is easily explained when the flight range and longevity of the flies is considered (see section on "Ecology").

Few fincas have the entire terrain under cultivation. In the Municipality of Yepocapa, some fincas have as little as 15 to 20 percent of the terrain planted to coffee or other income crops such as sugarcane and bananas. The latter also serves as a cover crop to supply the mottled sun and shade environment so necessary for proper development of coffee in Guatemala. The remainder of the finca terrain is composed of temperate to semitropical rain forest (pl. 6, fig. 1).

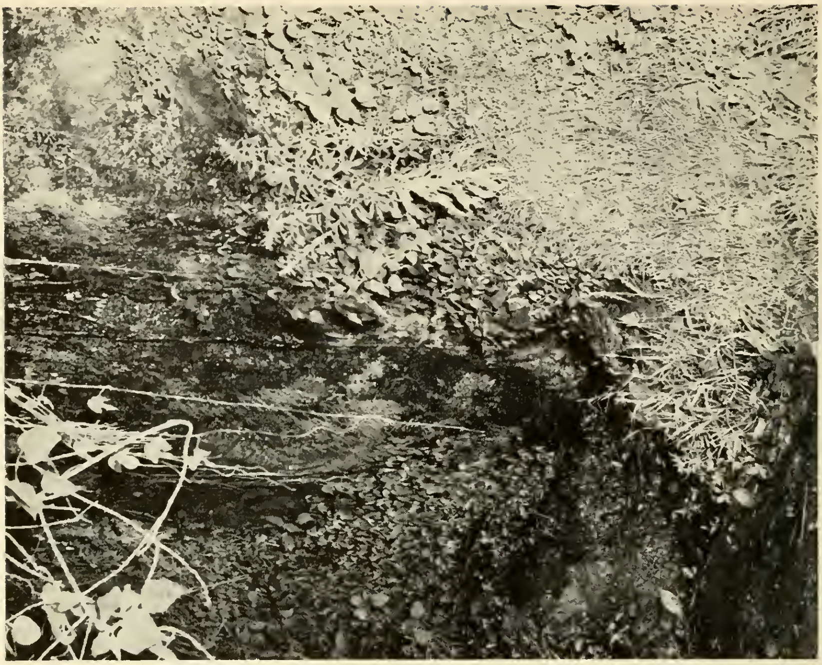
Usually all the buildings of a finca are concentrated in one area cut out of the woodland (pl. 6, fig. 2). Here will be found the home of the finquero (finca owner) and/or his administrator, the various offices, storerooms, garages, carpenter shop, stables, beneficio, drying patios, and the huts (ranchería) of the permanent residents. The administrative helpers are usually given quarters consisting of a fairly well-constructed wood or adobe building with cement floors. The peon and his family usually live in a one-room hut loosely constructed on the bare ground (pls. 4, fig. 1; 5, fig. 1; 7, fig. 1). The walls are constructed of cornstalks or bamboo reeds tied together with vines, or adobe, wood, or thatch. The roofs are usually thatched but at times galvanized iron, corrugated metal sheeting, or local tiles are used. The materials used depend, to a large extent, on the availability in the particular area, and what the individual finca owner cares to spend. All these huts (ranchos) are usually grouped together to form the ranchería (pl. 7, fig. 2). To supply water to all the inhabitants of the finca, a nearby river, flowing along terrain higher than the village area, is diverted into a canal leading to communal wash basins and tubs (pilas), to the pipe line for the hacienda (home of the owner), and to various other outlets. This canal (toma) is usually left with the natural earth walls (pl. 8, fig. 1), although some fincas do cement them. The sides of those that are not cemented are usually lushly covered with grasses and various plants, the leaves of which float on the surface of the water. Such canals serve as excellent breeding places for *Simulium metallicum*.

The proximity of all the finca buildings to the cafetales (coffee fields) and to the woodlands, as well as the loose construction of the

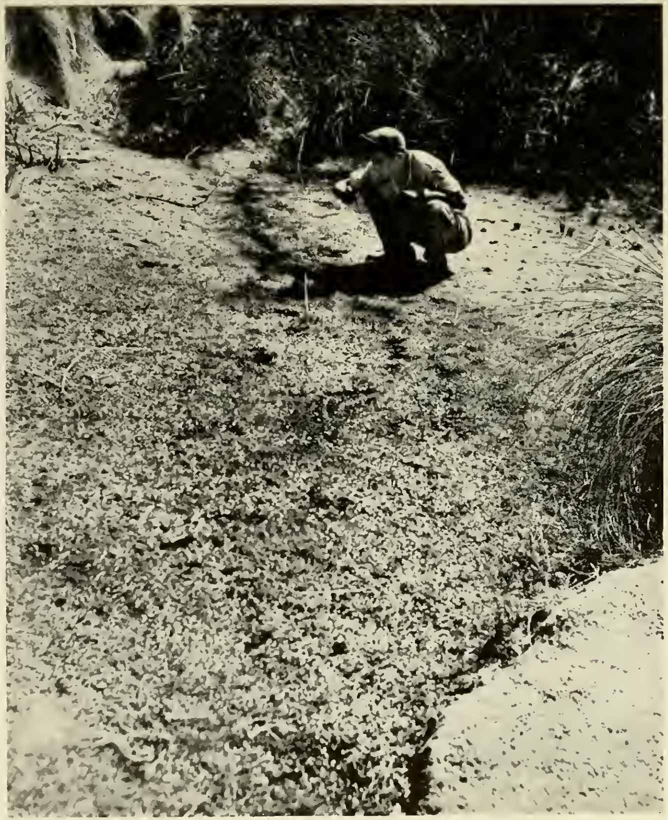
1. Temporary stream, Río Cañalito, Yepocapa. This stream exists throughout the rainy season and supports the development of *S. jacumbac,* as well as other species.

2. Streams also originate from extensive dripping from wet-faced walls.

1. Water seeping from comparatively recent volcanic deposit. Barranco Seco, Alotenango, Sacatepéquez.



2. Flow from cavern cut out by constant drip along wet-faced wall.



1. Trickles of water from soil unite to form slow-moving stream in which *Gigantodax wrighti* and a few other species breed.

2. Underground stream emerging from the wall of a gorge where it forms a short falls. Río Panimaché, Aldea Panimaché, Yepocapa.

1. Underground stream emerging as a spring. Río Peña Blanca, Yepocapa.

2. An infant stream. Note the lack of definite walls, the indefinite type of bed which is similar to the adjacent dry region, and the large quantity of vegetation debris. This is the preferred type of breeding ground for *S. ochraceum*.

huts, creates no barrier for insects that wish to enter. In most literature mentioning the habits of the black flies it is claimed that the adult flies do not often enter buildings (Bequaert, 1934, p. 195). However, I have commonly found them in goodly numbers within buildings, where they will readily bite. They are active in the laboratory buildings during the day and also at night when there is sufficient light. Their presence indoors was already mentioned in the section on the "Importance of the Simuliidae."

Of considerable importance in a discussion of the possible spread of onchocerciasis is the migratory worker. In the region of Yepocapa the majority of temporary workers (cuadrilleros) hired during the harvest and processing season come from the Department of El Quiché, in the north-central region of the country. Large parts of this department are located at altitudes comparable to those in the onchocerciasis zone and have meteorological conditions, stream types, crops, and *Simulium* species that are typical of that zone. These workers, with all their families, arrive at the fincas in Yepocapa and remain there for 4 or 5 months. As shown by medical examinations, a good number of these individuals become infected with *Onchocerca*. However, no endemic zone has been established in El Quiché by the returning workers. Besides *Simulium ochraceum* and *Simulium metallicum, Simulium veracruzanum,* which has been proved experimentally to be an excellent potential vector (Gibson and Dalmat, 1952), is present in abundance in El Quiché. It is believed that the failure of the disease to become endemic in this region may be explained by the wide dispersion of the people, who are primarily pastoral and live in isolated family groups. Under these conditions the flies do not come into sufficient contact with man to transmit the disease effectively. However, it is possible that the proper combination of factors at some particular time might bring about the beginning of an endemic zone in that region. The same is undoubtedly true of other areas from which transient laborers are hired for work on the coffee fincas in the onchocerciasis zones.

Another possible source of extension of the disease from its present confines is the itinerant salesman. To earn money for his minor purchases the man may buy various items in one locality and carry them on his back (pl. 9, fig. 1) for surprising distances, sometimes over 100 miles, for resale in another locality. Also, he will often carry additional items for sale that he or his wife has made. The Indian thinks nothing of carrying loads up to and even surpassing 200 pounds in that manner. Much of his wares is carried in a wooden-framed pack (cacaste) which is strapped to his back and also supported by a leather band (mecapal) across his forehead. Arranged around the cacaste and on top of it are the heavier and bulkier items. Very often the wife and children will accompany the salesman, and they too will carry loads, although not so heavy and not arranged in cacastes. These men (cargadores) are always to be seen on all Guatemalan roads but are more numerous near towns having a market day or fiesta. Many men living just above the disease zone in the Municipality of Yepocapa spend several weeks at a time on the infected fincas selling their surplus of beans, corn, or other crops. Such people could very possibly become infected during their extended sojourns in the onchocerciasis zones and thereby extend the limits of the disease.

PLANT ASSOCIATIONS

As already discussed under the description of the finca, the areas in which the coffee fincas have been developed mainly consist of dense, temperate to semitropical rain forests. The terrain along the volcanic Pacific slopes is extremely broken, with gentle to steep inclines, formidable canyons, and numerous and extensive ridges. According to the particular locality, the earth is arenaceous to rocky. The soil layer very often is 5 to 18 feet in depth. It is very fertile and its volcanic origin seems to peculiarly favor the growth of coffee. The forests support abundant tree ferns as well as *Cedrela* sp. (cedro or Spanish cedar), *Trichilia havanensis* Jacq. and *T. hirta* L. (cedrillo), *Ceiba pentandra* (L.) Gaertn. (ceiba), and other trees. Intertwined with these thick stands of trees are the endless number of lianas and other vines with their complex network of hanging roots. The trees, shrubs, dead logs, and rocks are extensively covered with ferns, orchids, mosses, and lichens. These, together with the pendent roots which sometimes reach the ground, make the forest dense and almost impenetrable (pl. 5, fig. 2). This environment, in places where the foliage is particularly heavy, is often so dark that it is difficult to make out clearly the narrow paths beneath, which must be frequented by the field workers to reach the cafetales (coffee fields) in which they work. The rain forest is kept relatively humid by the ever-present running water. Small trickles from underground streams emerge and soon reenter the earth. Along the sides of the slopes are found larger streams that originate where the water table concides with the natural slope of the ground. The latter flow down the slopes, cutting deep channels where the grade is more pronounced, and usually enter larger rivers that invariably flow along the bottoms of the valleys.

It was thought that those streams serving as breeding places of the anthropophilic species of Simuliidae might contain a preponderance of certain preferred aquatic or semiaquatic plants. We have rarely found eggs, larvae, or pupae on hirsute vegetation. It was also noticed that two particular semiaquatic plants, *Renealmia aromatica* and *R. strobilifera,* were very commonly used by the female flies as the substratum on which to deposit eggs. Perhaps, then, the larvae and pupae of the important biters of human beings also showed preference for certain plants as anchorage.

The vegetation, which plays such an important part in the ecology of *Simulium* larvae and to a large extent controls the breeding of the anthropophilic species, can be divided into four categories: (1) Border vegetation, (2) emergent vegetation, (3) debris, and (4) mosses and algae.

(1) The *border vegetation* includes those trees and shrubs along the margin of streams that offer shade to the breeding places, and the falling leaves and stems of which also produce debris that will be used for anchorage by the immature stages of black flies.

(2) The *emergent vegetation* encompasses all those plants that grow from the stream bed and banks, parts of which enter the water. These include the roots, vines, and trailing leaves of marginal plants, as well as truly aquatic vegetation. Upon this emergent vegetation are found the eggs, larvae, and pupae of the anthropophilic species.

(3) The *debris* of a stream is comprised of all floating parts broken loose from plants, and refuse and artifacts that are transported by the stream. The debris usually accumulates in certain spots where it may produce a small dam. The leaves and stalks of bananas, corn, and sugarcane, as well as decomposing members of various other trees and shrubs, all serve as excellent substrata for immature stages of both anthropophilic and zoophilic species.

(4) The *mosses* and *algae* may form dense mats over the walls of the stream, on the rocks and emergent vegetation, and in the water itself. These usually grow in the less turbulent parts of a stream and generally inhibit *Simulium* breeding. However, in several streams in the Yepocapa onchocerciasis zone *Simulium* larvae were found attached to the moss *Thuidium delicatulum* (Hedw.) Mitt., and were apparently thriving.

If the different species of *Simulium* showed definite preferences for particular vegetation associated with their breeding places, it was felt that a study to determine the species and characteristics of the aquatic and semiaquatic plants in the streams within the onchocerciasis zone and outside of it might, in part, explain the circumscribed distribution of the disease. Also, in considering the establishment of a sound *Simulium* control program, the resting places of the adult flies should be taken into account. With this information, chemical control of the adults becomes feasible.

A study was undertaken to determine how the aquatic and semiaquatic vegetation might affect the distribution of *Simulium* species, and which terrestrial plants might serve as diurnal and nocturnal resting places for the adult flies. Plant samples were pressed and prepared on herbarium sheets for identification. Two taxonomic lists are given in Appendix I. The first contains those plants found in streams serving as breeding places of *Simulium* species. These plants were emergent from the stream bed itself, or grew along the margins of the streams, their terminal portions trailing on the surface of the water. Data in the lists indicate those species of plants found outside of the onchocerciasis zone only, those found both inside and outside the zone, and plants serving as substrata for pupae, larvae, and eggs of *Simulium* species. The second list includes those plants that are commonly found in the woodlands and in the cultivated portions of the coffee plantations in the Municipality of Yepocapa, and indicates the plants used as shade for the coffee trees, and those that serve as a resting place for the adult *Simulium* during the daylight hours.

Of the 121 plants listed as being associated with Guatemalan streams, only 26 acted as anchorage for *Simulium* larvae and pupae. Of these 26, 22 were found only within the onchocerciasis zones in streams that favored the development of the anthropophilic species. The three other plants, *Tripogandra cumanensis, Hyptis sinuata,* and *Ipomoea* sp., which were found both inside and outside the onchocerciasis zones, are rather broad-leaved plants. They contained primarily larvae and pupae of species more commonly found outside the zone which usually do not bite human beings. *Renealmia aromatica* and *R. strobilifera* were used most often by the adults as a substratum for deposition of their eggs. These findings seem to indicate that the type of vegetation present in a stream may very well affect the *Simulium* fauna found therein. Although much more extensive plant collections were made within the onchocerciasis zones, enough were made outside of the zone to warrant mention of these observations.

Eighty-eight terrestrial plants were identified. The adults of *Simulium ochraceum, S. metallicum, S. callidum,* and *S. downsi* were found resting on the leaves of the following plants: *Ricinus communis* L. (higarillo), *Polymnia maculata* Cav. (shorotot), *Inga punctata* Willd. (cuxim), *Inga leptoloba* Schlecht. (caspirol), *Inga micheliana* Harms (chalúm), *Lueuma salicifolia* H.B.K. (zapotillo), *Casuarina equisetifolia* L. (cipres), *Bunchosia cornifolia* H.B.K. (cereza), *Tabebuia pentaphyla* (L.) Hemsl. (mano de León), *Sideroxylon* *tempisque* Pittier (tempisque), *Ficus hemsleyana* Standl. (amate), *Calocarpum mammosum* Pierre (zapote), *Mangifera indica* L. (mango), and *Struthanthus orbicularis* (H.B.K.) Blume (matapalo). These represent the first records of diurnal resting places of black flies. Used in conjunction with information concerning the flight range and longevity of the anthropophilic species (see section on ecology), these findings can be of great importance in any consideration of control of the adult black flies.

ANIMAL ASSOCIATIONS

The only animals that can be considered of any interest or importance in relation to onchocerciasis are those that may serve as reservoirs or vectors of the disease, or those that may in some way affect the incidence of the vectors by their predatory or parasitic habits.

RESERVOIRS AND VECTORS

There have been very few studies concerning possible animal reservoirs of *Onchocerca volvulus* (Leuckart, 1893) Railliet and Henry, 1910. None of the filariids of the genus *Onchocerca* taken from animals other than man have proved to be *O. volvulus*. Blacklock's (1926b, 1927) attempts to transmit the infective larvae of *O. volvulus* to monkeys by intracutaneous and subcutaneous injections resulted negatively.

Brumpt (1904) suggested that *Glossina* spp. or *Simulium* spp. must be the vectors of *Onchocerca volvulus* in Central Africa since all the cases he had studied were located near the banks of rivers where these insects were prevalent. Leiper (1914), working in Nigeria, did the first experimental work in the transmission of this parasite. He successfully fed *Stomoxys nigra* and *S. calcitrans* with microfilariae but no development took place in the insects. Similar experiments carried out by Rodhain and van den Branden (1916) with *Aedes* (*Stegomyia*) *aegypti* and *Cimex hemipterus* yielded negative results at the end of 4 days.

Robles (1919), after discovering the presence of onchocerciasis in Guatemala, initiated epidemiological studies in the disease zone to determine the mode of transmission. He reasoned that since the inhabitants of fincas below the infected zone drank water from the same streams that both supplied water to the people of the infected region and served as the outlet for their sewerage, it was unlikely that the disease organisms were transmitted in the water or excrement. Robles also found that, although many species of blood-sucking arthropods existed above and below the onchocerciasis zone as well as within it, there were two species of black flies that seemed to be most numerous within the altitude belt in which the disease was most prevalent. He therefore correctly surmised that the black flies were the probable vectors. Unfortunately, he did not carry out further investigations to verify his hypothesis.

Macfie and Corson (1922) got negative results with *Glossina palpalis* and *G. longipalpis* fed on infected persons. Dissections of 100 specimens of *Pediculus humanus* yielded no filariid larvae. Twenty lice taken from a noninfected individual were permitted to feed on persons harboring larvae of both *O. volvulus* and *Acanthocheilonema perstans.* Only larvae of the latter were found upon dissection, suggesting that lice could only ingest the blood-inhabiting microfilariae and not those in the skin (*O. volvulus*). Blanchard and Laigret (1924) fed *Ornithodorus moubata, Cimex lectularius, Auchmeromyia luteola* (Congo floor maggot), *Simulium* spp., and leeches (unidentified) on infected individuals. All these took up microfilariae, but only in the tick did the larvae remain alive. Although the microfilariae remained viable in the ticks up to 12 days, they did not undergo development. The simuliids also ingested large numbers of microfilariae, but their rapid death (after one day) terminated further observations.

Blacklock (1926a,b), working in Sierra Leone, Africa, noted that persons heavily infected with microfilariae of *O. volvulus* in the skin had no larvae in their blood. He reasoned that if a blood-sucking arthropod was the vector, it was one that had to rasp and tear the skin in order to reach the blood, thus dislodging the larvae that would then be ingested with the blood. In his early experiments with *Glossina palpalis, Auchmeromyia luteola,* and *Simulium damnosum,* results were negative. In later, large-scale investigations carried out in 1925 he successfully infected wild-caught *S. damnosum* on infected patients, and for the first time traced the subsequent development of the parasites in the gut, thorax, head, and proboscis of the flies. Infective larvae were found in the proboscis as early as 7 days after the infective meal.

Sharp (1927), in Nigeria, fed *S. damnosum* on a person infected with microfilariae of both *Onchocerca volvulus* and *Dipetalonema streptocerca* (also skin-inhabiting) in the proportion of 1:5. One hour after exposure he found microfilariae of both species in the stomach of the flies, but *O. volvulus* predominated 10:1, indicating that the flies had selectively ingested *O. volvulus* in preference to *D. streptocerca.* By the third day *O. volvulus* had migrated to the thorax and had transformed to the "sausage" stage, while very few *D. strep-*

tocerca could be found and none showed development. Bequaert (1929), working in Liberia, found developmental forms of *O. volvulus* larvae in a number of black flies, which he identified as *S. damnosum.* These findings of Sharp and Bequaert certainly help confirm the conclusion of Blacklock that *S. damnosum* is at least one of the vectors of *O. volvulus* in Africa.

Hoffmann (1930a,b,c,d,e; 1931a), working in Mexico, traced the path and development of the larvae of *O. volvulus* in *S. callidum* Dyar and Shannon, *S. ochraceum* Walker, and *S. metallicum* Bellardi, using wild-caught flies. From his observations he concluded that the larvae of *O. volvulus* can completely develop in *S. callidum* and in *S. metallicum* but not in *S. ochraceum.* Strong (1931a,b,c; et al., 1934), working in Guatemala, demonstrated that *S. ochraceum, metallicum,* and *callidum* were concerned in the transmission of onchocerciasis, and he also described a further (infective) stage in the development of the larva, thereby completing the entire cycle in the fly.

De León (1940a,b) reported having found various developmental stages of the larvae in wild-caught *S. metallicum, ochraceum,* and *callidum* in Guatemala. In 1947 he reported the tracing of the development of the larva in *S. callidum* through 130 hours. He was unable to maintain the other two principal anthropophilic species of *Simulium* in captivity for more than 3 days. De León charted his results of dissections of wild-caught flies to show the percent of natural infection with larvae of *O. volvulus.* In the month of December (coffee harvest and period of coffee processing when laborers are most exposed to bites of the flies) he found 0.89 percent of 433 *S. ochraceum* infected and 1.86 percent of 631 *S. metallicum* infected on various fincas of the Yepocapa onchocerciasis zone.

Wanson, Henrard, and Peel (1946), working in the Belgian Congo, were the first to report the entire development of *O. volvulus* in laboratory-reared flies (*S. damnosum*). Like Blacklock (1926b), they found that the microfilariae reached the infective stage in only 6 to 7 days.

Vargas (1948), in Mexico, was able to infect one laboratory-reared *S. mangabeirai* with microfilariae of *O. volvulus.* After 124 hours he killed the fly, sectioned it, and found several "sausage"-stage larvae in the thorax. In 1949 Vargas and Ruiz Reyes reported two wild specimens of *S. exiguum* from Oaxaca, Mexico, infected with "sausage" forms which they believed to be *O. volvulus.*

In Guatemala, Gibson (1951a), using wild-caught flies fed on infected individuals, traced the development of *O. volvulus* in *S. metallicum* up to 166 hours; in *S. callidum* up to 176 hours, and in *S. ochra-*

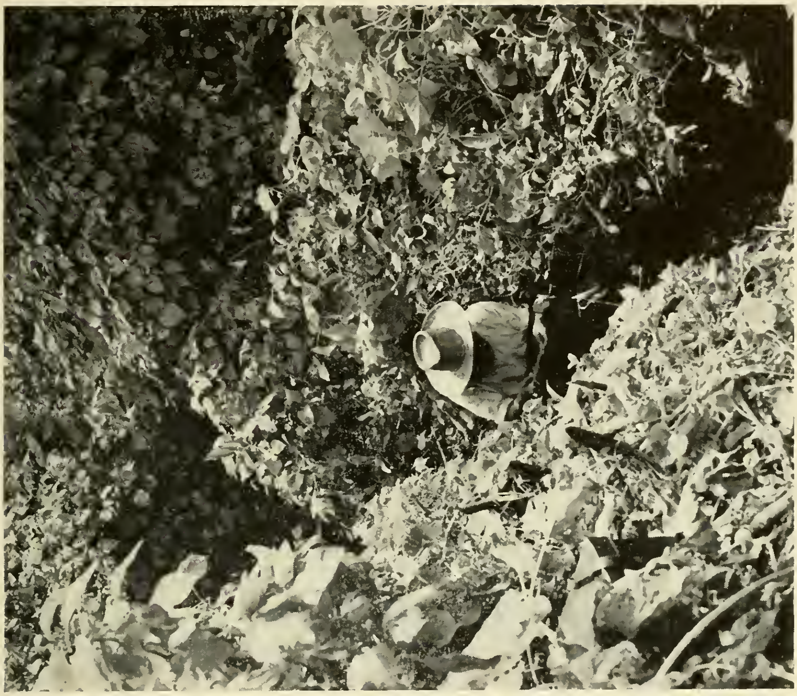
ceum up to 48 hours after the flies had taken an infective blood meal. Gibson reported that, over a period of a year, he found natural infection in 0.38 percent of 1,839 *S. ochraceum,* 1.04 percent of 1,734 *S. metallicum,* and 0.62 percent of 162 *S. callidum.* These data on natural infection rates, as well as the data on experimental infection rates, are summarized in table 6. The data demonstrate: that *S. ochraceum, metallicum,* and *callidum* will support the development of the human microfilariae and that most advanced development was observed in *S. metallicum;* that both *metallicum* and *callidum* appear capable of surviving in captivity for longer periods than *ochraceum;* that all three species support infections in nature. Recently Gibson (1951b) found an advanced larva in a specimen of *S. metallicum* that was dissected 310 hours after feeding on an infected person. This larva was in a preinfective stage, thus adding additional evidence to the probability of this species serving as a vector of onchocerciasis.

It has been our experience that not only do the *Simulium* flies ingest the microfilariae and support their development, but they also seem to attract the microfilariae to the region of their bite. In taking numerous biopsies from an infected person, much fewer microfilariae are found than in dissections of flies that have just fed on the same patient. Biopsies taken in the immediate regions of bites, soon after the flies are removed, will also contain more microfilariae than the biopsies taken in other regions of the body, or in the same region prior to the feeding of the fly.

Gibson (1951b) also found the natural-infection rate in the three principal anthropophilic species to be extremely low to zero from October through December, when the finca workers are most exposed to the bites of the flies. This was not the experience of the present author. It will be seen in table 5 that naturally infected flies were caught during the dry months of November, January, February, March, and April. No flies were collected during December, probably owing to the small samples of the fly population that were dissected during this month when the adult population, and, therefore, the dilution of infected flies, are at a peak. This table is further discussed under "Natural Infection of Adults with *Onchercerca volvulus*" in the section on ecology.

The identity of the microfilariae in naturally infected flies was not given by De León (1947) or Gibson (1951a). As stated by the latter, skin biopsies of 884 local animals (mainly horses and cattle) showed that 12 percent of the horses and cattle were infected with skin-inhabiting microfilariae, superficially similar to those of human onchocerciasis. There still remains the problem of developing adequate

1. Infant stream with irregular pattern and small cascades. Kilometer 103.4, Route No. 1, above Panajachel, Sololá.



2. Young stream with definite course and walls, but with zigzag pattern. This stream has a steep grade and is covered by heavy vegetation.

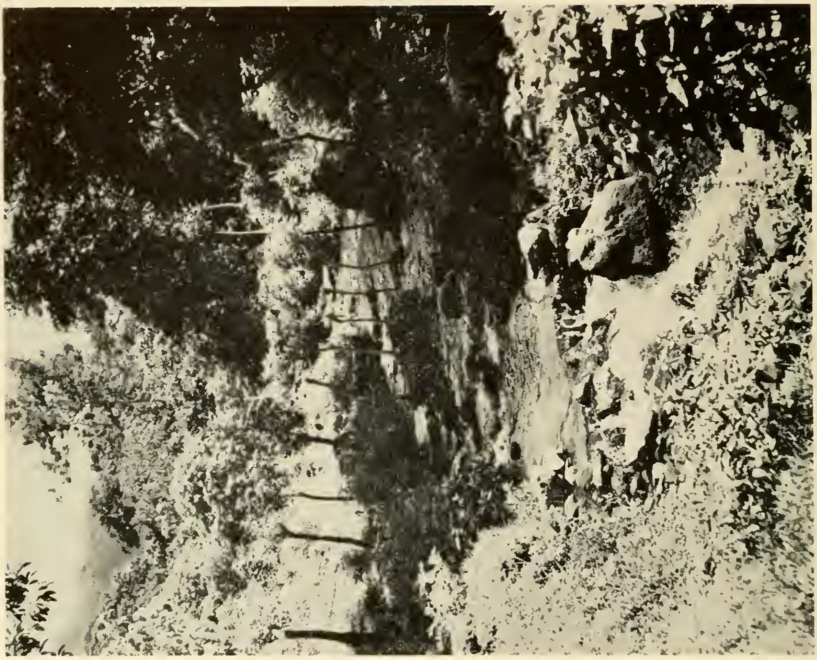
1. Union of several young streams. *S. ochraceum* breeds in the smaller tributaries, while *S. metallicum*, *S. callidum*, and other species breed in the resultant larger streams.

2. Young stream, showing the zigzag pattern and steep walls with V-shaped cross section. Rio Castaño, Suchitepéquez.

1. Young stream that serves as the breeding grounds for *S. ochraceum*, the principal vector of onchocerciasis in Guatemala. Note the abundant emergent and cover vegetation.

2. Adolescent stream, with tributaries and less abrupt walls than the young stream. Union of Ríos Queleyá and Sacayá, Yepocapa.

1. Adolescent stream with more graded bed and less emergent vegetation than in the infant or young stream.



2. Adolescent stream showing dense shade, vegetation, graded bed, and meanders.

TABLE 6.—*Comparison of natural and experimental infection rates with microfilariae of* Onchocerca volvulus *

NATURAL INFECTION

(Wild flies collected in the field were immediately examined for presence of developing stages of microfilariae.)

Days after feeding	*S. ochraceum*			*S. metallicum*			*S. callidum*		
	Total number examined	Total infected with microfilariae	Percent infection	Total number examined	Total infected with microfilariae	Percent infection	Total number examined	Total infected with microfilariae	Percent infection
0	1,839	7	0.38	1,734	18	1.04	162	1	0.62

EXPERIMENTAL INFECTION

(Wild-caught specimens of the three principal anthropophilic species of *Simulium* were fed on an onchocercotic patient and held in the laboratory until they died, at which time they were examined for developmental stages of microfilariae.)

Days after feeding	*S. ochraceum*			*S. metallicum*			*S. callidum*		
	Total number examined	Total infected with microfilariae	Percent infection	Total number examined	Total infected with microfilariae	Percent infection	Total number examined	Total infected with microfilariae	Percent infection
1	285	126	44	198	86	43	22	15	68
2	387	181	47	342	162	47	38	16	42
3	115	44	38	247	84	34	29	17	59
4	39	19	49	241	110	46	15	2	13
5	2	0	0	93	13	14	8	0	0
6	4	0	0	35	1	3	5	0	0
7	—	—	—	21	1	5	4	0	0
8	—	—	—	32	5	16	—	—	—
9	—	—	—	8	1	13	1	0	0
10	—	—	—	2	0	0	—	—	—
11	—	—	—	—	—	—	1	0	0

* Adapted from Gibson, 1951a.

taxonomic characters with which to distinguish the species of microfilariae developing in the flies. Since *S. ochraceum, metallicum,* and *callidum* not only attack man, but are also avid feeders on horses and cattle (table 9), it is quite possible that flies found infected in nature may have acquired their infection from the latter animals. The more zoophilic tendencies of *S. metallicum* and *callidum* (table 10) may also explain the higher natural infection rate in these species, reported by both De León and Gibson.

Assuming that the species of *Onchocerca* infecting humans is the same in both hemispheres, the difference in the length of the developmental cycle of *O. volvulus* in the simuliid vector, as reported by Blacklock (1926b) and Wanson, Henrard, and Peel (1946) in Africa, and by Gibson (1951a,b) in Guatemala, may be due to the species of black fly involved or to the effect of environmental factors.

In an attempt to determine whether temperature affects the duration of the developmental stages in the flies, an experiment was conducted by our laboratory in a hot coastal region. *Simulium haematopotum,* known to ingest microfilariae and support their subsequent development experimentally, were collected while they were biting several infected individuals. The flies were maintained in tubes in the same area where they had been captured, and were fed on sugar water. Of 295 flies examined upon death, 10 were infected. Eight contained "sausage" forms from 3 to 5 days after their infection, one still contained microfilariae 2 days after infection, and one had what appeared to be preinfective larvae 5 days after infection. Biopsies taken from numerous horses and cattle in the region all resulted negatively, thus indicating that the fly infections resulted from feeding on the infected human subjects. Although the number of infected flies examined was small, the results indicate the possibility that high temperature may hasten the development of *Onchocerca volvulus* in the flies. It was desired to repeat these studies with *S. ochraceum* and *metallicum,* infecting them in the highland region of San Pedro Yepocapa where onchocerciasis is endemic, and taking them immediately thereafter to the coastal area for observation of the developmental stages. However, lack of time and other factors precluded the possibility of executing these plans.

Gibson and Dalmat (1952) found wild-caught *S. exiguum* and *S. haematopotum* naturally infected, but an investigation of the skin biopsies of man, cattle, and horses in the region of capture of the former species proved that its natural infection must be of bovine origin (table 7). The authors were able to infect *S. exiguum, haematopotum,* and *veracruzanum* by feeding them on subjects infected with *O. volvulus,* and found that all three species were capable of supporting the development of the parasite (table 8).

During a 3-year period the present author made approximately 4,000 collections of larvae and pupae of *Simulium* spp. in 510 streams throughout Guatemala. Over 160,000 larvae and more than 115,000 pupae were represented in these collections; of the latter, 78,500 were reared to adults. In addition approximately 70,000 adult simuliids were collected while feeding on human subjects during 3,200 individual exposure periods. A study of these collections indicates that in some areas of one of the nearly inaccessible onchocerciasis zones of Huehuetenango (contiguous with the disease zone in Chiapas, Mexico), *S. ochraceum* is completely absent and apparently is replaced by *S. veracruzanum* as the principal anthropophilic species. In the lower altitude range of the Yepocapa onchocerciasis zone (below 2,500 feet), *S. exiguum* is the dominant human biter, while in other regions in the same zone *S. haematopotum* seems to replace *S. ochraceum* in importance. These findings stimulated the study of Gibson and Dalmat, just reported. The results indicate that *S. veracruzanum, haematopotum,* and *exiguum* must be considered potentially capable of transmitting human onchocerciasis in those parts of the endemic zones where they replace or supplement *S. ochraceum, metallicum,* and *callidum,* the three species commonly accepted as the intermediate hosts in Mexico and Guatemala.

S. ochraceum is most frequently referred to as the principal intermediate host of *Onchocerca volvulus.* Some grant it this distinction because they claim *ochraceum* bites man alone while the other anthropophilic species also bite animals; other authors favor *ochraceum* because it prefers to attack principally the upper regions of the body, where nodules and microfililariae are more numerous, while *S. metallicum, callidum,* and other biters of humans prefer the lower regions. Neither of these reasons seems particularly valid. The findings of the present author (see section on ecology) show that *S. ochraceum* attacks man as well as other animals, and that *ochraceum, metallicum,* and *callidum* will bite any exposed part of the body should their preferred regions be covered. Our experience has been that the flies can more easily be infected by feeding them on the thighs of an infected subject than on his back or shoulders. Although biopsies are usually taken from the upper regions for convenience, certainly those species that prefer biting on the lower extremities will also become infected. In support of this, Gibson (1951a) reported the rate of natural infection in *S. metallicum* (which prefers the lower regions) as being approximately three times that of *S. ochraceum* (which prefers the upper regions).

TABLE 7.—*Examinations of skin biopsies near Pastores, Department of Sacatepéquez* *

Source of biopsies	Number examined	Number showing microfilariae	Percent showing microfilariae
Man	207	0	0.0
Cattle	75	12	16.0
Horses	12	0	0.0

* From Gibson and Dalmat, 1952.

TABLE 8.—*Results of dissections of unfed flies (natural infection) and of flies fed on infected subjects (experimental infection)* *

	Natural infection			Experimental infection							
							Maximum development observed				
Species	No. exam.	No. inf.	Percent inf.	No. exam.	No. inf.	Percent inf.	Days	Hours	No. flies	No. larvae	Stage
S. exiguum	463	12	2.6	514	83	16.2	12	288	2	2	Advanced "sausage"
S. veracruzanum	415	0	0.0	368	106	28.8	4	96	1	2	Preinfective †‡
							9	200	1	3	Preinfective ‡
							13	312	1	27	Advanced "sausage"
S. haematopotum	1,276	2	0.2	759	47	6.2	13	310	2	9	Preinfective ‡
							14	334	1	2	Preinfective ‡

* From Gibson and Dalmat, 1952.

† This probably was a spontaneous (natural) infection, since the preinfective stage is never seen in experimental infections as early as 96 hours after infection.

‡ It is now considered that what is here called the preinfective stage actually is the infective stage.

TABLE 9.—*Biting preferences of various simuliid species for different animal hosts*

The preference of each of the species is expressed as a percentage of the total number of flies collected from the particular hosts. In the second column there is listed the number of actual visits to the particular host for the purpose of collecting biting flies.

Hosts	Number of times collections were made	Total flies collected	Preference by species (percent)												
			acatenangoensis	*callidum*	*downsi*	*exiguum*	*haematopotum*	*metallicum*	*mexicanum*	*ochraceum*	*pulverulentum*	*rubicundulum*	*smarti*	*veracruzanum*	*pachecolunai*
Man	3,249	69,337	—	4.0	0.1	0.14	0.4	65.3	—	30.0	—	—	—	0.059	0.001+
Horse	815	6,164	0.2	4.3	1.0	0.1	—	52.9	15.5	2.4	0.4	22.7	0.1	0.4	—
Mule	298	1,793	—	5.8	1.8	0.2	—	67.0	12.9	5.9	0.2	5.8	0.3	0.1	—
Donkey	5	25	—	—	—	—	—	80.0	12.0	—	—	8.0	—	—	—
Cattle	428	2,249	0.1	10.6	2.0	0.4	—	67.2	5.9	8.8	0.2	4.4	0.3	0.1	—
Pig	80	319	—	10.9	2.8	0.6	—	56.8	1.3	27.6	—	—	—	—	—
Goat	46	172	—	6.3	1.7	0.6	—	63.4	3.5	22.7	—	1.2	0.6	—	—
Sheep	21	88	—	8.0	3.4	1.1	—	56.8	5.7	23.9	—	1.1	—	—	—
Deer	2	14	—	—	—	—	—	100.0	—	—	—	—	—	—	—
Dog	270	1,751	—	1.8	0.4	4.2	9.4	78.8	—	3.9	—	0.7	0.1	0.7	—
Ocelot	1	2	—	—	—	—	—	100.0	—	—	—	—	—	—	—
Domestic cat	33	77	—	11.7	3.9	1.3	—	66.4	—	15.4	—	1.3	—	—	—
Guatemalan gray fox	7	34	—	—	—	—	—	67.6	—	32.4	—	—	—	—	—
Mexican tayra	8	22	—	4.5	—	—	—	59.1	—	36.4	—	—	—	—	—
Opossum	1	17	—	—	—	—	—	64.7	—	35.3	—	—	—	—	—
Chicken	90	256	—	6.3	0.8	0.8	—	82.8	0.4	8.9	—	—	—	—	—
Turkey	99	262	—	4.9	1.9	0.4	—	66.8	0.4	25.6	—	—	—	—	—
Duck	16	35	—	5.7	2.9	—	—	80.0	2.9	8.5	—	—	—	—	—
Pigeon	2	3	—	—	—	—	—	33.3	—	66.7	—	—	—	—	—

TABLE 10.—*Biting preferences of principal anthropophilic species of* Simulium—*Comparison between man and other animal hosts*

The biting preference in each group is expressed as the percentage of the total number of flies biting man and the other animal subject. Each pair is comprised of two 6-hour observation periods. "Total number biting" represents the number of flies that were collected from both subjects during the two 6-hour observation periods.

Subject	Percent biting		
	ochraceum	*metallicum*	*callidum*
Man	85	10	8
Horse	15	90	92
Total number biting	404	985	114
Man	99	26	31
Mule	1	74	69
Total number biting	670	1,183	129
Man	100	15	44
Donkey	0	85	56
Total number biting	205	772	34
Man	98	15	41
Cow	2	85	59
Total number biting	812	1,033	27
Man	99	87	92
Pig	1	13	8
Total number biting	870	255	25
Man	94	67	53
Sheep	6	33	47
Total number biting	2,531	902	153
Man	90	54	69
Dog	10	46	31
Total number biting	1,128	687	80
Man	78	61	40
Goat	22	39	60
Total number biting	303	259	78
Man	99	98	100
Cat	1	2	0
Total number biting	692	333	16
Man	99	94	100
Pigeon	1	6	0
Total number biting	231	51	3
Man	100	80	100
Duck	0	20	0
Total number biting	77	135	4
Man	99	96	94
Turkey	1	4	6
Total number biting	1,077	424	33
Man	99	94	100
Chicken	1	6	0
Total number biting	363	88	23

It is true that the distribution of *ochraceum* more nearly coincides with that of the disease than does the distribution of *metallicum* or *callidum*. *S. ochraceum*, although found breeding in areas 500 to 6,000 feet in altitude inside and outside of the disease zone, is much more abundant in the infected regions, 3,000 to 5,000 feet. On the other hand, *S. metallicum* is just as numerous inside the disease zone as it is on the outside, and it is found in a far greater range of altitude. Both species will ingest microfilariae in equal numbers.

Investigators, up to the present time, have been attempting to trace *Onchocerca* development in various bloodsucking arthropods other than simuliids but have met with little success. Since some species of *Culicoides* are voracious feeders on man, attacking all parts of the body, biting actively inside and outside of buildings, and since they are known to serve as the intermediate host of certain other filariid worms of both man and animals, they have been the subject of a good deal of study in regard to their possible role in the transmission of onchocerciasis. Dampf (1936a,b), in Chiapas, Mexico, found developmental forms of filariid larvae in 3 of 107 wild-caught *Culicoides filariferus* which he dissected. Dampf stated that some of these forms correspond in size to *O. volvulus* and others to *O. cervicalis*. De León (Pan American Sanitary Bureau, 1945), in Guatemala, found the "sausage" form of a filariid worm in the thoracic muscles of a wild-caught *Culicoides*. Gibson and Ascoli (1952) collected numerous examples of five species of *Culicoides* from infected individuals in the Yepocapa region. Although two species ingested microfilariae, none of them supported development of the larvae. They found no natural infection in flies of this genus, and concluded that at least the species of *Culicoides* with which they worked did not transmit onchocerciasis. Strong et al. (1934) found that *Aëdomyia squamipennis*, prevalent in the part of the Guatemalan onchocerciasis zone where they were working, did not ingest microfilariae from infected patients, while more than 50 percent of the *Simulium* flies fed on the same patients did take up microfilariae. Strong stated that the mosquito probably does not take up microfilariae because of its long proboscis, which penetrates deeply while sucking blood, with a minimum of laceration or abrasion. He also believes that the saliva of the mosquito might repel microfilariae. De León (1941) found "sausage" forms, which he considered to be *O. volvulus*, in dissections of fleas collected from onchocercotic patients. Vargas (1941), in Mexico, fed the following arthropods on infected subjects: *Pulex irritans, Ctenocephalides canis, Cimex lectularius, Triatoma picturata, Pediculus humanus, Aedes aegypti, Anopheles pseudopunctipennis*, and *Ornithodorus turicata*. Although

Ornithodorus turicata did ingest microfilariae in significant numbers, it was not demonstrated whether or not it could support development to advanced stages.

In searching for an appropriate vector, one would naturally choose for study those arthropods that can be suspected by virtue of the coincidence of their distribution with that of the disease, and those that experimentally will ingest microfilariae. In Guatemala, *Culicoides* spp. and *Simulium* spp. appear most likely. However, *Culicoides* are most prevalent in the onchocerciasis zone during the rainy season when human exposure to their bites is at a minimum. Also, they are more active in the shade, somewhat reducing their opportunity for frequent blood meals on the field workers. In the cases of natural infection of *Culicoides* reported above, the species to which the filariid larvae belonged were not carefully determined. The experimental findings of Gibson and Ascoli clearly demonstrated that microfilariae of *O. volvulus,* although ingested, did not develop further in *Culicoides* spp. For these reasons it is believed that *Culicoides* can be eliminated as a possible vector of onchocerciasis.

The aforementioned investigations of Blacklock, Strong, Hoffmann, Vargas, De León, Wanson, Henrard and Peel, Gibson, and Dalmat indicate that *Simulium* species transmit onchocerciasis. The failure of microfilariae to develop in arthropods other than *Simulium* spp., the finding of black flies naturally infected with larvae of *O. volvulus,* the successful infection of these flies with subsequent development of the microfilariae, plus epidemiological evidence concerning the distribution of the anthropophilic species in Guatemala, quite definitely incriminate the Simuliidae as the vectors of the disease.

PREDATORS OF THE SIMULIIDAE

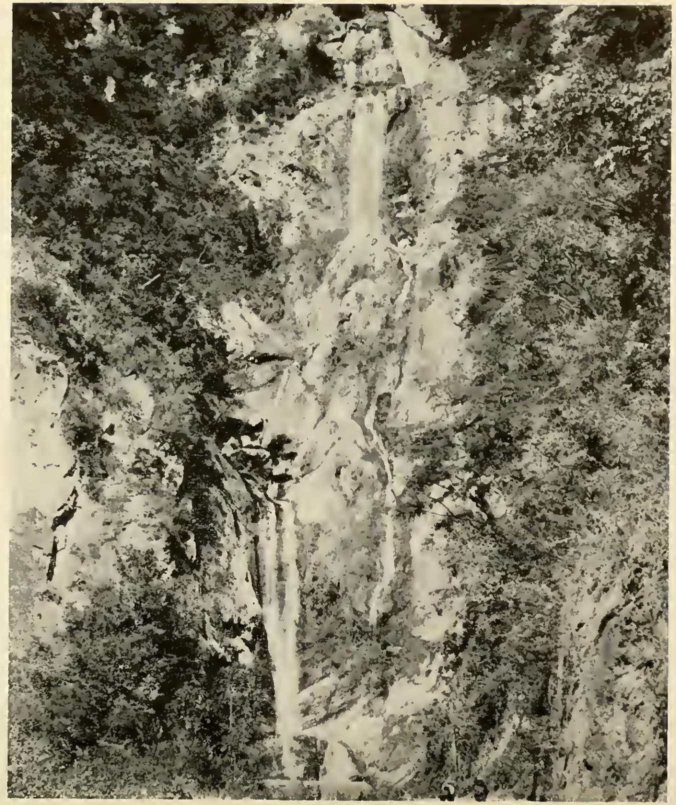
To help determine the relationship of animal life to the incidence of *Simulium* in the onchocerciasis zone, and in an attempt to ascertain if there are other reservoirs of *Onchocerca volvulus* besides man, a survey was made of both the aquatic and terrestrial fauna in the region of San Pedro Yepocapa. The taxonomic list of those species collected is given in Appendix II.

Only certain of the insects, fishes, and birds played any role in the reduction of the black-fly population. The larvae of dobson-flies (*Corydalus* sp.) and caddiceflies (*Smicridea,* or near), the naiads and adults of dragonflies (*Libellula* sp.) and damselflies (*Hetaerina* sp.), and the nymphs and adults of the giant water bug (*Abedus ovatus*) were found to feed on the larval and adult black flies. Investigators have reported finding some of these insects feeding on black-fly larvae

1. Mature stream. Note how the region adjacent to the stream has been brought to the slope of the stream bed; also, the formation of sand bars. Such streams serve as the principal breeding places of zoophilic species of black flies, although some of the anthropophilic species will also breed therein.

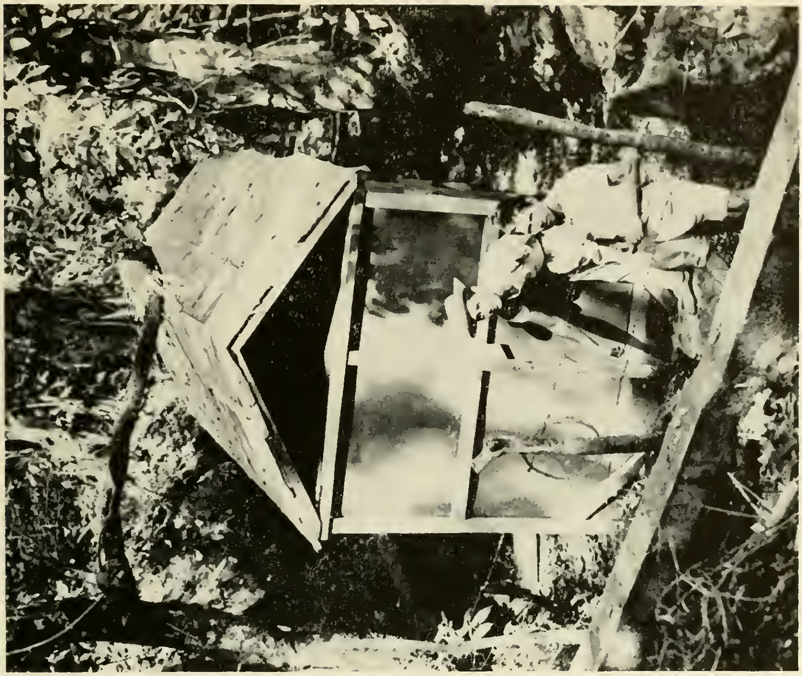
2. Old stream, flowing through terrain with a gentle, rolling topography and with a minimum slope. Such streams have wide beaches, practically no emergent vegetation, and the tree and shrub line is removed from the water's edge. They support the breeding of zoophilic species only.

1. Man-made channel (toma) with cement wall, passing through coffee plantation. The cement walls will inhibit the development of anthropophilic species if the channel is kept free of vegetation debris.



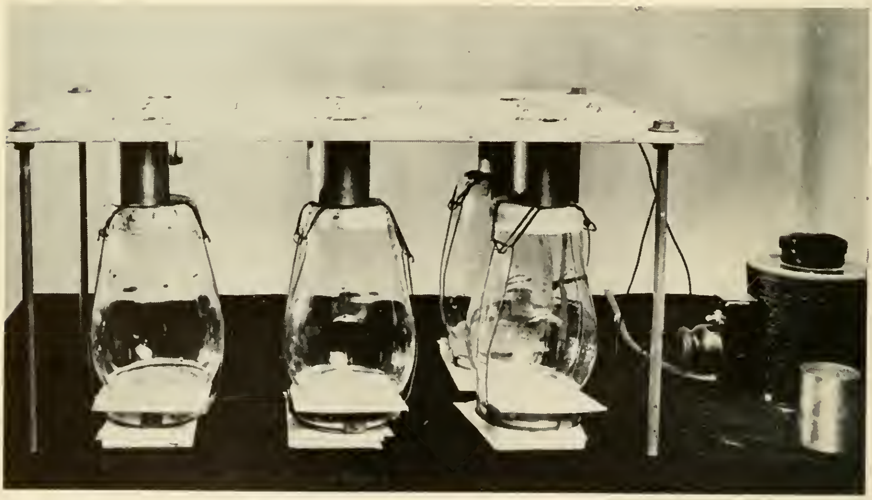
2. Waterfall of Panajachel, Sololá. *S. carolinae* is the predominant species, the larvae and pupae of which are found on the rocks along the side of the falls where the force of the water is somewhat reduced.

1. System developed for rearing adult black flies from eggs and larvae collected in streams.



2. Oviposition cage constructed over a stream for the purpose of establishing a self-perpetuating laboratory colony of black flies. Note the cement flood wall to prevent blocking of the watercourse by debris carried downstream during heavy rains.

1. Bamboo node adapted for use in the stream in the rearing of adults from eggs and larvae.



2. Apparatus used for feeding adult black flies through membrane. (Photograph courtesy of Dr. Joseph Greenberg, National Institutes of Health.)

in such numbers that they concluded that they play an important role in reducing the black-fly population. However, the observations made in the Guatemalan streams indicate that they have very little, if any, practical effect. The adults of the fossorial wasp, *Oxybelus pyrurus*, were the most obvious predators of adult black flies. When collecting black flies from human subjects, these wasps would hover nearby, grabbing the flies as they began to feed. The wasps themselves are often numerous enough to constitute a pest. Since simuliids are only one of several groups of flies that serve as prey for these wasps, it is doubtful whether the number of black flies consumed would significantly reduce the total population.

Although representatives of 7 of the 25 species of birds collected contained remains of adult simuliids in their stomachs, the number of flies ingested was actually small. In the case of several of these birds, the ingestion of black flies must have been accidental, since insects do not form a normal constituent of their diet.

The fish *Profundulus punctatus* Günther has been found to be the most efficient predator of *Simulium*. Examination of over 200 of these minnows yielded numerous larvae in all but 10, these being fry too small to feed on insects as large as the black flies. In addition, the contents of the digestive tract of 12 of these fish contained parts of adult flies, indicating that the fish also devour the simuliids as the latter are emerging from the pupal case or while they are ovipositing. It should be noted that the more typical breeding places of *Simulium ochraceum*, the species believed to play the major role in the transmission of onchocerciasis in Guatemala, are too shallow and small to support development of *Profundulus punctatus*, the predatory minnow. Undoubtedly this minnow must reduce the black-fly population in the streams where it exists, but owing to the enormous breeding potential of the flies and the constant reduction of the fish by the Indians who use them as food, the actual effect on the over-all fly population must be small. However, in restricted areas which can be kept under supervision, this fish may be useful as a possible agent for biological control.

PARASITISM OF THE SIMULIIDAE

Mention should be made of a few other forms found associated with Guatemalan Simuliidae that probably affect their normal development. On numerous occasions comparatively large nematode larvae of the family Mermithidae have been found coiled in the abdomen of *Simulium* larvae. At times two or three were taken from one black-fly larva which did not seem to be particularly hampered by them. Since the same have been noted in the adults of *S. metallicum* and *S. ochra-*

ceum, the parasite apparently remains within the larva and pupa without destroying either.

In the highlands above 6,000 feet, large numbers of dead and dying larvae and pupae have been encountered frequently on stones during the months of January and February, when the water level of the streams is greatly reduced. The larvae all had a milky appearance owing to great multiplication of a Protozoan parasite of the order Microsporidia (probably *Thelohania* sp.). The dead larvae were soft and in all stages of decomposition, while the live ones seemed extremely sluggish and with small swellings. The pupae were covered with what seemed to be a network of fungal mycelia that also extended over many of the stones. It may be that the fungus did not cause the death of the simuliids, but took hold upon their dead bodies. In situations where the Microsporidia were widespread, the number of healthy larvae and pupae seemed negligible and the simuliid population of the entire stream seemed especially low.

THE STREAMS

In the foregoing sections, the following environmental factors and their possible influence on the presence of onchocerciasis and its insect vectors have already been discussed: Geography, climate, the inhabitants and their customs, plant associations, and animal associations (reservoirs and vectors, predators and parasites of the Simuliidae). Considering the members of the family Simuliidae as the vectors of the disease, it naturally becomes important to learn more about the streams in which they pass their immature stages and how these streams may affect the development and, therefore, the presence of particular species.

As stated in the subsection "Reservoirs and Vectors," approximately 4,000 collections of larvae and pupae of *Simulium* species were made throughout Guatemala in over 500 streams during a 3-year period. Streams in the Municipality of San Pedro Yepocapa, which support a preponderance of anthropophilic species, were revisited regularly. With each collection, ecological data (see section on ecology) were taken. A well-established relationship was found between the type of stream and the species of *Simulium* that will breed in it. The optimum stream conditions for each species are sufficiently well marked, so that by mere observation of a stream we can predict rather accurately what species of *Simulium* will be found in it, in which section of the stream, and upon what substratum.

There follows a general discussion of streams as a breeding place of *Simulium,* the formation of the streams in Guatemala, their morphological age in relation to black-fly breeding, and the characteristics of a stream that determine which species of black flies will be found therein. In the section on ecology the actual relationship between stream characteristics and the species groups will be discussed.

The immature stages of the Simuliidae seem to be extremely adaptable to aquatic environmental conditions. Thus, as a family, they are encountered in Alaska, Labrador, Newfoundland, in many areas of Europe and Asia north of the Arctic Circle, to the Equator and then south to the southern tips of South America, Africa, Australia, and New Zealand. They occur from sea level up to the snow line in mountainous areas. Perhaps the only type of area in which they are lacking is the desert, and that because of the lack of aquatic breeding haunts. It is usually stated in the literature that *Simulium* species require for their larval development rapidly flowing, shallow, clear, cool water; that the bodies of water must be of a permanent nature; and that there must always be emergent or floating vegetation, stones, or debris on which the larvae can anchor themselves. These are good generalizations, but they do not cover exclusively black-fly habitats. In the course of the present work, black-fly larvae have been found in extremely slow-flowing streams, in almost stagnant water, in pools with only a small overflow, completely covered by mud with no attachment to any fixed object, and attached to the cement walls of man-made waterways and to discarded tin cans. They have also been collected in streams immediately below a spot where clothes were being washed with extremely alkaline soap. The pH of the water in which they are found ranges from 5 to 8. This variability of habitat will become more apparent in the section on ecology.

FORMATION OF THE STREAMS

Water that falls on the surface of the land as rain either (1) evaporates, (2) becomes channeled immediately to form surface wash, flash (ephemeral) streams, temporary (intermittent) streams, or to swell permanent streams, or (3) percolates through the soil, collecting in underground deposits which form somewhat defined channels, later reappearing at other sites as permanent springs and rivers. The runoff water that immediately becomes channeled reaches permanent streams only by flowing over the surface of the ground until it washes into already established tributaries. It can be classified as transient insofar as its distinctive existence is concerned, while the water that is channeled underground, feeding already formed streams, can be classified as sustained, permanent, or perennial.

The surface wash and flash streams (pl. 8, fig. 2) can be disregarded as far as their contribution to black-fly breeding is concerned. These last only for a period of hours to a few days, hardly long enough for the completion of the development of the immature stages of black flies. However, temporary streams, lasting from 2 to 5 weeks, have been found to support the breeding of *Simulium metallicum* and *S. downsi,* while others, flowing from a month to the entire 6 months of the rainy season (pl. 10, fig. 1), have been found to serve as breeding grounds for *S. mexicanum, jobbinsi, jacumbae,* and *veracruzanum,* as well as for the two species just mentioned.

In the Yepocapa region, permanent streams originate in one of the following manners: The water may merely percolate from the exposed wet surface of an earthen wall or from faults in rocks (pls. 9, fig. 2; 10, fig. 2; 11, fig. 1). This constant flow usually forms pools beneath the wall, and the constant erosion will gradually produce a stream course. If there is sufficient drip, the wall may be cut back to form a cavern (pl. 11, fig. 2). At other times, especially in the formation of infant streams, the water may percolate from muddy soil over a large area on gently sloping land, giving the appearance of a small swamp (pl. 12, fig. 1). The almost imperceptible trickles of water gradually unite to form a resultant stream. The streams most commonly originate from an underground spring or from several such springs that unite to form one stream of water which leaves the earth at a point where the natural curvature of the land intersects a water table, and where the earth is sufficiently porous (pls. 12, fig. 2; 13, fig. 1). Usually the flow at the point of emergence or origin of the stream is slight, but at times, where the stream has been flowing underground for a good distance, the flow may be very great. Thus, it can be seen that along any one slope where the water table is intersected, several streams might emerge at about the same level. Any one of these streams may join with other similar streams to form a resultant large stream, or it may form a tributary of an already established stream. During the dry season of the year (November to April), the volume of the permanent streams is practically constant; during the rains (May to October), the volume is greatly increased with the flash swells during and immediately following a heavy rain, but it subsides again as soon as the surface runoffs have been channeled away. Weaker or less-resistant larvae are loosened from their anchorage in large numbers and killed by mechanical means as a result of these sudden and violent swells. It is these permanent streams that serve as the principal breeding places of both the anthropophilic and zoophilic species of *Simulium.* The larvae and pupae are found in all parts of the stream from its source to its mouth, where it enters another larger stream.

CLASSIFICATION OF PERMANENT STREAMS BY MORPHOLOGICAL AGE [4]

The permanent streams referred to can be classified as: (*a*) infant, (*b*) young, (*c*) adolescent, (*d*) mature, and (*e*) old. In discussing any one of these stream "ages," it should be understood that the characteristics of the stream are being given at only one locality. It is the morphological "age" rather than the geological "age" of a particular section of a stream that is referred to when the terms "infant," "young," "adolescent," "mature," or "old" are applied. Thus, the same stream may show different ages at intervals along its course. The classification serves, therefore, more as a convenience in associating certain stream characteristics with the *Simulium* fauna they support or favor than as an index of the geological development of the stream.

(*a*) An *infant* stream is one formed by the convergence of several minute trickles of water, generally originating as collections of underground or cliff seepage. This stream may vary in width from one inch to about one foot. It has no definite wall or cross section and the water channel seems almost haphazard. The stream bed is hardly distinguishable from the contiguous dry areas (pls. 13, fig. 2; 14, fig. 1). Vegetation, rather than being of a truly aquatic type, appears to be composed of trailing parts of plants that grow along the sides of the water course, as well as of debris and decaying leaves that also cover the adjacent ground. Such streams, which may enter and emerge from the ground several times as they pass along a slope, are often tributaries of young or adolescent streams. Only anthropophilic species are found breeding in them.

(*b*) The *young* stream (pl. 14, fig. 2; pl. 15; pl. 16, fig. 1) is relatively narrow, with steep walls, and V-shaped cross section. It has few, if any, tributaries, and these are very short. The stream presents a zigzag, ungraded pattern, often with rapids and small falls, and sometimes with pools. Characteristically, it has abundant emergent and cover vegetation and small deposits of debris. The bed of the young stream consists mainly of an arenaceous mixture topped with small to large stones, and rarely with large rocks. In some streams the sand accumulates around the large rock outcroppings to such a height that the upper faces of the rocks themselves form the main part of the stream bed, the spaces between them being filled with sand and gravel. The walls of the stream may be composed of earth, vegetation, rocks, or any combination of these. These young streams serve primarily as breeding places for the anthropophilic species.

(*c*) The *adolescent* stream (pl. 16, fig. 2; pl. 17) has the walls less

[4] Adapted, in part, from Elishewitz, 1944.

steep than the young ones, the falls and rapids usually are replaced by a more graded river bed, the zigzag pattern gives way to meanders, and the river assumes a dendritic pattern rather than a singular one. The bed is approximately like that of the young stream, still supporting a large growth of emergent vegetation and being shaded by dense growth. Both anthropophilic and zoophilic species of *Simulium* breed in these streams.

(*d*) The more *mature* stream exhibits a broad U-shaped profile. There is usually a complex network of streams with piracy as a common manifestation. Because of the extensive number of tributaries, a large part of the adjoining region is brought more to the slope of the river bed. Deposition may occur, forming narrow flood plains, sandbars, and beaches (pl. 18, fig. 1). This type of stream favors the breeding of zoophilic species of *Simulium,* although a number of anthropophilic species will also be found in them.

(*e*) The *old stream* flows through a terrain that exhibits a very gentle rolling topography with a minimum of vertical slope. There is a great reduction in the number of tributaries with the single stream remaining dominant. In spite of the small grade, the flow is great except toward the mouth of the river where it usually becomes sluggish. Wide beaches, often much wider than the main stream itself, prevail along many sections of such a river. There is practically no emergent vegetation and the shrub and tree line is far removed from the water's edge (pl. 18, fig. 2). Small, smooth, somewhat rounded boulders are often dispersed along the shore line with driftwood deposited among them. Almost without exception these streams only support the development of zoophilic species.

In the Municipality of Yepocapa there are about 10 rather large adolescent streams (volumes from 5,000 gal./min. to 765,000 gal./min.), each with from 50 to several hundred tributaries entering them just in that section of their course passing through Yepocapa (approximately 5 miles). More than 85 percent of the tributaries are less than 200 feet long, and morphologically are "infant" or "young" streams. In the main body of these 10 adolescent streams are found large populations of zoophilic species and very few anthropophilic ones. Near the banks of these streams, where vegetation may be trailing along the surface of the water, *S. metallicum* will be found. In the hundreds of infant and young tributaries that cross the Yepocapa terrain are found abundant breeding places of *S. ochraceum, metallicum,* and *callidum,* the principal anthropophilic species of that region. It can be seen that, in a region abounding in streams of this type, the chances for transmission of onchocerciasis are excellent.

One further type of waterway, present on every coffee finca in the Yepocapa region, should be mentioned at this time. It is the toma (pl. 8, fig. 1), or man-made water channel used to lead water off from natural streams to the area of greatest finca activity. During the period of the coffee harvest, when the toma is constantly used to supply water to the processing plant, its earthen banks are usually maintained with straight, steeply sloped walls, the cover vegetation along its borders is regularly trimmed, and the debris and emergent vegetation is kept to a minimum. At such times, black-fly breeding is at a minimum in the tomas. However, during the rest of the year, when large quantities of water are not mandatory for the work of the finca, the tomas are often neglected, becoming overgrown with marginal and emergent vegetation. With their usual volume of 250 to 300 gal./min., they assume the characteristics of a young stream, thereby offering excellent breeding facilities for the anthropophilic species, especially *S. metallicum*. In those regions at the bottom of the onchocerciasis zone where only larger streams are found, the toma may be the waterway most important for the development of the anthropophilic species. Several fincas cement the walls of the tomas (pl. 19, fig. 1), at least along that part entering the processing plant. Unless debris gathers in these sections of the toma, breeding will not usually be found. Although experiments in which the flow of water in the toma was discontinued for a few days and then reestablished showed that larvae and pupae were killed, this management of the tomas would be of little significance in controlling the flies since other larvae migrate into the toma from above as soon as the water flow is continued.

Another type of waterway that should be mentioned is the waterfall (pl. 19, fig. 2), which does not seem to fit in any of the categories already discussed. The waterfall does support breeding of several species of black flies in Guatemala, none of which are anthropophilic. The larvae usually attach to pendent vegetation or to the upper faces of rocks along the edges of the falls where the current is less severe, but still extremely rapid.

It has been noticed in the literature that many investigators, in calculating the amount of insecticide necessary for treating a particular stream, determine the volume of the stream at its origin. This would not be practical in the Yepocapa region. If the volume of a large stream is taken at a particular point, it will be found greater than the sum of the volume of the same stream taken at its origin plus the volumes of all the tributaries entering it between the origin and the point of calculation. The tributaries also increase in volume from their origin to the point of entering the larger stream, although they may not join with other streams along their course. This phenomenon is brought about by underground springs that feed the streams at various levels, corresponding to different water tables. When the upper section of small streams dries up during the dry season of the year, the streams then originate at that level where a particular water table can still supply a sustained flow. During the rainy season this same water table would also be adding to the volume of water in the stream. Thus, when a particular stream is to be treated in its entirety, it has been found more accurate to determine its volume at the point where it joins with another stream.

THE STREAM BED

The floor and walls of a stream, those structural characteristics that form the watercourse, are considered as the stream bed. It is composed primarily of earth, stones, rocks, sand, gravel, mosses, ferns, and higher plants. The composition of the stream bed, to some extent, determines what age classification a particular section of the stream will have, and this, in turn, is a controlling factor in the breeding of various species of *Simulium*. As evidence of this fact, where bare sand or gravel alone forms the bed, no breeding of black flies will be found; the larvae of many zoophilic species prefer for their anchorage the flat faces of the larger rocks, where they are exposed to the strongest flow of the stream, and they are therefore not often found in the younger streams which are lacking in such substrata; the larvae and pupae of a few of the zoophilic species prefer mud to other substrata; in general, the anthropophilic species prefer abundant marginal and emergent vegetation and debris found in infant and young streams.

The bed, vegetation, and morphological age of a particular portion of a stream is affected to a considerable extent by the substratum through which the stream passes. Harder soils will tend toward beach formation; softer, more porous soils will favor erosion and the formation of a deeper stream floor; certain soils will favor the growth of various classes of vegetation while others will inhibit it.

SUMMARY

The larvae and pupae of different species of black flies are adaptable to widely different stream conditions. They will be found from the source of a stream to its mouth; they will breed in extremely slow-flowing streams, in almost stagnant water, in pools with only small overflow, or in waterfalls; they may be completely encased in mud, attached to vegetation, stones, rocks, debris, or to a variety of artifacts.

However, they generally prefer rapidly flowing, shallow, clear, cool water where they can attach to vegetation or stones.

Different species of Simuliidae show a definite predilection for certain stream characteristics. It can be said that the morphological "age" of a stream (i.e., its size, form, current flow, bed, and vegetation) at a particular section will, to a large degree, determine which species of Simuliidae will breed there. The principal anthropophilic species, considered to be the vectors of onchocerciasis, prefer "infant" or "young" sections where the stream is narrow, having a comparatively low volume of water, and where the bed is earthen to arenaceous, with an abundance of cover and emergent vegetation to serve as anchorage for larvae and pupae, and as shade for the breeding haunts. Tomas, or man-made waterways, resemble young streams in their morphological characteristics and are often a source of prolific breeding of the anthropophilic species, especially *Simulium metallicum*. The zoophilic species prefer "adolescent" to "mature" streams with a large volume of water, the stream bed composed of gravel, stones, and rocks for anchorage of the immature stages, and with a paucity of emergent and cover vegetation. Certain species choose waterfalls as their preferred breeding ground.

The streams of the Yepocapa region are all formed from underground springs or seepages which leave the ground at a point where the natural curvature of the land intersects a water table and where the earth is sufficiently porous.

Relative to chemical control of *Simulium* larvae in the Yepocapa region, accurate determination of stream volumes can best be made at the mouths, where they join with other streams.

ENTOMOLOGICAL STUDIES IN GUATEMALA

Since Dr. Robles' discovery of the presence of onchocerciasis in Guatemala in 1915, and since the confirmation by Blacklock in 1926 of Robles' hypothesis of transmission by *Simulium* species, comparatively few entomological investigations of these flies have been made in Guatemala. In 1931 and again in 1932 Harvard University sent an expedition to Guatemala, headed by Dr. Richard P. Strong, for the purpose of investigating all phases of onchocerciasis. Dr. Joseph C. Bequaert (1934), who was in charge of the entomological investigations, reported that up to the time of his studies he was able to find published records of only three Guatemalan Simuliidae, *Simulium metallicum* Bellardi, *S. mexicanum* Bellardi, and *S. exiguum* Roubaud. During the course of his work he discovered three more species, *S. ochraceum* Walker, *S. callidum* (Dyar and Shannon), and

S. rubicundulum Knab, thereby bringing the total to six. Bequaert, in his valuable study, discussed, in addition to the taxonomy of this group of flies, techniques for rearing and breeding them, their developmental stages and habits, and parasites of the larvae, pupae, and adults. He presented an excellent review of the literature of these phases, as well as his personal experiences with the Guatemalan species.

De León (1943) added *S. pulverulentum* Knab and *S. haematopotum* Malloch to the Simuliidae known from Guatemala, and he described one new species he found in the highlands, *Cnephia roblesi* (De León). He also presented photographs of the respiratory apparatus of four other species, unknown in Guatemala at that time, and identified them by letters, awaiting subsequent formal description. A discussion was given of the general distribution of the known species. In 1944 De León described nine additional new species for Guatemala, again using the form of the pupal respiratory filaments as the sole distinguishing characters. In 1948 he gave a complete description of another new species. The 10 new species were: *S. tricornis, pachecolunai, vargasi, diazi, capricornis, aquamarensis, carolinae, guatemalensis, boydi,* and *larvispinosum.* In 1946 Vargas, Martínez, and Díaz synonymized *vargasi* De León (1944) [5] with *wrighti* Vargas, Martínez, and Díaz (1944), and *diazi* De León (1944) with *aureum* (Fries) (1824). In 1948 Vargas and Díaz synonymized *guatemalensis* De León (1944) with *jacumbae* Dyar and Shannon (1927), and in 1951 Dalmat placed *boydi* De León (1944) in synonymy with *haematopotum* Malloch (1914). However, since the first three of these synonyms were, nevertheless, new records for the country, the actual number of species was brought to 18. In 1948 Vargas and Díaz also placed *larvispinosum* De León in synonymy with *carolinae* De León, but a close study of numerous examples of these species collected at the type locality has demonstrated to the present author that they are definitely distinct.

Fairchild and Barreda (1946) performed the only studies in control of black-fly larvae in Guatemala reported to date. They were able to control successfully larvae in mountain streams in the region of San Pedro Yepocapa by using an emulsion concentrate of DDT diluted to give 0.1 part per million, dispensed over an hour period. Further studies have since been carried out at the Onchocerciasis Laboratory and will be reported in the future.

[5] Vargas et al. consider the paper of De León to have been published in 1945 instead of 1944. The former was a separate, using distinct pagination, reprinted from his 1944 publication. However, *wrighti* Vargas, Martínez, and Díaz does have priority over *vargasi* De León by virtue of the month of publication.

Dalmat (1950a,c; 1952a) presented experimental data on the flight range and longevity of wild-caught flies of the principal anthropophilic species of Simuliidae as well as a technique for inducing oviposition of these species by exposing them to CO_2. Dalmat and Gibson (1952) gave results of experiments on flight range and longevity of infected flies, and Gibson and Dalmat (1952) discussed three new potential intermediate hosts of onchocerciasis. Dalmat (1951) reports the finding of 18 additional species in Guatemala, 9 of which he described as new (Dalmat, 1949, 1950b, 1951). He reallocated various species to other genera and subgenera and gave the distribution of the 36 species which he listed for Guatemala at that time. In 1952(b), he described two additional new species and in 1953 and 1954, he described two more new species and included one new record. At the present time, 41 species of Simuliidae are known to exist in Guatemala. They are:

S. (*D.*) *acatenangoensis* Dalmat
Cnephia aguirrei Dalmat
Gigantodax aquamarensis (De León)
S. (*D.*) *ardeni* Dalmat
S. (*E.*) *aureum* (Fries)
S. (*B.*) *benjamini* Dalmat
S. (*H.*) *burchi* Dalmat
S. (*L.*) *callidum* (Dyar and Shannon)
S. (*H.*) *capricornis* De León
S. (*H.*) *carolinae* De León
S. (*L.*) *colvini* Dalmat
S. (*H.*) *delatorrei* Dalmat
S. (*L.*) *dowsni* Vargas, Martínez, and Díaz
S. (*L.*) *dugesi* Vargas, Martínez, and Díaz
S. (*D.*) *earlei* Vargas, Martínez, and Díaz
S. (*H.*) *ethelae* Dalmat
S. (*N.*) *exiguum* Roubaud
S. (*L.*) *haematopotum* Malloch
S. (*L.*) *jacobsi* Dalmat
S. (*S.*) *jacumbae* Dyar and Shannon
S. (*S.*) *jobbinsi* Vargas, Martínez, and Díaz
S. (*S.*) *kompi* Dalmat
S. (*H.*) *larvispinosum* De León
S. (*D.*) *mathesoni* Vargas
S. (*S.*) *metallicum* Bellardi
S. (*D.*) *mexicanum* Bellardi
S. (*H.*) *microbranchium* Dalmat
S. (*H.*) *nigricornis* Dalmat
S. (*S.*) *ochraceum* Walker
Cnephia pacheco-lunai (De León)
S. (*S.*) *parrai* Vargas, Martínez, and Díaz
S. (*D.*) *pulverulentum* Knab
Cnephia roblesi (De León)
S. (*D.*) *rubicundulum* Knab
S. (*L.*) *samboni* Jennings
S. (*D.*) *smarti* Vargas
S. (*S.*) *tricornis* De León
S. (*L.*) *trivittatum* Malloch
S. (*L.*) *veracruzanum* Vargas, Martínez, and Díaz
Gigantodax wrighti Vargas, Martínez and Díaz
S. (*D.*) *yepocapense* Dalmat

Dalmat (1954), in an ecological study of *Simulium ochraceum, metallicum,* and *callidum,* the principal anthropophilic species in Guatemala, presented for the first time the resting places of these flies during the day and night. Optimum stream conditions for development of the immature stages, plant associations, and associations of species breeding in the same streams were discussed. The developmental cycle of the flies, their oviposition habits, and host preferences were given.

TAXONOMY OF THE GUATEMALAN SIMULIIDAE

The species represented in the following systematic treatment were collected in all the 22 Departments of Guatemala. Their distribution, biology, and ecological preferences are discussed in the subsequent section on ecology.

Keys to the genera, subgenera, and species have been used to introduce the taxonomic study. As far as possible, an attempt was made to employ structural characters. In the case of the males, two sets of keys to the genera were presented, as well as to the subgenera of the genus *Simulium*. Although the genitalia are particularly useful in distinguishing the males in these categories, it was felt that other characteristics should also be given since it may not always be convenient to use the genitalia.

The keys have been followed by descriptions of the male, female, pupa, and larva of all species, their completeness depending upon the availability of sufficient material. Descriptions were based only on material collected in Guatemala by the author or other members of the onchocerciasis project, unavailable stages being omitted completely. With few exceptions it was not felt necessary to include in the descriptions the characteristics that distinguish the particular species from closely related ones, since this is adequately covered in the keys. When considered desirable, drawings were prepared to illustrate distinctive parts. Those terms used in the keys or in the descriptions that are not in common usage, are not employed in the usual way, or are not figured in the plates, have been diagrammed or defined at the beginning of this section.

No attempt has been made to give complete references to the species, except in the case of those species described after the publication of the catalog of Luis Vargas (1945a) entitled "Simúlidos del Nuevo Mundo." This excellent work adequately treats the references to those Guatemalan simuliids known up to that time. However, before giving the description of each species, the reference is given to the paper in which it was originally described, as well as references to other papers that are considered particularly valuable taxonomically.

TECHNIQUES FOR COLLECTION AND PREPARATION OF MATERIAL

Adult representatives of the family Simuliidae are only occasionally obtained by the usual collecting techniques, and then only females because of their bloodsucking habits. Pupae are frequently taken with aquatic collections, but they are not often related to the corresponding adults. At the inception of this study, many Guatemalan species were known only in the pupal stage, some only as females, and comparatively few in the larval form. In order to become acquainted with the simuliid fauna throughout the country, and to be able to distinguish species in whichever developmental stage they may be encountered, specialized methods had to be employed. In general, pupae were collected from all types of breeding haunts and held for emergence of the adults. Thus, both sexes of a given species were secured and the pupal skins were available for study along with the cocoons. Larvae were immediately preserved in 70-percent alcohol.

A method was used whereby pupae and larvae could be transported from the field to the laboratory, or maintained alive in the field for extended periods until it was convenient to arrange them for rearing. The leaves, stems, stones, or other objects, along with their attached pupae and larvae, were placed in a moist canvas bag which permitted cooling by evaporation, thereby facilitating favorable respiratory exchanges for the immature stages. When convenient, sections of leaves were cut into small pieces so that each piece had a single attached pupa. Each was placed in a small length of glass tubing ($\frac{1}{4}$-inch bore), both ends of which were loosely stoppered with slightly moistened cotton. Pupae formed on small stones were removed and placed in the tube without adding pieces of leaf; pupae attached to large rocks had to be carefully removed in the field and arranged in the same fashion. The pupae were maintained in the vials for 5 to 7 days, always protected from the direct rays of the sun. The usual method of removing the pupae and placing them on strips of moist cotton was not employed since the cotton seemed to accelerate the formation of mold, and the added handling in unnecessarily removing the pupae from their substrata was time-consuming and often caused damage to the pupae.

After the flies emerged and sufficient time was allowed to elapse for hardening of the cuticula, the adults were pinned on minuten nadeln and the pupal exuvia were preserved in alcohol along with the corresponding cocoons. Duplicate accession numbers were arranged.

For each species the following slides were made: *Female:* (1) Legs, showing the inner and outer surfaces; (2) wings, dorsal and ventral surfaces; (3) head; (4) buccopharyngeal apparatus; and (5) genitalia, dissected, ventral view, and profile. *Male:* 1-4 as for female; and (5) genitalia, dissected and dorsal view. *Pupa:* (1) Dorsal and ventral views; and (2) respiratory apparatus. *Larva:* (1) Dissected, dorsal view, ventral view, and profile; (2) anal gills; and (3) terminal region, dorsal view, to show the X-shaped sclerite and the presence of rectal scales. The larva was most easily related with the corresponding pupa of the species by comparing the lateral thoracic histoblasts of the former with the pupal respiratory structures they were to ultimately form.

TERMS USED IN THE KEYS AND DESCRIPTIONS

Adults

Buccopharyngeal apparatus.—That organ to which the proximal ends of the hypopharynx and the labrum-epipharynx are attached. The dorsolateral parts are produced as arms (cornuae) that are usually heavily sclerotized, serving as points of muscle attachment. The median space between the cornuae may bear teeth, the arrangement of which appears constant for a particular species. (Text fig. 2.)

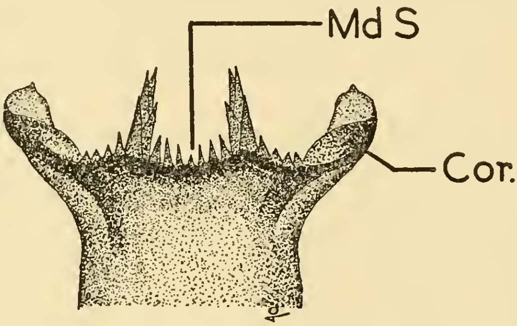


FIG. 2.—Buccopharyngeal apparatus of female. *Md S*, median space; *Cor.*, cornua.

Calcipala.—A broad apical extension of the inner face of the hind basitarsus, usually narrower than the distal margin of the latter; it may be absent in some species and very well formed in others; its relationship to the pedisulcus appears to be constant for any one species. (Text fig. 3.)

Pedisulcus.—A split or break in the dorsal surface of the second hind tarsal segment; its position on the segment and degree to which it is marked appear constant for any one species. (Text fig. 3.)

Postnotum.—That plate of the thorax situated behind, and somewhat beneath, the scutellum.

Prescutellar region.—The posterior area of the scutum that is just anterior to the scutellum; usually clothed with pruinosity, and with pilosity that is longer than that on other parts of the mesonotum.

Pruinose or Pruinosity.—Covered with a fine dust or bloom, at times almost metallic in luster, which obscures the base color of the region.

Pupa (text fig. 8)

Collar.—A raised portion of the cocoon between the base and the anterior aperture which gives the cocoon the form of a "slipper."

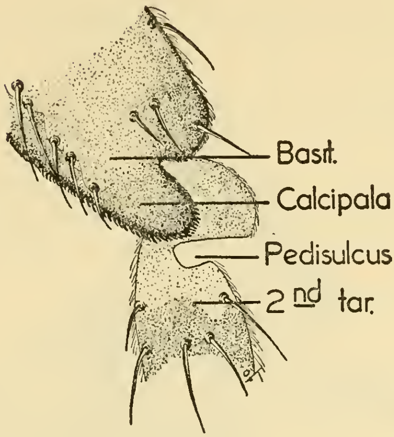


FIG. 3.—Inner surface of apical portion of right hind leg of female showing the position and form of the calcipala and pedisulcus. *Basit.*, basitarsus; *2nd tar.*, second tarsal segment.

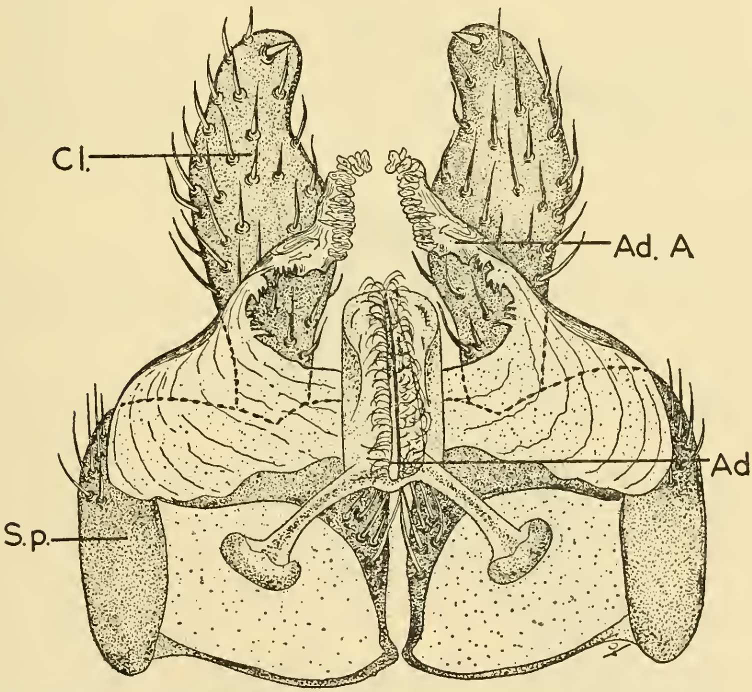


FIG. 4.—Diagrammatic representation of the male genitalia (dorsal view). *Cl.*, clasper; *Ad.*, adminiculum; *Ad. A*, adminicular arm; *S.p.*, sidepiece.

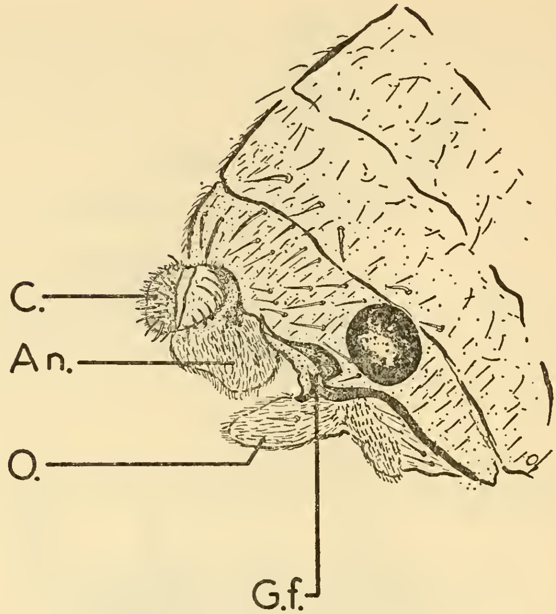


FIG. 5.—Diagrammatic representation of hind region of female showing the genitalia (profile view). *C.*, cercus; *An.*, anal lobe; *O.*, ovipositor; G.f., genital fork.

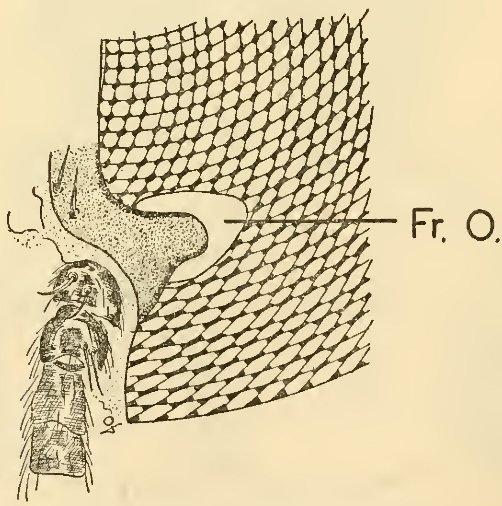


FIG. 6.—Diagrammatic representation of the eye of female. *Fr. O.*, fronto-ocular triangle.

Combs.—Groups of minute spines that are contiguous to one another, their bases forming a single line, giving the appearance of the teeth of a comb. (Text fig. 8, *5-7.*)

Granulosity (granulose).—The state of being covered by granules or minute, usually circular, grainlike elevations. Among the pupae of Guatemalan species the granulosity is microscopic and may be present on the thorax and/or on the abdominal segments. (Text fig. 8, *1-2.*)

Slipper-shaped.—That form of the cocoon that has a collar. (See "collar.")

Terminal spines.—Two spines or tubercles sometimes present on the dorsum of the ninth abdominal segment of the pupa, one on either side of the midline; in some genera or subgenera these are quite large, pointing dorsally and anteriorly so that they can help maintain the pupa in its cocoon. (Text fig. 8, *1, 2, 4, 5, 7,* and *8.*)

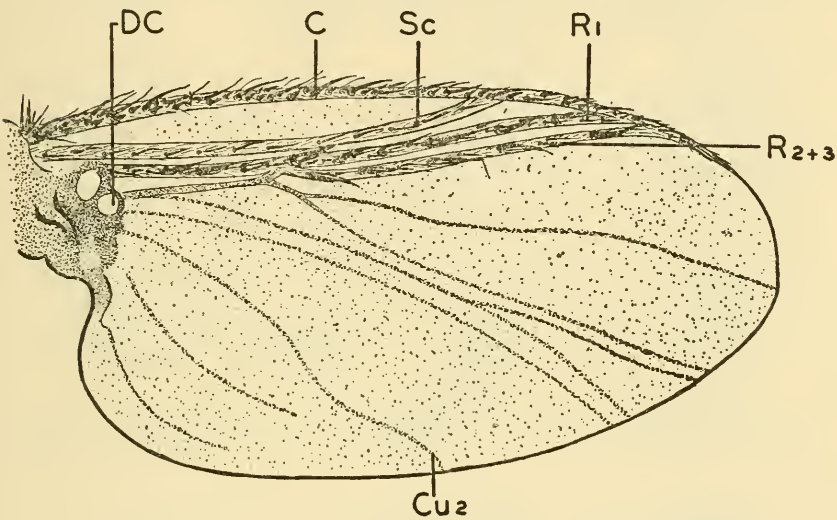


FIG. 7.—Diagrammatic representation of the wing of adult female, with important veins indicated. DC, discal cell; C, costa; Sc, subcosta; R_1 and R_{2+3}, branches of the radius; Cu_2, 2d branch of cubitus.

Trichomes.—Erect hairs present on the thorax of the pupa; may be simple or branched.

Wall-pocket.—That form of a cocoon that does not have a collar; it appears somewhat conical, the anterior aperture being at the wide end, the base flat, very much like a type of receptacle that might be hung on the wall to hold flowers.

Larva (pls. 40-43, text fig. 9)

Basal stalk of cephalic fan.—That part of the cephalic fan from which the hairlike branches emerge.

Occipital cleft.—An opening or concavity along the posterior ventral margin of the larval head capsule; it may be absent or very large, with a diversity of form and size according to the species. (Pls. 42-43.)

Pectinate.—That condition of the branches of the cephalic fan in which it has numerous minute hairs, somewhat equidistant, all extending in the same direction, giving the appearance of a comb.

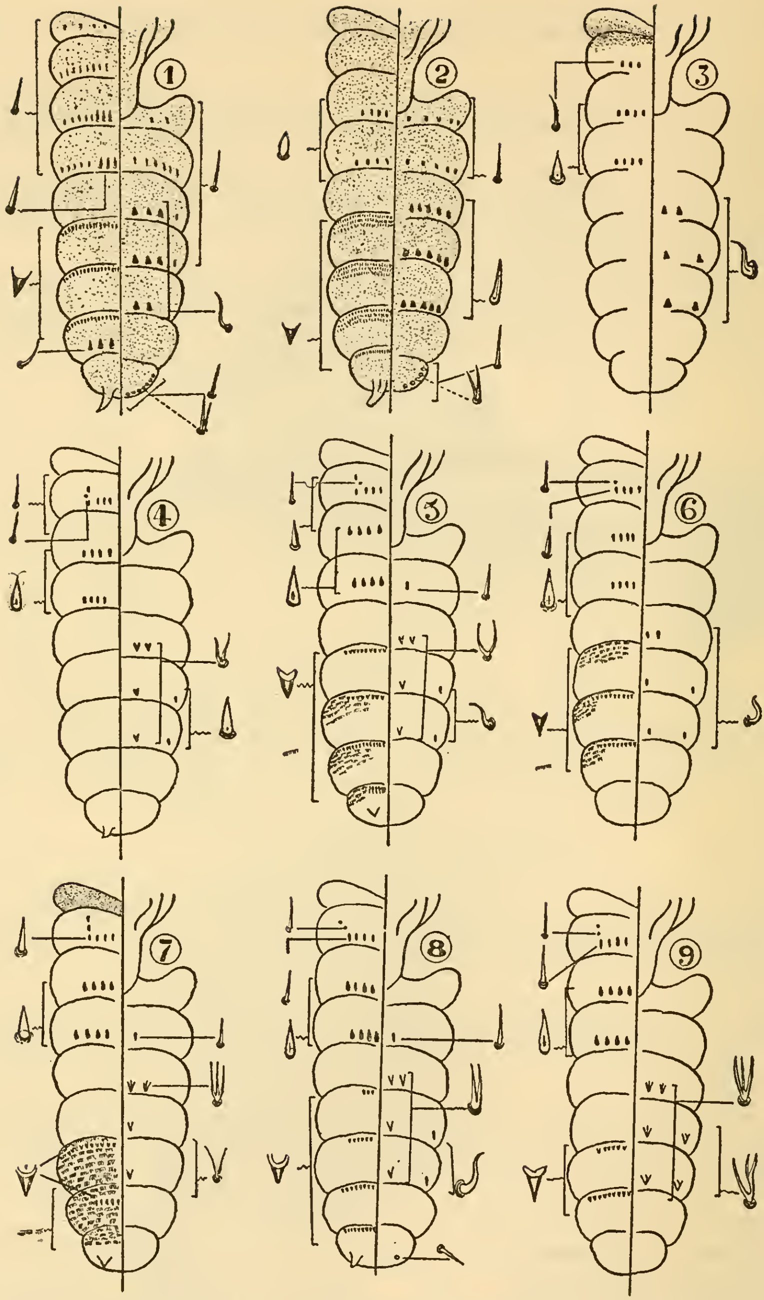


FIG. 8.—Diagrammatic representation of distinguishing characteristics of the pupae of the different genera and subgenera (left side of midline shows the left dorsal pattern; right side of midline shows the left ventral pattern): *1, Gigantodax aquamarensis; 2, Cnephia aguirrei; 3, Simulium (Dyarella) rubicundulum; 4, S. (Notolepria) exiguum; 5, S. (Lanea) downsi; 6, S. (Hearlea) microbranchium; 7, S. (Simulium) jacumbae; 8, S. (Eusimulium) aureum; 9, S. (Byssodon) benjamini.*

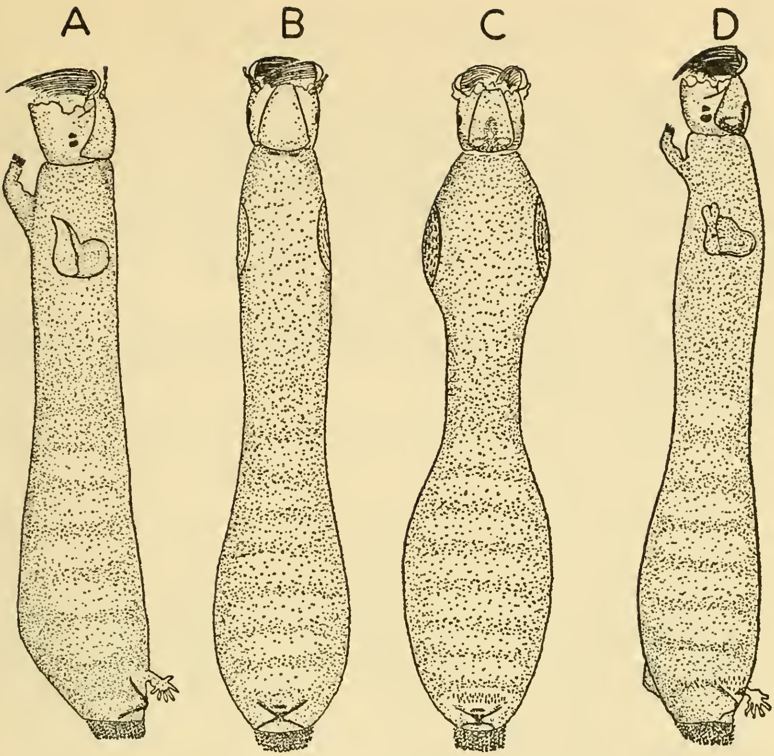


Fig. 9.—Diagrammatic representation of larval types: *A* and *B*, Profile and dorsal views of the *Dyarella-Hearlea* type of larva. *C* and *D*, Dorsal and profile views of the *Simulium-Lanea* type of larva.

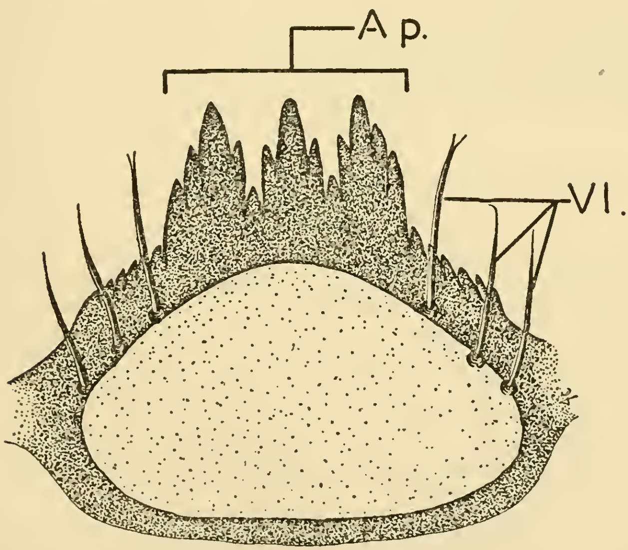


Fig. 10.—Submentum of larva. *Ap.*, Apical teeth; *Vl.*, ventrolateral row of hairs.

Posterior sucker.—Disc-shaped structure at the posterior end of the larva, containing numerous rows of hooks that are arranged radially as well as concentrically along its periphery; serves to fix the larva on the substratum. The number of radial rows of hooks serves as a good diagnostic character.

Pseudopod.—A single conical, truncate, soft, footlike appendage on the ventral surface of the thorax which has on its apex numerous rows of hooks; also called the "thoracic prolog" or "anterior sucker." The pseudopod is used by the larva for its peculiar type of motion.

X-shaped sclerite.—Sclerotized area forming an X on dorsum of eighth abdominal segment, the anterior arms of which extend toward either side of the anus (or anal gills) and the posterior arms of which pass along all or part of the margin of the posterior sucker.

KEYS TO THE SIMULIIDAE OF GUATEMALA[6]

GENERA, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. Pedisulcus present on second segment of hind leg....*Simulium* Latreille, 1802
   Pedisulcus absent 2
2. Cu_2 arcuate, discal cell present; basitarsus of hind leg spindle-shaped, shorter than tibia; the calcipala present but rather short...*Cnephia* Enderlein, 1921
   Cu_2 straight, discal cell absent; basitarsus of hind leg parallel-sided, approximately equal to length of tibia; the calcipala very well developed, long, and almost as broad as basitarsus itself............*Gigantodax* Enderlein, 1925

GENERA, BASED ON MALE GENITALIA (ALTERNATE KEY)

1. Clasper cone-shaped, with more than one terminal spine...................2
   Clasper cylindrical, quadrangular, or in other form; if conical, then with only one terminal spine..............................*Simulium* Latreille, 1802
2. Clasper with two stout terminal spines both emerging approximately at apex; body of adminiculum broader than long...........*Cnephia* Enderlein, 1921
   Clasper with two stout terminal spines, one emerging at apex, the other definitely subapical; body of adminiculum longer than broad.
   Gigantodax Enderlein, 1925

SPECIES OF THE GENUS CNEPHIA, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. Mesonotum clothed with long, narrow, yellow, scalelike hairs as well as with short bristlelike black hairs; basal three-fourths to all of Sc pilose........2

[6] Subsequent to the preparation of this monograph, Vargas and Díaz (1953a) placed the subgenus *Dyarella* Vargas, Martínez, and Díaz, 1946, as used throughout the taxonomic section of this monograph, in synonymy with *Hemicnetha* Enderlein, 1934, and the subgenus *Lanea* Vargas, Martínez, and Díaz, 1946, in synonymy with *Psilopelmia* Enderlein, 1933. In the same paper they synonymized *Simulium* (*Dyarella*) *mathesoni* Vargas, 1945, with *Simulium* (*Hemicnetha*) *paynei* Vargas, 1942. Vargas and Díaz (1953b) also gave a new name, *Simulium* (*Notolepria*) *gonzalezi*, to what has here been called *Simulium* (*Notolepria*) *exiguum* Roubaud, considering the material from Guatemala and Mexico to be distinct from the type material of *exiguum* which came from Venezuela.

Mesonotum with only black hairs; only basal third of Sc pilose.
aguirrei Dalmat

2. Sc pilose along its entire length; length of hind basitarsus 3.1-3.4 times its width .... *pacheco-lunai* (De León)

Sc pilose along its basal three-fourths; length of hind basitarsus never more than 2.8 times its width .... *roblesi* (De León)

SPECIES OF THE GENUS GIGANTODAX, BASED ON EXTERNAL CHARACTERS OF THE MALES

Hind leg with calcipala evenly rounded; the basal heel of claw produced to form a rather blunt, short spur; mesonotum orange to brown; relation of basitarsus to second tarsal segment 7.2 : 1 .... *wrighti* Vargas, Martínez, and Díaz

Hind leg with calcipala more angular, the basal heel of claw produced to form a sharp, well-developed spur; mesonotum reddish brown; relation of basitarsus to second tarsal segment 8 : 1 .... *aquamarensis* (De León)

SUBGENERA OF THE GENUS SIMULIUM, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. Mesonotum without definite designs 2

Mesonotum with definite designs, usually in the form of longitudinal or transverse bands or lines 3

2. Scutellum with long black hairs; postnotum bare; golden-yellow scalelike hairs on mesonotum dispersed in groups of 3 or 4 hairs to the group; all hairs on abdomen black; total length approximately 2.0 mm.
Notolepria Enderlein, 1930
(*Simulium* (*N.*) *exiguum* Roubaud *)[7]

Scutellum with long yellow hairs; postnotum usually with group of several golden-yellow scalelike hairs; scalelike hairs on mesonotum single; abdominal hairs mainly long and yellow, with few short black ones along midregion; total length approximately 3.5 mm..... *Eusimulium* Roubaud, 1906
(*Simulium* (*E.*) *aureum* (Fries) *)

3. Mesonotal designs always gray- or white-pruinose, formed in central region, extending from anterior margin posteriorly, without dark lines; prescutellar region devoid of long hairs 4

Mesonotal patterns in other form; prescutellar region usually with long hairs (exceptions: *S.* (*S.*) *ochraceum* and *S.* (*D.*) *pulverulentum*) 5

4. Elongate gray-pruinose designs on either side of midline in form of two triangles having their bases anteriorly; the smaller one has its base almost contiguous to the anterior margin of the mesonotum and the larger one has its base just posterior to the apex of the smaller triangle and slightly lateral to it .... *Byssodon* Enderlein, 1952
(*Simulium* (*B.*) *benjamini* Dalmat *)

Elongate pruinose designs simple, not divided.
Lanea Vargas, Martínez, and Díaz, 1946

5. Mesonotum with either longitudinal dark lines contrasting with the base color, or with these lines plus longitudinal pruinose stripes.
Dyarella Vargas, Martínez, and Díaz, 1946

Mesonotum only with pruinose band around its periphery, the band being either complete or interrupted on the anterior margin 6

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[7] Asterisk (*) indicates the only representative of the subgenus in Guatemala.

6. Relative length of hind basitarsus to second segment 4.8-5.1 : 1, average 5 : 1; hind basitarsus about 4 times longer than broad........... *Simulium,* s. str.
   Relative length of hind basitarsus to second segment 2.4-4.2 : 1, average, 3.8 : 1; hind basitarsus about 2.8 times longer than broad..... *Hearlea* Rubzov, 1940

SUBGENERA OF THE GENUS SIMULIUM, BASED ON MALE GENITALIA (ALTERNATE KEY)

1. Clasper half, or less, the length of sidepiece.............................. 2
   Clasper more than half the length of sidepiece........................... 3
2. Clasper broad at base, tapering to point at apex; terminal spine so small it can be seen only as a minute point on apex of clasper; external border of clasper strongly arched so that the apex almost reaches the sidepiece; body of adminiculum approximately triangular in shape, its basal prolongations very short.................................... *Notolepria* Enderlein, 1930
   (*Simulium* (*N.*) *exiguum* Roubaud *)
   Clasper rather narrow at base, with humplike expansion near the middle of its external border, the apex truncate; terminal spine very well formed, stout, on inner angle of apex; adminiculum in form of inverted Y, the apex very acutely angular, the other two basal prolongations broad.
   Eusimulium Roubaud, 1906
   (*Simulium* (*E.*) *aureum* (Fries)*)
3. Clasper conical 4
   Clasper not conical; either quadrangular, cylindrical, or in other form....... 5
4. Clasper inserted at middle of apical margin of sidepiece, approximately equilateral, with single, terminal spine on inner angle of truncate apex; terminal spine bifid from near its middle to the extremity; sidepiece without dorsal concavity near apex; body of adminiculum almost triangular in shape.
   Byssodon Enderlein, 1925
   (*Simulium* (*B.*) *benjamini* Dalmat *)
   Clasper inserted inward from the middle of apical margin of sidepiece; outer margin of clasper longer than inner, the clasper arched with convexity on outer surface; terminal spine small, undivided, close to rounded apex; sidepiece with concavity on outer dorsal region near apex; body of adminiculum semicircular to quadrangular in shape.... *Simulium* (*Simulium*) *ochraceum* Walker (exception to usual form of species belonging to subgenus *Simulium*)
5. Clasper flattened, somewhat quadrangular, with the inner angle of apex usually elongated; clasper shorter than sidepiece.
   Lanea Vargas, Martínez, and Díaz, 1946
   Clasper cylindrical in shape, longer than sidepiece.......................... 6
6. Clasper sinuous, caused by expansions along one or both margins; length of clasper approximately 3.0-3.7 times its width.
   Dyarella Vargas, Martínez, and Díaz, 1946
   Clasper with its margins not sinuous....................................... 7
7. Clasper from 6-8 times longer than broad; adminiculum broader than long, the body appearing almost rectangular in shape (except *S.* (*H.*) *larvispinosum* De León, the adminiculum of which is longer than broad and the body of which is in form of a pointed arch)......... *Hearlea* Rubzov, 1940
   Clasper 3.0-4.5 times longer than broad; adminiculum longer than broad, its apex rounded or truncate (*S.* (*S.*) *tricornis* De León), but never pointed (*S.* (*S.*) *ochraceum* Walker keys out in couplet 4)........ *Simulium,* s. str.

SPECIES OF THE SUBGENUS DYARELLA, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. In addition to longitudinal dark lines, mesonotum with longitudinal white-pruinose bands, stripes or lines....2
   Mesonotum with dark lines only....6
2. Longitudinal white-pruinose designs in form of very wide bands, occupying most of central region of mesonotum....3
   Longitudinal white-pruinose designs in form of narrow stripes....4
3. Mesonotum with two extremely wide, longitudinal, white-pruinose bands, each about one-quarter the width of scutum, separated by a black line which ends at the prescutellar region; scalelike hairs on mesonotum always single; posterior femur and tibia black, except for a small yellow basal region; apical half of posterior basitarsus somewhat expanded, its basal half yellow, apical half black; pedisulcus very poorly marked.......*yepocapense* Dalmat
   White-pruinose longitudinal bands similar to those on *yepocapense,* the black line separating them being extremely narrow; a few scalelike hairs on mesonotum, often in groups of 2-3; on posterior leg the femur is yellow except for apical black ring; posterior tibia is yellow with dark rings near base and at apex; posterior basitarsus with sides parallel to each other, all yellow except for somewhat darkened area at apex; pedisulcus well marked. *ardeni* Dalmat
4. Base color of mesonotum velvety black, the two white-pruinose longitudinal stripes expanded anteriorly....*mathesoni* Vargas
   Base color reddish or yellowish brown, the white-pruinose stripes not expanded anteriorly....5
5. Mesonotum light yellowish brown with longitudinal pruinose stripes curved to form a lyre-shaped pattern....*rubicundulum* Knab
   Mesonotum light yellowish brown with longitudinal pruinose stripes parallel to each other....*acatenangoensis* Dalmat
6. Basitarsus of posterior leg much expanded on its apical half; scalelike hairs in groups on anterior half of mesonotum....7
   Basitarsus of posterior leg parallel-sided; scalelike hairs usually single; when in groups, these are found only on anterior margin of mesonotum.........8
7. Mesonotum shiny black, its scalelike hairs pale golden yellow, narrow; calcipala of hind basitarsus short, not reaching pedisulcus; pedisulcus poorly formed, near base of second tarsal segment...........*mexicanum* Bellardi
   Mesonotum velvety black, its scalelike hairs bronze-colored, long and broad; calcipala of hind basitarsus reaching pedisulcus which is well formed one-third the distance from the base of the second segment.......*smarti* Vargas
8. Mesonotum light orange brown, its scalelike hairs in groups on anterior margin, single elsewhere; prescutellar region and scutellum with long black hairs; average total length, 4.0 mm......*earlei* Vargas, Martínez, and Díaz
   Mesonotum dark reddish brown, its scalelike hairs single on all regions; prescutellar region without long black hairs; long hairs on scutellum tan; average total length, 2.8 mm....*pulverulentum* Knab

SPECIES OF THE SUBGENUS HEARLEA, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. Band of white pruinosity around entire periphery of mesonotum without interruption 5

Band of white pruinosity interrupted or diffuse on anterior margin to form two medially directed arms....................................2

2. Postnotum with definite cluster of golden scalelike hairs on its midregion; band of white pruinosity about of equal width all around mesonotum. *ethelae* Dalmat

Postnotum bare, without scalelike hairs....................................3

3. Coxa, trochanter, and femur of anterior leg tan.....*microbranchium* Dalmat

These parts of anterior leg dark brown to black....................................4

4. Arms of anterior band of white pruinosity very narrow, directed posteromedially; scalelike hairs of mesonotum narrow, short, almost copper-colored ....*larvispinosum* De León

Arms of anterior band of white pruinosity about equal in width to lateral bands, widening somewhat toward their termination near the midline, contiguous with anterior edge of mesonotum along their entire extent; scalelike hairs of mesonotum wider and longer..............*carolinae* De León

5. Scalelike hairs on mesonotum silvery white; Sc pilose along its basal fourth; calcipala not reaching pedisulcus........................*delatorrei* Dalmat

Scalelike hairs yellow to golden; Sc pilose at most along its basal sixth; calcipala well developed, reaching pedisulcus....................................6

6. Coxa, trochanter and femur of leg 1 and trochanters of legs 2 and 3 tan; femora of legs 2 and 3 tan except for apical dark ring; white-pruinose band contiguous with anterior margin of mesonotum and of about equal width along its entire extent..............................*capricornis* De León

Coxa, trochanter, and femur of leg 1 as well as trochanters and femora of legs 2 and 3 dark brown to black; white-pruinose band curved, somewhat removed from anterior margin of mesonotum near the midregion. *burchi* Dalmat

SPECIES OF THE SUBGENUS LANEA, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. Mesonotum orange yellow or dark reddish brown........................2

Mesonotum black 6

2. Mesonotum dark reddish brown, with two longitudinal bands of steel-gray pruinosity, one on either side of the midline, each in the form of a large triangle, the base contiguous with the anterior margin and the apex pointing posteriorly; apices of triangles extending into narrow bands which fuse with steel-gray pruinosity of the prescutellar region; all segments of abdomen black; pedisulcus formed at middle of second segment of hind tarsus. *dugesi* Vargas, Martínez, and Díaz

Mesonotum orange yellow, the pruinose bands not extending to prescutellar region; segments of abdomen black and yellow; pedisulcus situated one-third the distance from the base of second hind tarsal segment................3

3. White-pruinose band on either side of midline of mesonotum curved in form of a comma which extends posteriorly about one-third the length of mesonotum and has the convex margin facing mesially; numerous fine black hairs distributed over entire mesonotum, these somewhat longer in prescutellar region; very few, if any, scalelike hairs on mesonotum; pre-alar hair cluster black, with at most one to two yellow hairs; abdominal segments 3-8 velvety brown to black; calcipala passing the pedisulcus. *callidum* (Dyar and Shannon)

White-pruinose bands not in form of comma; black hairs not longer in prescutellar region than on rest of mesonotum; yellow scalelike hairs well distributed on mesonotum; prealar cluster composed of yellow hairs only; abdominal segments 3-8 with at least some yellow coloration; calcipala not passing pedisulcus 4

4. R_1 with spines along its distal half, at most with one hair; tergites of abdominal segments 4-8 velvety brown; hairs on first abdominal segment black. *downsi* Vargas, Martínez, and Díaz

R_1 with both spines and hairs along its distal one-half to two-thirds; tergites of abdominal segments 4-8 with some yellow coloration; hairs on first abdominal segment yellow..5

5. Longitudinal band of white pruinosity on either side of midline with its borders almost parallel, hardly expanded at anterior end; scalelike hairs on mesonotum very short; calcipala not quite reaching pedisulcus. *samboni* Jennings

Longitudinal band of white pruinosity on either side of midline expanded anteriorly and tapered posteriorly to form a definite triangle; scalelike hairs on mesonotum long and narrow; calcipala reaching pedisulcus. *colvini* Dalmat

6. White-pruinose band on either side of midline of mesonotum in form of elongated triangle, the base of which is on the anterior margin and the apex extending posteriorly to fuse with the white pruinosity of the prescutellar region; scalelike hairs on mesonotum dark brown in central region from anterior margin to prescutellar area, golden yellow on other parts; R_1 with both spines and hairs on its distal half; trochanter and femur of hind leg completely black; calcipala almost reaching pedisulcus which is situated one-third distance from base of second hind tarsal segment; approximate length of male 3.0 mm...........*veracruzanum* Vargas, Martínez, and Díaz

White-pruinose band on either side of midline of mesonotum in form of broad triangle, the apex of which extends posteriorly only one-third the distance to the prescutellar region; scalelike hairs on mesonotum all golden yellow; R_1 with spines on its distal half and with at most two hairs; trochanter of hind leg tan, the femur black with a basal tan ring; calcipala well removed from pedisulcus which is situated at middle of second hind tarsal segment; approximate length of male 2.0....................*haematopotum* Malloch

SPECIES OF THE SUBGENUS SIMULIUM, BASED ON EXTERNAL CHARACTERS OF THE MALES

1. Mesonotum lacking scalelike hairs......................................2

Mesonotum with yellow to golden scalelike hairs..........................3

2. Mesonotum orange-yellow; R_1 completely pilose, the distal half with spines as well as hairs....................................*ochraceum* Walker

Mesonotum black; distal half of R_1 with spines only, the basal half bare. *metallicum* Bellardi

3. White-pruinose band along periphery of mesonotum without interruption, indented toward center of dorsum where it passes the middle of anterior margin ....*tricornis* De León

White-pruinose band interrupted at middle of anterior margin of mesonotum 4

4. R_1 with spines and hairs on distal half 5
   R_1 with only spines on distal half .... *jobbinsi* Vargas, Martínez, and Díaz
5. A single hair emerging midway between the most basal spine on R_1 and the origin of R_{2+3}, situated more than twice as far from the basal spine as the distance between any other two spines or spines and hairs on R_1; golden-yellow scalelike hairs over entire mesonotum; coxa and basal half of trochanter of leg 1, as well as basal half of trochanter of leg 2 yellow; calcipala of hind basitarsus reaching pedisulcus.
   parrai Vargas, Martínez, and Díaz
   No hair between most basal spine on R_1 and origin of R_{2+3}; golden-yellow scalelike hairs lacking on middle of dorsum; all coxae and trochanters black; calcipala of hind basitarsus not reaching pedisulcus.
   jacumbae Dyar and Shannon

GENERA, BASED ON FEMALE CHARACTERS

1. Pedisulcus present .... *Simulium* Latreille, 1802
   Pedisulcus absent 2
2. Discal cell present; Cu_2 arcuate; relation of length of basitarsus to that of segments 2-5 taken together 4-5 : 1; calcipala normal; claw of hind tarsus with heel strongly recurving apically, with very large lancelike structure emerging at base; head normal .... *Cnephia* Enderlein, 1921
   Discal cell absent, at times barely indicated; Cu_2 straight, relation of basitarsus to tarsal segments 2-5, 8-9 : 1; calcipala extremely long and broad; claw of hind tarsus with heel not retrorse, with shorter, narrower projection emerging beyond heel; head greatly elongated anteriorly.
   Gigantodax Enderlein, 1925

SPECIES OF THE GENUS CNEPHIA, BASED ON EXTERNAL CHARACTERISTICS OF THE FEMALES

1. Mesonotum clothed with numerous silver-colored, scalelike hairs as well as a few yellow hairs of same type; tergites of abdominal segments clothed with white hairs .... *aguirrei* Dalmat
   Mesonotum clothed with golden-colored hairs; tergites of abdominal segments with black or brown hairs only 2
2. Mesonotum with 3 longitudinal stripes of gray pruinosity, always visible although contrast not very sharp; cornuae of buccopharyngeal apparatus broad, sclerotized only along outer margins .... *roblesi* (De León)
   Mesonotum with no longitudinal stripes differentiated; cornuae of buccopharyngeal apparatus sharply pointed and well sclerotized.
   pacheco-lunai (De León)

SPECIES OF THE GENUS GIGANTODAX, BASED ON EXTERNAL CHARACTERISTICS OF THE FEMALES

All legs brown, with very little color variation in the form of bands; relation of basitarsus to second tarsal segment 8.1 : 1; buccopharyngeal apparatus with wide, bifurcate, sclerotized cornuae .... *aquamarensis* (De León)
Legs with variable color patterns; relation of basitarsus to second tarsal seg-

ment 7.4:1; cornuae of buccopharyngeal apparatus narrowly triangular in shape, very slightly sclerotized.........*wrighti* Vargas, Martínez, and Díaz

SUBGENERA OF THE GENUS SIMULIUM, BASED ON FEMALE CHARACTERS

1. Fronto-ocular triangle absent....................*Notolepria* Enderlein, 1930
(*Simulium* (*N.*) *exiguum* Roubaud *)
Fronto-ocular triangle present..2
2. Median space of buccopharyngeal apparatus with two long projections composed of very long teeth; median space with a total of approximately 23 well-defined teeth in regular pattern, all but those forming the projections in a single row.............................*Byssodon* Enderlein, 1925
(*Simulium* (*B.*) *benjamini* Dalmat *)
Median space without long projections; if numerous teeth are present, they are arranged in several rows and are never very long....................3
3. Claw of hind tarsus without well-defined heel, with or without tooth.
Lanea Vargas, Martínez, and Díaz, 1946
Claw of hind tarsus always with well-developed heels; claw with secondary tooth (or projection), the heel extended to form secondary spur, or with both tooth (or projection) and secondary spur.........................4
4. Ovipositor longer than wide, well developed, lance-shaped.
Dyarella Vargas, Martínez, and Díaz, 1946
Ovipositor usually shorter than wide; when long, not lance-shaped..........5
5. Genital rod with basal dilatation; postnotum usually without scalelike hairs, when present (*S. ethelae*), the pilosity on the frons, clypeus, and occipital region is black and there are white-pruinose longitudinal bands on the mesonotum ....*Hearlea* Rubzov, 1940
Genital rod without basal dilatation; postnotum with a number of yellow, appressed, scalelike hairs; pilosity on frons, clypeus, and occipital region composed of either yellow scalelike hairs or yellow, erect, longer hairs; mesonotum without white-pruinose longitudinal bands.
Eusimulium Roubaud, 1906
(*Simulium* (*E.*) *aureum* (Fries)*)

SPECIES OF THE SUBGENUS DYARELLA, BASED ON FEMALE CHARACTERS

1. Mesonotum with longitudinal bands of white pruinosity....................5
Mesonotum without these white-pruinose longitudinal bands...............2
2. R_1 pilose on its distal half to three-fifths; base color of mesonotum brown....3
R_1 completely pilose; base color of mesonotum black........................4
3. Base color of mesonotum light brown, with silvery-white scalelike hairs, these in groups of 2 or 3 on anterior margin; Sc usually completely pilose, or, at most, with 1-2 hairs lacking at apical end; spicules on R_1 appear the same as on other veins and on wing membrane in general; median space of buccopharyngeal apparatus with several wide, scalelike teeth.
earlei Vargas, Martínez, and Díaz
Base color of mesonotum dark reddish brown, with golden-yellow scalelike hairs, never in groups; Sc pilose on basal fourth only; spicules on R_1 somewhat larger and more concentrated than on other veins or on wing membrane; median space of buccopharyngeal apparatus smooth, without teeth.
ardeni Dalmat

4. Tibia of anterior leg black except for minute yellow basal ring, all clothed with black hairs; apical fourth of ventral surface of Sc with at least 2 or 3 rows of hairs, the basal three-fourths with a single row......*smarti* Vargas
   Tibia of anterior leg with basal half yellow, this part clothed with appressed silvery-white hairs; apical sixth of ventral surface of Sc with at most 2 rows of hairs, the basal five-sixths with a single row....*mexicanum* Bellardi
5. Base color of mesonotum light brown, almost orange........................6
   Base color darker, approaching copper red..................................8
6. Scalelike hairs on mesonotum silvery white; femur of anterior leg with three transverse dark bands; average length of fly 2.5 mm....*pulverulentum* Knab
   Scalelike hairs on mesonotum golden yellow; femur of anterior leg without these dark bands; average length 3.1 to 4.0 mm..........................7
7. Hairs on clypeus black; Sc pilose on basal three-fourths; average length 4.0 mm ....*rubicundulum* Knab
   Hairs on clypeus yellowish white; Sc pilose only on basal half; average length 3.1 mm..*yepocapense* Dalmat
8. Sc pilose at least along basal half, often with additional hair near apex; R_1 pilose from point of origin of R_{2+3}; height of fronto-ocular triangle 2.2 times base ....*acatenangoensis* Dalmat
   Sc pilose only along basal fourth; R_1 pilose from a point beyond origin of R_{2+3}; height of fronto-ocular triangle 1.6 times base......*mathesoni* Vargas

SPECIES OF THE SUBGENUS HEARLEA, BASED ON FEMALE CHARACTERS

1. Postnotum with several long, narrow, appressed, yellow, scalelike hairs. *ethelae* Dalmat
   Postnotum bare, without scalelike hairs....................................2
2. Buccopharyngeal apparatus with pronounced indentation on median space....3
   Buccopharyngeal apparatus with median space evenly concave, without any pronounced indentation at its midregion................................5
3. Median space of buccopharyngeal apparatus serrated..........*burchi* Dalmat
   Median space of buccopharyngeal apparatus not serrated.................4
4. Cornuae of buccopharyngeal apparatus simple, pointed, not expanded; base of fronto-ocular triangle 1.5 times its height..............*nigricornis* Dalmat
   Cornuae of buccopharyngeal apparatus expanded; base of fronto-ocular triangle equal to its height.............................*capricornis* De León
5. Femora of all legs dark brown to black.............*larvispinosum* De León
   Femora of legs either yellow, or yellow with small dark areas..............6
6. Median space of buccopharyngeal apparatus serrated; scalelike hairs on mesonotum long, bronze to copper in color; length of ovipositor $1\frac{1}{2}$ times the base. *microbranchium* Dalmat
   Median space of buccopharyngeal apparatus smooth; scalelike hairs on mesonotum very short, pale yellow in color; base of ovipositor equal to, or greater than, its length...7
7. Cornuae of buccopharyngeal apparatus broad, spatulate; base of ovipositor greater than its length................................*delatorrei* Dalmat
   Cornuae of buccopharyngeal apparatus sharply pointed; ovipositor dome-shaped, its base equal to its length......................*carolinae* De León

SPECIES OF THE SUBGENUS LANEA, BASED ON FEMALE CHARACTERS

1. Mesonotum orange or yellow 2
   Mesonotum gray, dark reddish brown, or black 5
2. Hairs on occipital region long and black, with few, if any, yellow scalelike hairs 3
   Hairs on occipital region yellow, scalelike, with few, if any, long black ones .. 4
3. Claw of hind tarsus without teeth; tergites of abdominal segments 3 and 4 dark brown to black; in fresh or alcoholic specimens, the dorsum of each of these segments divided into 3-5 square to rectangular dark patches separated by yellow; tergites of segments 7 and 8 not shiny yellow.
   downsi Vargas, Martínez, and Díaz
   Claw of hind tarsus with one or two teeth; abdominal tergites 3-8 graduating from brown to black, never divided into square or rectangular patches.
   callidum (Dyar and Shannon)
4. Claw of posterior tarsus with a single small tooth near base; longitudinal bands on mesonotum not connected anteriorly, running parallel to each other, approximately of equal width all their length, fusing with white pruinosity of prescutellar region; basal half of Sc pilose .... *colvini* Dalmat
   Claw of posterior tarsus without teeth; longitudinal bands emerging from transverse pruinose band on anterior margin of mesonotum, wider anteriorly, diverging posteriorly, each passing to the side of the prescutellar depression; basal two-thirds of Sc pilose .... *samboni* Jennings
5. Mesonotum completely gray-pruinose, except for a single longitudinal, copper-colored band which is found on the midline, extending along approximately three-fourths of the length of the mesonotum.
   dugesi Vargas, Martínez, and Díaz
   Mesonotum dark reddish brown or velvety black with two longitudinal white-pruinose bands, one on either side of the midline 6
6. Mesonotum dark reddish brown, the longitudinal bands not very broad; Sc pilose along its basal three-fifths .... *trivittatum* Malloch
   Mesonotum velvety black, the longitudinal bands very broad 7
7. Longitudinal bands of white pruinosity so situated on either side of midline of mesonotum that the distance between them is less than the width of one band; only basal fourth of Sc pilose .... *haematopotum* Malloch
   Longitudinal bands farther apart; basal two-thirds of Sc pilose.
   veracruzanum Vargas, Martínez, and Díaz

SPECIES OF THE SUBGENUS SIMULIUM, BASED ON FEMALE CHARACTERS

1. Buccopharyngeal apparatus with teeth on median space 2
   Buccopharyngeal apparatus without teeth on median space 4
2. Mesonotum yellow orange, without scalelike hairs; R_1 completely pilose, with spines also along its distal two-thirds .... *ochraceum* Walker
   Mesonotum black, with yellow scalelike hairs; R_1 pilose and with spines along distal half only 3
3. Median space of buccopharyngeal apparatus with 4 rows of broad, blunt teeth; claw of posterior leg with submedian tooth.
   parrai Vargas, Martínez, and Díaz

Median space of buccopharyngeal apparatus serrated, with a single large central tooth; claw of posterior leg with subbasal tooth.
jacumbae Dyar and Shannon

4. Mesonotum with yellow scalelike hairs.................... *tricornis* De León
Mesonotum without yellow scalelike hairs.................................5

5. Band of white pruinosity around entire periphery of mesonotum, in addition to white-pruinose longitudinal bands or stripes; R_1 with spines and hairs along its distal half........................ *jobbinsi* Vargas, Martínez, and Díaz
Anterior margin of mesonotum not completely white-pruinose; R_1 with spines only along its distal half............................ *metallicum* Bellardi

SPECIES OF THE SUBGENUS SIMULIUM, BASED ON FEMALE CHARACTERS (ALTERNATE KEY)

1. Genital rod with basal dilatation...2
Genital rod not expanded basally...5

2. Basal dilatation small, triangular.............. *jacumbae* Dyar and Shannon
Basal dilatation more extensive, oval.....................................3

3. Mesonotum orange yellow; ovipositor longer than wide, not triangular in shape .... *ochraceum* Walker
Mesonotum black; ovipositor wider than long..............................4

4. Expansions of genital fork with two triangular-shaped structures near midregion and with apices pointed............................ *kompi* Dalmat
Expansions of genital fork without triangular-shaped structures, the apices not pointed........................ *jobbinsi* Vargas, Martínez, and Díaz

5. Median space of buccopharyngeal apparatus with 4 rows of wide, blunt teeth.
parrai Vargas, Martínez, and Díaz
Median space hyaline and smooth, without teeth...........................6

6. Mesonotum with long, narrow, yellow, scalelike hairs, denser on anterior fourth.. *tricornis* De León
Mesonotum without scalelike hairs.................... *metallicum* Bellardi

GENERA OF SIMULIIDAE, BASED ON PUPAL CHARACTERS

1. Posterior extremity of pupa with prominent spines (terminal spines); 3-7 simple to trifid hairs on either side of ventral surface of ninth abdominal segment; ventral surfaces of abdominal segments 5-7 with at least 4 spines, always simple; ventral surfaces of all abdominal segments with granulosity; cocoon soft, composed of a very loose network of threads, attached to substratum along at least 80 percent of its base............................2
Spines at posterior extremity of pupa very small or absent; at most, one short, simple hair on either side of ventral surface of ninth abdominal segment; ventral surfaces of abdominal segments 5-7 with a maximum of 4 spines: simple, bifid, trifid, or in combination; when all these spines are simple, those on segment 5 are closer together than those on segments 6 or 7; ventral surfaces of abdominal segments lacking granulosity; cocoon of firmer texture, the threads, when visible, are held together in a parchmentlike matrix; cocoon attached to substratum along a maximum of only 60 percent of its base .... *Simulium* Latreille, 1802

2. Dorsum of first two abdominal segments covered with granulosity and with transverse row of simple spines; dorsum of segments 3 and 4 with more than 8 spines in transverse row; 3 or 7 hairs on either side of ventral surface of ninth abdominal segment, of which no more than 1 is bifid; terminal spines cone-shaped.......................... *Gigantodax* Enderlein, 1925

Dorsum of first two abdominal segments with or without granulosity, without transverse row of simple spines; dorsum of segments 3 and 4 with only 8 spines in transverse row; 5 hairs on either side of ventral surface of ninth abdominal segment, of which 2 are bifid (*C. aguirrei* Dalmat and *C. pacheco-lunai* (De León)) or 1 trifid (*C. roblesi* (De León)); terminal spines tubular or fingerlike in appearance.................. *Cnephia* Enderlein, 1921

SPECIES OF THE GENUS CNEPHIA, BASED ON PUPAL CHARACTERS

1. Respiratory apparatus of each side composed of only two tubular filaments, each tapering toward apex; ventral surfaces of segments 3-7 each with transverse row of 10 simple spines; cocoon covering only posterior half of abdomen.. *aguirrei* Dalmat

Respiratory apparatus of each side composed of more than two branches; ventral surfaces of segments 3-7 with, at most, 4 simple spines in transverse row; cocoon covering all of abdomen and approximately one-fourth of thorax.. 2

2. Respiratory apparatus composed of 12-13 filaments, each tapering from its base to apex; thorax and dorsum of abdomen covered with granulosity; terminal spines approximately 0.15 mm. long...... *pacheco-lunai* (De León)

Respiratory apparatus of each side composed of 4 saclike trunks, two thin filaments extending from the apex of each of three of the trunks, and one filament from the fourth; thorax and abdomen without granulosity; terminal spines approximately 0.06 mm. long.................... *roblesi* (De León)

SPECIES OF THE GENUS GIGANTODAX, BASED ON PUPAL CHARACTERS

Respiratory apparatus of each side composed of 9 somewhat flattened branches, each ovoid in cross section and spatulate at the apex; dorsal surface of each of abdominal segments 6-8 with single transverse row of at most 30 spines; ventral surface of segments 5-7 each with row of 6 spines; three simple hairs on either side of ventral surface of ninth abdominal segment; cocoon covering abdomen and three-fourths of thorax...... *wrighti* Vargas, Martínez, and Díaz

Respiratory apparatus of each side divided into 13-15 tubular branches, each tapering toward its apex and several with elongate filaments extending from their extremities; dorsal surface of each of abdominal segments 6-8 with transverse row of at least 40 spines, segment 8 also with second row of 6 heavier spines; ventral surfaces of segments 5 and 6 each with row of 8 spines, that of segment 7 with row of 4 spines; 1 bifid and 6 simple hairs on either side of ventral surface of ninth abdominal segment; cocoon covering three-fourths of abdomen only................................ *aquamarensis* (De León)

SUBGENERA OF THE GENUS SIMULIUM, BASED ON PUPAL CHARACTERS

1. Transverse row of heavy spines on dorsal surface of segments 2-4 only...... 2

Transverse row of heavy spines on other segments in addition to 2-4........ 3

2. Six heavy spines in transverse row on dorsal surface of segment 2; ventral spines on segments 5-7 all simple; terminal spines absent; cocoon slipper-shaped, with definite "collar"....*Dyarella* Vargas, Martínez, and Díaz, 1946
   Twelve heavy spines in transverse row on dorsal surface of second abdominal segment; segments 5-7 each with at least one of its ventral spines bifid; terminal spines present but small; cocoon without "collar."
   Notolepria Enderlein, 1930
   (*Simulium* (*Notolepria*) *exiguum* Roubaud *)
3. At least some of the abdominal segments with dorsal groups of contiguous teeth in form of "combs"..4
   None of abdominal segments with groups of teeth in form of "combs"......6
4. Ventral spines on abdominal segments 4-7; terminal spines present, although small; network of threads visible in structure of cocoon..................5
   Ventral spines present on abdominal segments 5-7 only; terminal spines absent; cocoon parchmentlike, threads not visible......*Hearlea* Rubzov, 1940
5. Abdominal segment 8 with at least 16 spines (rarely as few as 16 in *S.* (*L.*) *downsi* Vargas, Martínez, and Díaz) in transverse row; respiratory apparatus composed of 8 filaments only; thorax without granulosity.
   Lanea Vargas, Martínez, and Díaz, 1946
   Abdominal segment 8 with a maximum of 16 spines (rarely as many as 16 in *S.* (*S.*) *ochraceum* Walker); respiratory apparatus with fewer than, or more than, 8 filaments; when composed of 8 filaments (*S. ochraceum* only), the thorax lacks granulosity............................*Simulium,* s. str.
6. Respiratory apparatus composed of 4 filaments only; abdominal segment 6 with transverse row of dorsal spines; ventral spines present on abdominal segments 4-7, simple or bifid; terminal spines present, although small.
   Eusimulium Roubaud, 1906
   (*Simulium* (*E.*) *aureum* (Fries)*)
   Respiratory apparatus composed of 8 filaments; segment 6 devoid of dorsal spines; ventral spines present on abdominal segments 5-7 only, all trifid; terminal spines absent.........................*Byssodon* Enderlein, 1925
   (*Simulium* (*B.*) *benjamini* Dalmat *)

SPECIES OF THE SUBGENUS DYARELLA, BASED ON PUPAL CHARACTERS

1. Respiratory apparatus of each side composed of 8 filaments................2
   Respiratory apparatus of each side with more than 8 filaments..............4
2. Respiratory apparatus with rather long, narrow basal stem from which arise two main trunks in form of V, each with 4 filaments emerging at different levels; festoons on each side usually in form of 5 ribbons that are connected to one another at their dorsal end by transverse bands, and 1 separate ribbon at anterior part of dorsal aperture; festoons are so connected that their dorsal margins form a straight line; 3 trichomes on either side of midline of thorax......................................*rubicundulum* Knab
   Respiratory apparatus with short, wide basal stem with more than two trunks ramifying from it; the branching of each trunk being closer to the base; festoons less extensive..3
3. Filaments arising in groups of 2-1-1-2-1-1 so close to the basal stem that each one appears to arise singly; bases of two uppermost festoons on each side of dorsal aperture almost contiguous to one another; three simple trichomes on each side of midline of thorax................*acatenangoensis* Dalmat

Filaments arising in groups of 2-2-1-1-1-1, the ramifications occurring rather high above basal stem; the origin of the lowest single filament is quite removed from that of the other filaments; bases of two uppermost festoons on each side of dorsal aperture somewhat removed from each other; four simple trichomes on each side of midline of thorax....... *mathesoni* Vargas

4. Respiratory apparatus composed of 10 filaments.........................5
   Respiratory apparatus composed of more than 10 filaments.................7
5. Six trichomes on either side of midline of thorax; granulosity on abdominal segments 1 and 2 only..6
   No trichomes on thorax; granulosity on abdominal segments 1-4 *pulverulentum* Knab
6. Entire dorsum of thorax with granulosity; dorsal surface of abdominal segments 1-2 with granulosity, except for midregion of segment 1; filaments arise in groups of 4-4-2, the ramifications originating somewhat removed from the base; filaments smooth, without microscopic spicules *ardeni* Dalmat
   Granulosity on posterior fourth of dorsum of thorax only; abdominal segments 1-2 with granulosity on their posterior margins only; filaments arise in groups of 2-1-2-2-1, the branches emerging close to the base; filaments covered with microscopic spicules.................... *yepocapense* Dalmat
7. Respiratory apparatus with 12 filaments; anterior part of cocoon extended dorsally in form of two spatulate processes; dorsal surface of cocoon forming straight line in profile; three long, simple trichomes on either side of midline of thorax................................ *mexicanum* Bellardi
   Respiratory apparatus with more than 12 filaments; anterior part of cocoon not extended into spatulate processes; more than 3 trichomes on either side of midline of thorax; dorsal surface of cocoon curved in profile..........8
8. Respiratory apparatus composed of 16 filaments; rim of anterior aperture of cocoon not thickened, approximately parallel to base; 2 bifid and 3 trifid trichomes on either side of midline of thorax; single, anteriorly directed spine on each lateral margin of abdominal segments 3-7. *earlei* Vargas, Martínez, and Díaz
   Respiratory apparatus composed of 18 filaments; thickened rim of anterior aperture of cocoon at marked angle to base; 6 simple trichomes, not very long, on either side of midline of thorax; no spines on lateral margins of abdominal segments 3-7................................ *smarti* Vargas

SPECIES OF THE SUBGENUS HEARLEA, BASED ON PUPAL CHARACTERS

1. Cocoon without raised collar; respiratory apparatus antlerlike, with several branches...2
   Cocoon with raised collar; respiratory apparatus in other form, at most with dorsal and ventrolateral elements and posteromedially directed extension...3
2. Secondary branches of respiratory apparatus with several further subdivisions at their apices, these being very short and close together, often appearing like a crown of small spines, the 4 spines on either side of midline of second abdominal segment equidistant from each other; 10 short, stout, simple, spinelike trichomes on thorax..................... *larvispinosum* De León
   Secondary branches of respiratory apparatus with fewer, longer subdivisions, these more distinctly formed, each with a single spine at its apex; on either side of midline of second abdominal segment, the distance between the outer-

most of the 4 spines in the transverse row and the spine adjacent to it is greater than the distance between any of the others; 12 short, stout, simple, spinelike trichomes on thorax........................*carolinae* De León

3. Respiratory apparatus of either side with posteromedially directed prolongation extending from junction of dorsal and ventrolateral elements.........4
   Respiratory apparatus without this prolongation..........................6
4. Respiratory apparatus with dorsal element expanding gradually from its base to apex, forming a club-shaped structure; band of spines in comblike groups crossing anterior margin of fifth abdominal segment........*burchi* Dalmat
   Distal end of dorsal element of respiratory apparatus tapered, narrower than the more basal section; fifth abdominal segment devoid of spines..........5
5. Dorsal element of respiratory apparatus curved, with concavity on upper surface, this element broadening from base to midregion and then tapering toward apex; posteromedially directed extension long and somewhat pointed; cocoon without lateral "wings"; dorsum of the seventh abdominal segment with four large spines in transverse row, and dorsum of ninth segment devoid of spines..................................*delatorrei* Dalmat
   Dorsal element of respiratory apparatus curved, with concavity on lower surface, this element tapering gradually from its base to apex; posteromedially directed extension very short and blunt; cocoon with lateral "wings"; dorsum of seventh abdominal segment with 10-16 large spines in transverse row, and dorsum of ninth segment with uninterrupted band of spines in comblike groups........................*capricornis* De León
6. Dorsal element of respiratory apparatus spatulate and short, its apex very broad and darker than remainder of structure; four simple, thin, spinelike trichomes on thorax...................................*nigricornis* Dalmat
   Dorsal element tapering, never spatulate, and of the same color as the remainder of respiratory apparatus; usually eight trichomes on thorax..........7
7. Dorsal element of respiratory apparatus very short and straight, only slightly more than one-half the length of ventrolateral element; length of base of cocoon 1.8 times its width; dorsum of ninth abdominal segment devoid of spines....................................*microbranchium* Dalmat
   Dorsal element curved with ventral concavity, approximately 1.5 times the length of ventrolateral element; length of base of cocoon less than 1.2 times its width; dorsum of ninth abdominal segment with band of small spines in comblike groups along anterior margin...................*ethelae* Dalmat

SPECIES OF THE SUBGENUS LANEA, BASED ON PUPAL CHARACTERS

1. Filaments of respiratory apparatus very short, measuring approximately 60 percent of length of cocoon; trichomes usually absent from dorsum of thorax; a single short, heavy spine on either side of midline on dorsal surface of segment 9, posterior to transverse row.
   dugesi Vargas, Martínez, and Díaz
   Filaments longer, measuring more than three-fourths the length of cocoon; trichomes present; the short, heavy, single spine posterior to transverse row never present on dorsum of segment 9...................................2
2. Spines or teeth present on dorsum of ninth segment.......................3
   Spines or teeth absent on dorsum of ninth segment.......................7
3. Spines present on dorsum of sixth segment...............................4
   Spines absent on dorsum of sixth segment...............................6

4. Dorsum of segment 9 with numerous comblike groups of minute spines, and with 4-12 larger spines in a transverse row, these divided into two groups by a median space; cocoon without lateral "wings."
downsi Vargas, Martínez, and Díaz
Dorsum of ninth segment without comblike groups of minute spines; cocoon normally with lateral "wings"..5
5. Ninth segment with continuous transverse row of 8 spines, without median space; spines on ventral surface of segment 4 simple......*samboni* Jennings
Ninth segment with transverse row of 15-18 spines, these divided into two groups by median space; spines on ventral surface of segment 4 bifid.
colvini Dalmat
6. Four arborescent trichomes on either side of midline of thorax; all respiratory filaments arched dorsally, appearing like a fan; dorsal surface of seventh abdominal segment with 0-8 simple spines in transverse row, divided into two groups by median space, and with several minute spines arranged in comblike groups..........................*callidum* (Dyar and Shannon)
Two bifid trichomes on either side of thorax; respiratory filaments not arched or in form of fan; dorsum of seventh abdominal segment with 8-18 spines in transverse row, divided by median space, but with no comblike groups of minute spines..................................*haematopotum* Malloch
7. The filaments of each respiratory apparatus forming a compact group; usually seven trichomes on either side of midline of thorax, 5 bifid and 2 simple; dorsum of eighth abdominal segment with 13-22 simple spines in transverse row, divided into two groups by a median space.
veracruzanum Vargas, Martínez, and Díaz
The filaments of each respiratory apparatus well separated from one another, not in compact groups; usually 5 simple, hairlike trichomes on either side of midline of thorax, close to lateral margins; dorsum of eighth abdominal segment with approximately 30 simple spines in an uninterrupted transverse row...*trivittatum* Malloch

SPECIES OF THE SUBGENUS SIMULIUM, BASED ON PUPAL CHARACTERS

1. Branches of respiratory apparatus filamentous............................2
Branches of respiratory apparatus tubular, inflated........................5
2. Respiratory apparatus of each side composed of 6 filaments.................3
Respiratory apparatus composed of more than 6 filaments..................4
3. Cocoon with lateral "wings" usually so well developed, the cocoon appears circular when viewed from above; dorsal surface of sixth abdominal segment with 5-12 spines in a row, the spines being at irregular intervals and in groups of 1, 2, or 3, but without separation near midline; same surface with numerous comblike groups of minute spines lateral to the main row as well as between the spines of that row................*metallicum* Bellardi
Cocoon without lateral "wings"; dorsal surface of sixth abdominal segment without spines or comblike groups of minute spines.
jobbinsi Vargas, Martínez, and Díaz
4. Respiratory apparatus with 8 filaments; dorsum of thorax smooth; all spines on dorsal surface of second abdominal segment in straight row; ventral surfaces of segments 6 and 7 each with 4 spines; margin of anterior aperture of cocoon thickened, without dorsal prolongation........*ochraceum* Walker

Respiratory apparatus with 26 branches; dorsum of thorax with granulosity; outermost 2 spines on either side of transverse row on second abdominal segment anterior to spines closer to midline; ventral surfaces of segments 6 and 7 with only 2 spines; margin of anterior aperture of cocoon not thickened, with long dorsal prolongation...... *jacumbae* Dyar and Shannon

5. Respiratory apparatus consisting of three inflated tubular branches, arising from common base, one above the other, all directed anteriorly, appearing like a pitchfork; superficial transverse divisions well marked. *kompi* Dalmat

Respiratory apparatus not in this form, branches not arising regularly......6

6. Respiratory apparatus inflated, the narrow base expanding and soon dividing into two branches, each of these again subdividing irregularly; dorsal element of apparatus with numerous hairs on most of its dorsal face; cocoon appearing circular in shape when viewed from above, with short "ribbon" joining both sides of cocoon beneath anterior aperture; dorsal surface of segments 5 and 6 without spines or combs. *parrai* Vargas, Martínez, and Díaz

Respiratory apparatus consisting of a 3-branched structure, each branch tubular and tapering toward the apex, without hairs; cocoon triangular in shape when viewed from above, with heavily sclerotized ridge running along its midline for the entire length of the dorsal surface; without ventral "ribbon"; dorsal surface of segments 5 and 6 entirely covered by comblike groups of minute spines.. *tricornis* De León

GENERA OF SIMULIIDAE AND SUBGENERA OF THE GENUS SIMULIUM, BASED ON LARVAL CHARACTERS [8]

1. Mandible with 1-3 teeth along the inner margin...... *Simulium* Latreille, 1802

Mandible with more than 3 teeth along the inner margin...................2

2. Submentum with 13 apical teeth.................... *Cnephia* Enderlein, 1921

Submentum with 17 apical teeth................. *Gigantodax* Enderlein, 1925

3. Occipital cleft lacking or very poorly formed; anal gills consisting of three single, fingerlike processes.................... *Eusimulium* Roubaud, 1906 (*Simulium* (*E.*) *aureum* (Fries)*)

Occipital cleft always present and well formed...........................4

4. Antennae 5-segmented, the second segment showing further superficial divisions, indicated principally by color bands............ *Hearlea* Rubzov, 1940

Antennae 4-segmented, the second segment either simple or showing signs of secondary divisions...5

5. Posterior sucker with 150 or more rows of hooks. *Dyarella* Vargas, Martínez, and Díaz, 1946

Posterior sucker with less than 150 rows of hooks........................6

6. At least second segment of antenna usually with transverse striations; when these are lacking (in *S.* (*S.*) *ochraceum*), the occipital cleft reaches the submentum.. *Simulium,* s. str.

Antennal segments without transverse striations; occipital cleft never reaching submentum...7

7. Rectal scales present, forming easily visible dark band across dorsum of eighth segment; posterior sucker with 68-72 rows of hooks; eighth segment with-

[8] Subgenus *Byssodon* not included because of lack of larval forms.

out ventral tubercles.........................*Notolepria* Enderlein, 1930
(*Simulium* (*N.*) *exiguum* Roubaud*)

Rectal scales usually absent, when present (in *S.* (*L.*) *callidum*), posterior sucker has approximately 105 rows of hooks; eighth segment usually with ventral tubercles (exception: *S.* (*L.*) *dugesi*).
Lanea Vargas, Martínez, and Díaz, 1946

SPECIES OF THE GENUS CNEPHIA, BASED ON LARVAL CHARACTERS

1. Mandibles with 29-32 teeth along inner edge; submentum with 6 hairs in ventrolateral row and with 15 toothlike indentations along lateral edge; posterior sucker with 95-100 rows of hooks.............*roblesi* (De León)
   Mandibles with fewer than 29 teeth along inner edge.....................2
2. Mandibles with 25 teeth on inner edge; submentum with 8 toothlike indentations along lateral edge; mouth brushes with 25 branches; posterior sucker with 80-82 rows of hooks......................*pacheco-lunai* (De León)
   Mandibles with 23 teeth on inner edge; submentum with 6 toothlike indentations along lateral edge; mouth brushes with 30-35 branches; posterior sucker with 72-75 rows of hooks........................*aguirrei* Dalmat

SPECIES OF THE GENUS GIGANTODAX, BASED ON LARVAL CHARACTERS

Posterior sucker with 95-105 rows of hooks; cephalic fan with 26-30 branches; mandible with 9 or 10 teeth on inner edge, the first 2 of these being completely separated from each other and the second well removed from the third; pair of cone-shaped tubercles on ventral surface of segment 8; rectal scales present, arranged in 4 or 5 irregular rows; anterior arms of anal sclerite (X-shaped) expanded anteriorly to form heart-shaped structure.
wrighti Vargas, Martínez, and Díaz

Posterior sucker with 126-134 rows of hooks; cephalic fan with 34-40 branches; mandible with 11 teeth on inner edge, the first being contiguous to the second which appears to arise from the same base as the third; no cone-shaped tubercles on ventral surface of eighth segment; rectal scales absent; anterior arms of anal sclerite (X-shaped) not expanded anteriorly; well-sclerotized triangular patch on either side between the anterior and posterior arms.
aquamarensis (De León)

SPECIES OF THE SUBGENUS DYARELLA, BASED ON LARVAL CHARACTERS

1. Posterior sucker with more than 300 rows of hooks........................2
   Posterior sucker with fewer than 300 rows of hooks.......................3
2. Rectal scales present; posterior sucker with 450-460 rows of hooks; anal gills with 57 branches; frons-clypeus extremely dark brown, so dark that markings are scarcely visible..................................*smarti* Vargas
   Rectal scales absent; posterior sucker with 350-360 rows of hooks; anal gills with 36 branches; frons-clypeus light orange with 4 dark-brown longitudinal patches in form of cross.........................*acatenangoensis* Dalmat
3. Posterior sucker with 150-156 rows of hooks; anal gills usually with 10 branches...*pulverulentum* Knab
   Posterior sucker with more than 200 rows of hooks; anal gills with more than 20 branches...4

4. Posterior arms of anal sclerite (X-shaped) extremely short. *mexicanum* Bellardi
   Posterior arms reaching at least to sides of eighth segment................5
5. Only one flat tooth on inner margin of mandible; cephalic fan with fewer than 50 branches 6
   Two flat teeth on inner margin of mandible; cephalic fan with more than 50 branches..7
6. Occipital cleft rounded; cephalic fan with 46 branches; submentum with apical teeth well developed, with 9 hairs in ventrolateral row, and with 3 or 4 teeth on each of its lateral margins.................*yepocapense* Dalmat
   Occipital cleft pointed; cephalic fan with 36-40 branches; submentum with apical teeth poorly developed, with 8 hairs in ventrolateral row, and with 5 teeth on each of its lateral margins.......*carlei* Vargas, Martínez, and Díaz
7. Posterior sucker with 220-230 rows of hooks; submentum with 9 hairs in ventrolateral row; anal gills with 36 short branches; posterior arms of anal sclerite extending well onto the sides of the eighth segment. *rubicundulum* Knab
   Posterior sucker with 264-270 rows of hooks; submentum with 7-8 hairs in ventrolateral row; anal gills with 27-45 branches; posterior arms of anal sclerite not extending to the sides of the eighth segment...*mathesoni* Vargas

SPECIES OF THE SUBGENUS HEARLEA, BASED ON LARVAL CHARACTERS

1. Eighth segment with large, heavily sclerotized, and deeply pigmented dorsal and/or ventral processes..2
   Eighth segment without such processes................................3
2. Cephalic fan with 57-58 branches; ventrolateral row of submentum irregular, composed of 13 hairs, sometimes grouped in pairs; pseudopod with 72-74 rows of hooks; occipital cleft rather narrow and acute; length of mandible 2.3 times the width; 2 black transverse bands, 1 on either side of midline, crossing larva just anterior to anal gills, at times meeting at midline. *larvispinosum* De León
   Cephalic fan with 44-45 branches; ventrolateral row of submentum with 8-11 hairs in straight line; pseudopod with 45-46 rows of hooks; occipital cleft dome-shaped, somewhat pointed anteriorly; length of mandible 1.6 times the width; without black bands anterior to anal gills........*carolinae* De León
3. Posterior sucker with 170 or less rows of hooks..........................4
   Posterior sucker with more than 170 rows of hooks......................5
4. Posterior sucker with 114-125 rows of hooks; cephalic fan with 44-45 branches; ventrolateral row consisting of 6-10 hairs in straight row, either trifid or 4-branched; each of 3 anal gills branching into 4, giving 12 ramifications in all; rectal scales in irregular group near union of anterior arms of X-shaped sclerite...............................*capricornis* De León
   Posterior sucker with 160-170 rows of hooks; cephalic fan with 34-37 branches; ventrolateral row of submentum composed of 12-16 hairs in irregular row, simple to trifid; anal gills with 12-13-12 fingerlike branches, giving total of 37; rectal scales in 3 or 4 almost regular rows in front of anterior arms of X-shaped sclerites.......................*ethelae* Dalmat
5. Ventrolateral row of submentum composed of 14-15 hairs; posterior sucker with 172-178 rows of hooks; cephalic fan with 46-50 branches; anal gills

with 78 branches in all; mandible usually with 3 flat teeth on inner margin. *burchi* Dalmat

Ventrolateral row composed of more than 15 hairs; posterior sucker with more than 180 rows of hooks; anal gills with fewer than 78 branches; inner margin of mandible with only 2 flat teeth 6

6. Postclypeal sclerites almost meeting near midline; ventrolateral row of submentum with 21 hairs; posterior sucker with 184 rows of hooks; 2 flat teeth on inner margin of mandibles arising from common base.. *delatorrei* Dalmat

Postclypeal sclerites well separated; ventrolateral row with only 19 hairs; posterior sucker with 198-204 rows of hooks; 2 flat teeth of mandibles well separated .... *microbranchium* Dalmat

SPECIES OF THE SUBGENUS LANEA, BASED ON LARVAL CHARACTERS

1. Posterior sucker with more than 70 rows of hooks 2

Posterior sucker with 70 or fewer rows of hooks 6

2. Rectal scales present, arranged in approximately 10 transverse rows; posterior sucker with 105 rows of hooks .... *callidum* (Dyar and Shannon)

Rectal scales absent; posterior sucker with 71-85 rows of hooks 3

3. Cephalic fan not pectinate; eighth segment without ventral tubercles. *jacobsi* Dalmat

Cephalic fan pectinate; eighth segment with ventral tubercles 4

4. Cephalic fan with 37-39 branches, the pectinate hairs very fine and close together, with somewhat longer, bifid ones interspersed at regular intervals; apical teeth of submentum long, of varied length, triangular in shape; postclypeal sclerites well formed and pigmented; several slender, simple spines between anterior and posterior arms of anal sclerite (X-shaped); round, raised structure, somewhat green in color, just in front of anterior arms of anal sclerite; anal gills with 8-12 branches in all......... *samboni* Jennings

Cephalic fan with more than 40 branches or fewer than 30, the pectinate hairs all of one type; apical teeth of submentum short, all of approximately the same length, pentagonal in shape; postclypeal sclerites absent or hardly noticeable; no spines or raised structures in region of anal sclerite; anal gills usually with total of 3 branches, rarely up to 9 5

5. Cephalic fan with 27-28 branches, the pectinate hairs all simple; the two mandibular teeth contiguous to each other, but arising from separate bases; design on frons-clypeus extending only halfway to anterior margin. *haematopotum* Malloch

Cephalic fan with 42 branches, the pectinate hairs all bifid; the two mandibular teeth appearing to emerge from the same base; design on frons-clypeus extending to anterior margin .... *dugesi* Vargas, Martínez, and Díaz

6. Cephalic fan with 26-31 branches .... *trivittatum* Malloch

Cephalic fan with more than 32 branches 7

7. Two flattened teeth on inner margin of mandible arise from common base; cephalic fan with 36-42 branches, the fine, short hairs on these branches arising close together, interspersed with heavier, longer hairs at regular intervals .... *downsi* Vargas, Martínez, and Díaz

Two flattened mandibular teeth well separated from eath other; cephalic fan with 39-49 branches, the pectinate hairs on these branches of one type only 8

8. Cephalic fan with 39-42 branches, the pectinate hairs on these simple, very fine, and close together, except at the extreme tips of the branches where they are somewhat more separated; lateral margin of submentum with 4 teeth contiguous to each other, another small isolated one closer to the base, and 2 heavily-sclerotized, well-pigmented ones just posterior to apical teeth (7 in all)........................*veracruzanum* Vargas, Martínez, and Díaz

   Cephalic fan with 45-49 branches, the pectinate hairs on these branches bifid, stout, greatly separated, with no simple, finer hairs between; lateral margin of submentum with 7 teeth, rather evenly spaced, none more heavily sclerotized or pigmented than the other........................*colvini* Dalmat

SPECIES OF THE SUBGENUS SIMULIUM, BASED ON LARVAL CHARACTERS

1. Rectal scales present..2

   Rectal scales absent..3

2. Cephalic fan with 36-38 branches, these having well-developed hairs along their ventral margin; pseudopod with 16-20 rows of hooks; posterior sucker with 66-70 rows of hooks; submentum with apical teeth well developed and with 3-4 toothlike extensions along each lateral margin..*metallicum* Bellardi

   Cephalic fan with 28 branches, the hairs along their ventral margin minute; pseudopod with 30–32 rows of hooks; posterior sucker with 82-84 rows of hooks; submentum with apical teeth not as sharply defined and usually with 7 toothlike extensions along each lateral margin.
   jobbinsi Vargas, Martínez, and Díaz

3. Cephalic fan with fewer than 40 branches..................................4

   Cephalic fan with more than 40 branches..................................6

4. First two antennal segments with well-defined transverse striations; ventral tubercles lacking on eighth segment; ventrolateral row of submentum with 6-10 hairs; apical teeth of submentum broad and sharp-pointed..........5

   First two antennal segments without transverse striations; ventral tubercles present on eighth segment; ventrolateral row of submentum composed of 4-5 hairs; apical teeth of submentum rather slender and blunt.
   ochraceum Walker

5. Epicranial plates with dark markings anterior to the eye spots; occipital cleft with posteriorly directed prolongation at its apex; posterior sucker with 78-82 rows of hooks; inner margin of anterior arms of X-shaped sclerite with darkened band......................................*kompi* Dalmat

   Epicranial plates without dark markings anterior to eye spots; occipital cleft with rounded apex; without prolongation; posterior sucker with 86-94 rows of hooks; inner margin of anterior arms of X-shaped sclerite without darkened band......................................*tricornis* De León

6. Anal gills with 14-18 branches; posterior sucker with 84-86 rows of hooks; ventrolateral row of submentum with 7 hairs; cephalic fan with 46-48 branches..............................*parrai* Vargas, Martínez, and Díaz

   Anal gills with 3 simple trunks, or each of these subdivided into 3 to give a maximum of 9 branches in all; ventrolateral row of submentum composed of 4-5 hairs; cephalic fan with 58-64 branches....*jacumbae* Dyar and Shannon

DESCRIPTIONS OF THE GUATEMALAN SPECIES

Genus CNEPHIA Enderlein, 1921

CNEPHIA AGUIRREI (Dalmat)

Simulium (*Eusimulium*) *aguirrei* DALMAT, Ann. Ent. Soc. Amer., vol. 42, No. 4, pp. 544-548, figs. 10-18, 1949 (original description, ♀ and ♂ genitalia, pupa).
Cnephia aguirrei DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 48-50, 1951 (description of ♀ and pupa).

Male (pl. 22, figs. 1-3).—(First description of external characters of male.) 3.1 mm. long.

HEAD: Holoptic. Eyes brown. Antenna 610 μ long, 11-segmented, segments 1-3 very long and slender; segment $3<1+2$, $3>4+5$, $3>11$; scape and pedicel brown, the flagellum dark brown to black. Palpi black. Clypeus black, white-pruinose, clothed with long black hairs.

THORAX: Mesonotum velvety black; short black hairs over entire mesonotum, some long black ones in prescutellar region. Humeral angles dark brown, with short black hairs. Scutellum shiny dark brown, with long black hairs. Postnotum velvety black, anterior half white-pruinose, devoid of hairs. Pleura dark brown, with slight pruinosity. Stem of halter with black base and dark-brown apex, the knob dark brown, partially black. Wings, 3.0 mm. long and 1.2 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along its basal third; R_1 completely pilose, the basal half with several rows of hairs, the distal half with spines as well as hairs; R_{2+3} pilose except for minute basal section; Cu_2 arcuate; discal cell present.

LEGS: Leg 1, length, 2.8 mm.; coxa, trochanter, femur, and tibia dark brown; basitarsus and second segment light brown, remainder of tarsus black. Leg 2, length, 2.8 mm.; coxa black; trochanter, femur, and tibia dark brown; basitarsus tan, second segment light brown, segments 3-5 dark brown. Leg 3, length, 3.5 mm.; coxa and trochanter black; femur black with very small light-brown apical ring; tibia black with very small light-brown basal ring; tarsus black; basitarsus spindle-shaped, its length equal to 3.1 times its width; relation of basitarsus to second segment, 4.7 : 1; calcipala well developed but small; pedisulcus absent.

ABDOMEN: Tergite of segment 1 black with short black hairs; pleurites black with very long tan hairs that reach the fifth or sixth segment. Segment 2 black, the anterior half white-pruinose. Other segments velvety dark brown to black, the posterior margins brown with white pruinosity; all segments with short dark-brown hairs, tufts of longer hairs on pleura of segments 2-5. Sternites black, with white pruinosity.

Genitalia: Sidepiece (pl. 22, fig. 1) cylindrical in shape, the length 1.5 times the width; dorsal opening oval, occupying more than half the dorsal surface of sidepiece. Clasper (pl. 22, fig. 1) conical in shape, somewhat shorter than sidepiece; basal opening extending along about half its length; apex pointed, with two rather heavy terminal spines. Body of adminiculum (pl. 22, fig. 2) dome-shaped, wider than long, the median portion with small patchlike areas from which very short hairs appear to emerge; apical margin with longer hairs; basal processes short, blunt, heavily sclerotized only along margins and at very ends; outer margins of basal processes with spurlike projections that are directed posteriorly. Arms of adminiculum (pl. 22, fig. 3) without teeth, the lateral plate roughly triangular in shape.

Female (pl. 28, figs. 118-120, and pl. 35, fig. 269.).—3.2 mm. long.

Head: Dichoptic; base of fronto-ocular triangle equal to its height. Antenna 580 μ long, 11-segmented, flagellum tapering; segments 1 and 2 very wide and long; segment $3<1+2$, $3<4+5$, $3>11$; scape and pedicel light brown, flagellum dark brown. Palpi black. Frons and clypeus black, white-pruinose, irregularly clothed with both yellow and black hairs. Occipital region black, densely covered with yellow hairs. Cornuae of buccopharyngeal apparatus slender, sharp-pointed, heavily sclerotized at ends; median space hyaline and smooth.

Thorax: Mesonotum black, with bloom of gray pruinosity; at times with three very dull longitudinal stripes extending from anterior margin to prescutellar region; densely covered by very long, narrow, appressed, silvery hairs, and with a few pale yellow ones; a few long, fine black hairs in prescutellar region. Humeral angles brown, with silvery appressed hairs. Scutellum dark brown to black, with numerous flat, appressed, silvery hairs and several long black hairs. Postnotum velvety dark brown, white-pruinose, devoid of hairs. Pleura dark brown, with tan pruinosity; pre-alar group composed of both black and silvery hairs. Stem of halter with dark-brown base becoming lighter toward the apex, the knob light reddish brown. Wings, 3.4 mm. long and 1.4 mm. wide; relation of body length to wing, 1.1 : 1; Sc completely pilose; R_1 completely pilose, with spines also along the distal third; R_{2+3} completely pilose; Cu_2 arcuate; discal cell present.

Legs: Leg 1, length, 2.7 mm.; coxa brown; trochanter, femur, and tibia dark brown; basitarsus and basal half of second segment tan, the remaining tarsal segment brown. Leg 2, length, 2.5 mm.; coxa, trochanter, femur, and tibia dark brown; basitarsus tan; basal half of second and third tarsal segments tan, the remainder of these segments, as well as all of segments 4 and 5, dark brown. Leg 3, length, 3.4 mm.;

coxa, and trochanter dark brown; femur dark brown, with very small tan apical ring; tibia dark brown with very small tan basal ring; tarsus dark brown; basitarsus parallel-sided; relation of basitarsus to second segment, 4.7:1; calcipala small but well developed; no pedisulcus; claw with heel developed into a spur and with a flat, tonguelike process appearing to arise from the base of the spur; inner face of claw with transverse striations (pl. 35, fig. 269).

ABDOMEN: Tergite very dark brown, densely covered with silvery hairs; pleurites black with some silvery hairs, each with group of very long golden hairs that reach the fourth segment. Segment 2 black, the anterior half gray-pruinose, with dense cover of silvery-white hairs. All other segments black, the anterior margin of each tergite brown, densely covered with silvery-white hairs. Sternites tan.

GENITALIA: Cercus (pl. 28, fig. 118) dome-shaped, its height twice its length (width). Anal lobe (pl. 28, fig. 118) somewhat triangular in shape, expanded ventrally, the dorsal limit pointed, its height equal to twice its length (width). Genital rod (pl. 28. fig. 120) with small buttonlike expansion at extreme base; apical expansions of genital fork like wide ribbon, with 2 basal angular extensions that are well pigmented. Ovipositors (pl. 28, fig. 119) triangular in shape, the inner borders parallel, terminating in right angle, the base somewhat greater than the height.

Pupa (pl. 36, fig. 276, and pl. 39, fig. 316).—Granulosity on entire thorax; 5 short, hairlike trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Granulosity covering all segments; spines on segments 3 and 4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segments 3 and 4 with 8 simple spines in transverse row just before the posterior margin, divided in two by a median separation; segment 6 with about 137 simple spines in transverse band across the anterior margin, extending one-fourth the way back, the band composed of 3 rows; segments 7 and 8 each with transverse band situated as on segment 6, the band composed of only 2 rows, segment 7 with about 104 spines and segment 8 with 100 spines; segment 9 with single transverse row of 34 simple spines across the anterior margin, with median separation. Ventral surface of abdominal segments: Entire ventral surface of all segments with granulosity; all spines are anteriorly directed; segments 3 and 4 each with 10 simple spines in transverse row three-fourths the distance from the anterior margin, the spines evenly spaced, without median separation; segments 5-7 each with 10 simple spines, larger than on segments 3 and 4, arranged in transverse row across the posterior margin, the spines evenly spaced, without wider median separation; on each side of segment 9, there emerge from the margin 2 bifid and 3 simple long hairs. Each abdominal segment encircled by a dark band along its anterior two-thirds to three-fourths. Terminal spines very well developed, sclerotized, about 60 μ long.

Respiratory apparatus (pl. 36, fig. 276) of each side arising slightly behind the anterior margin of the thorax, in the region of the humeral angles; composed of 2 long, tubular filaments, tapered at apex, both arising at base of apparatus, so arched as to form a V. Both elements with superficial transverse annulations along their entire length and with minute spicules, never subdivided. Maximum length, 2.5 mm., about 1.3 times the length of cocoon; average diameter, 0.2 mm.

Cocoon (pl. 39, fig. 316): Length of base, 2.0 mm.; maximum width, 1.3 mm.; maximum height, 1.3 mm. Cocoon of wall-pocket type, without collar; rim around anterior aperture not thickened, rarely with dorsal prolongation; case composed of very loose threads that are intermixed with particles of earth and other material. Cocoon covering one-half of abdomen only; attached approximately along the posterior 0.8 of its base.

Larva (pl. 40, fig. 356, and pl. 42, fig. 393).—(First description of larva.) [9] Total length, 6.3 mm. Length of head capsule 1.2 times its width. Width of thorax 1.3 times that of head. First four abdominal segments 1.1 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.5 times segments 1-4; cross section of body oval; thorax and abdominal segments 1-4 less expanded than in members of the subgenus *Simulium*. General color gray, with very long, dark patches on ventrolateral regions of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 356. Each cephalic fan with 30-35 pectinate branches, the hairs on these branches simple, rather long and close together, with somewhat heavier simple hairs at regular intervals. Mandible with 23 sharp-pointed teeth on its inner margin, contiguous to one another, only the most-distal somewhat longer than the others. Antenna 430 μ long, 4-segmented, pale yellow; just about reaching the end of basal stalk of cephalic fan; segment 3 is 1.7 times the length of segment 2 which is 1.2 times the length of segment 1; no transverse striations. Submentum with 13 apical teeth arranged in three projecting groups, the middle group composed of a central long tooth and a shorter one to each side near its base, each lateral group composed of a central long tooth, a somewhat shorter tooth to each side reaching its midregion, and another still shorter tooth to each side near the

[9] Since the date this work was submitted for publication, a description of the larva was published by L. Vargas and A. Díaz N. (1952).

base; ventrolateral row with three hairs in straight line, the mostdistal hair bifid near the apex, the other two simple; lateral margin of submentum with 6 toothlike serrations. Occipital cleft very shallow, dome-shaped (pl. 42, fig. 393).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 22-26 rows of hooks on its apex; postclypeal sclerites well developed, long, wider at outer end, gradually narrowing toward inner end, almost meeting at midline; not heavily pigmented. Posterior sucker with 72-75 rows of hooks. Anal gills three in number, very broad at the base, tapered toward apex. Anterior arms of X-shaped sclerite short, not very heavily sclerotized; posterior arms well sclerotized, extending only to lateral margins of segment; small membranous connection between the two anterior arms, near their origin; no rectal scales but with a few bifid and trifid scales between the anterior and posterior arm of each side. Segment 8 with two ventral papillae, appearing like short but broad-based cones, translucent; no sclerotized plaques.

Types.—Holotype (♀), 6 slides, and allotype (♂ dissected from pupal case), 5 slides, in collection of the United States National Museum. Holotype collected in the Río San Diego, Finca San Diego, Acatenango, Chimaltenango, Guatemala, October 30, 1947; allotype collected in the Río Reposadera, Finca San Vicente Pacún, Acatenango, July 14, 1948. Metatype (♀), in collection of Herbert T. Dalmat, collected September 24, 1947. The ♂♂, ♀♀, larvae, and pupae used for the above description were collected from the Río Socorro, Acatenango, Chimaltenango, Guatemala.

CNEPHIA PACHECO-LUNAI (De León)

Simulium pacheco-lunai De León, Bol. Sanit. Guatemala, vol. 52, pp. 67-68, fig. 3, 1944 (original description, pupal respiratory filament).

Cnephia pacheco-lunai (De León), Dalmat, Ann. Ent. Soc. Amer., vol. 44, No. 1, p. 48, 1951 (distinguishing characters of ♂, ♀, and pupa).

Male (pl. 22, figs. 4-6).—(First description of male.) 3.9 mm. long.

Head: Holoptic. Eyes shiny dark brown. Antenna 650 μ long, 11-segmented, slightly tapering; segment 3 very long; segment $3=1+2$, $3>4+5$, $3>11$; scape and pedicel light brown, the flagellum dark brown to black. Palpi black. Clypeus dark brown, with numerous long black hairs along lateral margins.

Thorax: Mesonotum velvety black, when viewed at certain angles, the entire scutum may appear gray to white-pruinose; very long, narrow, yellow, scalelike hairs densely covering entire mesonotum; short, fine, black hairs also over entire surface, long black ones in prescutellar region. Humeral angles brown, with yellow scalelike hairs and with long black hairs. Postnotum velvety dark brown to black, gray-pruinose, devoid of hairs. Pleura dark brown to black, with gray pruinosity. Stem of halter brown, the knob dark brown. Wings, 3.6 mm. long and 1.4 mm. wide; relation of body length to wing, 1.1 : 1; Sc completely pilose; R_1 completely pilose, the apical half with spines also; hairs on basal section in several rows; R_{2+3} completely pilose; Cu_2 arcuate; discal cell present.

Legs: Leg 1, length, 3.2 mm.; entire leg dark brown except for tarsal segments 4 and 5 which are black. Leg 2, length, 3.1 mm.; entire leg dark brown. Leg 3, length, 4.1 mm.; entire leg dark brown; basitarsus spindle-shaped, its length 3.4 times its width; relation of basitarsus to second segment, 4.6 : 1; calcipala short; pedisulcus absent.

Abdomen: Tergite of segment 1 dark brown to black, with short black hairs; pleurites the same color, with long brown hairs that reach segment 5. Segment 2 velvety dark brown to black, white-pruinose on lateral areas, with short black hairs. Other segments velvety dark brown to black, white-pruinose along posterior margins, with short black hairs. Sternites dark brown, gray-pruinose, with black hairs, longer on more basal segments, shorter on posterior ones.

Genitalia: Sidepiece (pl. 22, fig. 4) longer than wide, cylindrical in shape, the basal and apical margins not parallel to each other; dorsal opening occupying approximately half of dorsal surface of sidepiece. Clasper (pl. 22, fig. 4) conical in shape, somewhat shorter than sidepiece, the apex rather blunt, with two strong terminal spines; basal opening wide, extending along less than half the length of clasper. Body of adminiculum (pl. 22, fig. 5) wider than long, the apical margin rounded; ventral surface rises slightly from lateral margins toward the midline; almost entire surface with small pigmented patches, each with several minute black spines or hairs; basal processes short, blunt, well sclerotized only at ends, with posteriorly directed spurlike processes. Arms of adminiculum (pl. 22, fig. 6) without teeth, the lateral plate elongate, without numerous wrinkles.

Female (pl. 28, figs. 121-123, and pl. 35, fig. 271).—(First description of female.) 3.7 mm. long.

Head: Dichoptic. Eyes black; height of fronto-ocular triangle 1.3 times its base. Antenna 710 μ long, 11-segmented, tapering; segment $3<1+2$, $3<4+5$, $3=11$; scape and pedicel light brown, the flagellum black. Palpi black. Frons and clypeus black, gray-pruinose irregularly covered with short, yellow, scalelike hairs and somewhat longer black hairs. Occipital region black, with few long black hairs and with many yellow hairs. Cornuae of buccopharyngeal apparatus well sclerotized, the ends sharply pointed; median space hyaline and smooth.

THORAX: Mesonotum black, completely gray-pruinose; long, narrow, appressed, yellow, scalelike hairs completely clothing the mesonotum; few long, fine, black hairs in prescutellar region. Humeral angles black, the anterior margin brown, with yellow scalelike hairs. Scutellum light brown, with yellow scalelike hairs and long black hairs. Postnotum velvety dark brown, white-pruinose, devoid of hairs. Pleura dark brown, with gray pruinosity; pre-alar cluster composed of golden-yellow hairs intermixed with a few black ones. Stem and knob of halter light brown. Wings, 4.1 mm. long and 1.7 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along basal three-fourths, at times with additional apical hair; R_1 completely pilose, the apical fourth also with spines; hairs arranged in several rows; R_{2+3} completely pilose; Cu_2 arcuate; discal cell present.

LEGS: Leg 1, length, 3.8 mm.; completely brown. Leg 2, length, 3.7 mm.; coxa dark brown; remainder of leg brown. Leg 3, length, 4.8 mm.; coxa dark brown; trochanter brown; femur, tibia, and tarsus dark brown; relation of basitarsus to second segment, 5.1 : 1; calcipala well developed; pedisulcus absent; claw with basal heel developed into long spur, and with lance-shaped process emerging at the base of spur; inner face of claw with transverse striations (pl. 35, fig. 271).

ABDOMEN: Tergite of segment 1 having the anterior half lighter brown than the posterior half, clothed with short tan hairs; pleurites brown, with long tan hairs that reach segment 4. Segment 2 black, with gray pruinosity and short black hairs. Other segments black, the posterior margins brown, with short black hairs. Sternites tan, with short black hairs.

GENITALIA: Cercus (pl. 28, fig. 121) somewhat rectangular in shape, the posterior angles rounded; height equal to twice the length (width). Anal lobe (pl. 28, fig. 121) with dorsal extremity pointed, expanded ventrally, similar to that of *aguirrei*. Genital rod (pl. 28, fig. 123) without basal dilatation, or with it very poorly formed; apical expansions of arms of genital fork ribbonlike, somewhat rectangular in shape, with a slightly pigmented process at outer basal angle. Ovipositors (pl. 28, fig. 122) triangular in shape, the base greater than the length, the inner margins parallel to one another and somewhat more heavily sclerotized.

Pupa (pl. 36, fig. 277, and pl. 39, fig. 317).—(First description of pupa other than of its respiratory apparatus.) Granulosity on entire thorax; 5 long, simple trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Granulosity over entire surface of all segments; spines on segments 5-8 are posteriorly directed; segments 3 and 4 each with 8 simple anteriorly directed spines in a transverse row before the posterior margin, the row divided in two by a median separation; segment 4 also with irregular row of about 90 posteriorly directed small spines just behind the anterior margin, without median separation; segments 5-8 each with an uninterrupted row of spines just posterior to the anterior margin, segment 5 with 102 spines, segment 6 with 104, segment 7 with 98, and segment 8 with 70. Ventral surface of abdominal segments: Entire ventral surface with granulosity; all spines are anteriorly directed, and all the rows are located a little before the posterior margin of the respective segment; segment 4 with a single simple spine on either side of midline, well separated by a median space; segments 5-7 each with 4 simple spines in a transverse row, all spines in the row well separated from one another; each of the lateral margins of segment 9 with 2 bifid and 3 simple long hairs. Terminal spines very well developed, about 150 μ long.

Respiratory apparatus (pl. 36, fig. 277) of each side arising a little behind the anterior margin of the thorax; composed of 12-13 filaments that branch as follows: 2-2-2-2-2-2-1; the single filament is much shorter than any of the others; filaments emerge in one plane like the spokes of a wheel; the apices of all filaments pointed; with superficial annulations and minute spicules. Maximum length, 1.3 mm.; average diameter, 80 μ.

Cocoon (pl. 39, fig. 317): Length of base, 4.0 mm.; maximum width, 3.0 mm.; maximum height, 1.2 mm. Cocoon of wall-pocket type, without collar; case composed of grouping of threads with attached particles of mud and other material; the case is very soft, not having a regular shape, and appears to cling to the pupa; this species is found in sluggish water running over mud. Cocoon covers the abdomen and one-fourth of the thorax; barely attached at the posterior end of its base.

Larva (pl. 40, fig. 357, and pl. 42, fig. 394).—(First description of larva.) Total length, 5.9 mm. Length of head 1.2 times its width. Width of thorax 1.3 times width of head. Abdominal segments 1-4 approximately 1.2 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.4 times the width of segments 1-4; general body shape like that of *aguirrei*. General color tan, without dark patches on ventrolateral regions of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 357. Each cephalic fan with 25 pectinate branches, the hairs on these branches simple, long, and close together, without hairs of other types intermixed. Mandible with 25 teeth along its inner margin, the distal tooth very much greater in size than any of the others. Antenna 450 μ long, 4-segmented, not quite reaching the end of the basal stalk of the cephalic fan; segments 1 and 2 pale yellow, segments 3 and 4 darker; segment 3 almost equal to segment 2 in length, either of these longer than segment 1; no transverse striations. Submentum with 13 apical teeth arranged in three projecting groups as in *aguirrei,* the central group with 3 teeth, each of the lateral groups with 5 teeth; ventrolateral row with 3 to 4 hairs in a straight line, the most-distal bifid, the others simple; lateral margin of submentum with 8 toothlike serrations, the more-apical ones large. Occipital cleft very small, triangular in shape (pl. 42, fig. 394).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 27-30 rows of hooks on its apex; postclypeal sclerites well sclerotized, heavily pigmented, long, wider at outer extremity, almost meeting at midline. Posterior sucker with 80-81 rows of hooks. Anal gills 3 in number, very broad at base, tapered toward apex, similar to those of *aguirrei.* Anterior arms of X-shaped sclerite short, poorly sclerotized, well masked by the pigmented patch that occupies all the space between them; posterior arms well sclerotized, extending only to lateral margins of segment; no rectal scales but with a few bifid and trifid scales between the anterior and posterior arms of each side. Eighth segment with two well-formed conical ventral papillae, the same color as the body, their bases very broad; no sclerotized plaques.

Types.—Pupa, in collection of J. Romeo de León, Guatemala City; collected in a stream in the high region called "María Tecúm," between Sololá and Totonicapán, Guatemala, 1940. Plesiotypes, 2 ♂♂ and 2 ♀♀, in collection of Herbert T. Dalmat, were also collected in the region of María Tecúm.

CNEPHIA ROBLESI (De León)

Simulium roblesi DE LEÓN, Bol. Sanit. Guatemala, vol. 51, p. 97, fig. 1, 1943 (original description, pupal respiratory apparatus).

Cnephia roblesi (De León), DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, p. 48, 1951 (distinguishing characters of ♂, ♀, and pupa).

Male (pl. 22, figs. 7-9).—(First description of male.) 3.9 mm. long.

HEAD: Holoptic. Eyes reddish brown. Antenna 610 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3>4+5$, $3>11$; scape and pedicel brown, flagellum black. Palpi black. Clypeus black, white-pruinose, irregularly covered with long black hairs.

THORAX: Mesonotum velvety black, densely covered with long, narrow, flat, appressed, golden hairs, and with some very long black ones in prescutellar region. Humeral angles black, with golden appressed hairs. Scutellum reddish brown, with numerous narrow, appressed golden hairs and with some long black ones. Postnotum velvety dark brown, white-pruinose on anterior half, devoid of hairs. Pleura brown, with gray pruinosity; pre-alar cluster composed of long golden hairs. Stem and knob of halter brown. Wings, 4.0 mm. long and 1.6 mm. wide; relation of body length to wing, 1:1; Sc pilose along basal three-fourths; R_1 completely pilose, with spines also along distal three-fifths, both spines and hairs in double row; R_{2+3} completely pilose; Cu_2 arcuate; discal cell present.

Leg: Leg 1, length, 3.4 mm.; coxa and trochanter dark brown; femur brown, with very long tan hairs; tibia brown, the median third somewhat lighter than the remainder; tarsus dark brown. Leg 2, length, 3.2 mm.; coxa and trochanter dark brown; femur brown, with very small black apical ring; tibia dark brown, its base and apex somewhat darker; basal half of basitarsus dark brown, the apical half black; tarsal segments 2-5 black. Leg 3, length, 4.5 mm.; coxa dark brown; trochanter brown; femur brown, with small black apical ring, covered with light hairs; tibia black; basitarsus and second segment brown; tarsal segments 3-5 black; basitarsus spindle-shaped, very wide, its length 2.8 times its width; relation of basitarsus to second segment, 4.5:1; calcipala very small; pedisulcus absent.

Abdomen: Tergite of segment 1 reddish brown to black, with short black hairs; pleurites the same color, with extremely long brown hairs that reach the fifth to seventh segment. Segment 2 velvety dark brown to black, with anterior band of white pruinosity, the sides also white-pruinose, with short black hairs. Other segments velvety dark brown to black, with short black hairs. Sternites tan, densely clothed with long black hairs.

Genitalia: Sidepiece (pl. 22, fig. 7) somewhat cylindrical in shape, longer than wide, the apical margin shorter than the basal; dorsal opening occupying about one-third the dorsal surface of sidepiece. Clasper (pl. 22, fig. 7) conical in shape, somewhat shorter than the sidepiece, the apex well tapered but blunt, with 2 strong terminal spines; basal opening wide, extending along less than half the length of clasper. Body of adminiculum (pl. 22, fig. 9) wider than long, the apical margin rounded; with several patchlike markings from which extend short hairs; longitudinal, triangular-shaped, keel-like structure along midline from which arise somewhat longer hairs; minute, black spicules toward middle of base; basal processes short, blunt, not heavily sclerotized, with retrorse spurlike structures. Arms of adminiculum (pl. 22, fig. 8) without teeth, the lateral plate elongate and without numerous wrinkles.

Female (pl. 28, figs. 124-126, and pl. 35, fig. 270).—(First description of female.) 3.9 mm. long.

HEAD: Dichoptic; base of fronto-ocular triangle equal to its height. Antenna 700 μ long, 11-segmented, well tapered; segment 3 less than half of segments $1+2$, $3<4+5$, $3=11$; scape and pedicel light brown, the flagellum black. Palpi black. Frons dark brown, with gray pruinosity, a single row of black hairs on either side of midline, and with several short, narrow, golden, scalelike hairs. Clypeus dark brown, gray-pruinose, irregularly covered with long, fine black hairs and shorter, appressed, golden scalelike hairs. Occipital region dark brown, with long black hairs and with somewhat shorter golden yellow hairs. Cornuae of buccopharyngeal apparatus heavily sclerotized along outer margins, which are broad and blunt; median space hyaline and smooth.

THORAX: Mesonotum black; prescutellar region gray-pruinose; from the middle of the prescutellar region, and from each of its anterior angles, there extends a narrow longitudinal stripe of gray pruinosity, these stripes converging at the middle of the anterior margin of mesonotum; the stripes are most easily visible when the specimen is placed with the head away from the light source, and the light hitting the scutum almost directly (90-degree angle); long, appressed, golden, scalelike hairs densely clothing entire mesonotum; very few long, fine, black hairs in prescutellar region. Humeral angles brown, gray-pruinose, with golden scalelike hairs. Scutellum brown, somewhat lighter posteriorly, with appressed, golden, scalelike hairs and long black hairs. Postnotum velvety dark brown, gray-pruinose, devoid of hairs. Pleura brown, with gray pruinosity; pre-alar cluster composed of both golden and black hairs. Stem of halter light brown at base, somewhat darker apically, the knob light brown. Wings, 4.3 mm. long and 1.8 mm. wide; relation of body length to wing, 1:1.1; Sc usually completely pilose; R_1 completely pilose, with several rows of hairs, the apical third also with spines; R_{2+3} completely pilose; Cu_2 arcuate; discal cell present.

LEGS: Leg 1, length, 3.5 mm.; entire leg dark brown except for femur which is somewhat lighter. Leg 2, length, 3.4 mm.; coxa dark brown; trochanter brown; femur brown with very small dark-brown apical ring; tibia brown with dark-brown apical and basal rings; basal half of basitarsus brown, the apical half dark brown; tarsal segments 2-5 dark brown. Leg 3, length, 4.4 mm.; coxa, trochanter, femur, and tibia as on leg 2; basitarsus brown; tarsal segments 2-5 dark brown; relation of basitarsus to second segment, 4.5:1; calcipala well developed, broad, pedisulcus absent; claw with basal heel developed into long spur, and with secondary shield-shaped process emerging from the base of the spur; inner face of claw with striations (pl. 35, fig. 270).

Abdomen: Tergite of segment 1 tan in middle, dark brown on sides, with short tan hairs; the pleurites dark brown, with long tan hairs that reach segment 3. Segment 2 dark brown, gray-pruinose, with some tan hairs and several black ones. Other segments dark brown, completely gray-pruinose, with short black hairs and a few yellow scalelike hairs. Sternites brown, with gray pruinosity.

Genitalia: Cercus (pl. 28, fig. 125) dome-shaped, its height about twice the length (width). Anal lobe (pl. 28, fig. 125) pointed at its dorsal extremity and expanded ventrally, similar to that of *aguirrei*. Genital rod (pl. 28, fig. 124) with basal dilatation oval, the base of rod rather pointed, pigmented only along narrow central region; apical expansions of genital fork broad, ribbonlike, the inner basal angle somewhat prolonged and slightly pigmented. Ovipositors (pl. 28, fig. 126) triangular in shape, the base slightly greater than the length, the inner margins parallel and somewhat more heavily sclerotized than the rest of the structure.

Pupa (pl. 36, fig. 278, and pl. 39, fig. 318).—(First description of pupa other than respiratory apparatus.) No granulosity on thorax; 4 long, simple trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: No granulosity; spines on segments 3 and 4 are anteriorly directed, those on segments 5-8 are posteriorly directed; segments 3 and 4 with 8 simple spines in transverse row somewhat before the posterior margin, the row divided in two by a median separation; segment 4 also with row of small but heavy plaques, like minute spines, somewhat behind the anterior margin, without median separation; segment 5 with uninterrupted transverse band of 90 simple spines somewhat behind the anterior margin, the band composed of 2-3 irregular rows; segments 6-8 each with an uninterrupted single row a little behind the anterior margin, segment 6 with 102 spines, segment 7 with 90, and segment 8 with 64. Ventral surface of abdominal segments: Band of granulosity across the anterior fourth of each segment; all spines are anteriorly directed; segments 3 and 4 each with a single simple spine on either side of the midline about three-fourths the distance from the anterior margin, the two spines well separated; segments 5-7 each with transverse row about three-fourths the distance from the anterior margin, composed of 4 simple spines, the two spines on either side of midline well separated, about equal to the median space between the two inner spines; each of the lateral margins of segment 9 with 4 simple and 1 bifid or trifid long hairs. Terminal spines well developed, about 60 μ long.

Respiratory apparatus (pl. 36, fig. 278) of each side arising a little behind the anterior margin of the thorax; composed of 4 inflated, saclike branches, 3 of them with 2 filaments each extending from the apex, the fourth with only a single filament; all branches and filaments show annulations and minute spicules. Maximum length of one branch, 3.6 mm.; maximum width of branch, 0.3 mm.

Cocoon (pl. 39, fig. 318): Length of base, 5.3 mm.; maximum width, 3.7 mm.; maximum height, 2.1 mm. Cocoon of wall-pocket type, without collar; rim around anterior aperture not thickened, no dorsal prolongation; case composed of soft matrix with the threads loosely grouped and with particles of earth and other material. Cocoon covers the abdomen and one-fourth of the thorax; attached along the entire base.

Larva (pl. 40, fig. 358, and pl. 42, fig. 395).—(First description of larva.) Total length, 8.3 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times the width of head. First four abdominal segments 1.1 times the width of head; segments 5-7 expanded, greatest at segment 6 which is 1.4 times the width of segments 1-4; general body shape like that of *aguirrei*. General color tan, the ventral surface of pseudopod gray; ventrolateral regions of segments 6 and 7 usually with long dark patches.

Head: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 358. Each cephalic fan with 24 pectinate branches, the hairs on these branches simple, rather long and close together, not interspersed with hairs of other types. Mandible with 29-32 teeth along its inner margin, some of the teeth at times appearing double-pointed, others appearing truncate; most-distal tooth longer than any of the others. Antenna 520 μ long, 4-segmented, light yellow, just reaching the end of the basal stalk of the cephalic fan; segment 2 is 1.1 times the length of segment 3 which is 1.5 times that of segment 1; no transverse striations. Submentum with 13 apical teeth arranged in 3 projecting groups as in *aguirrei*, the central group with three teeth, each of the lateral groups with five teeth; ventrolateral row with 6 hairs, at times in irregular row, the most distal hair bifid, the others simple; lateral margin of submentum with 15 toothlike serrations. Occipital cleft minute, triangular in shape (pl. 42, fig. 395).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 27-30 rows of hooks on its apex; postclypeal sclerites well sclerotized, heavily pigmented, long, wider at outer extremity, almost meeting at midline. Posterior sucker with 95-100 rows of hooks. Anal gills three in number, very broad at base, tapered toward apex, longer than in *aguirrei*. Anterior arms of X-shaped sclerite short, poorly sclerotized; pigmented patch occupies all the space between them; posterior arms well sclerotized, extending only to lateral margins of segment; no rectal scales, but a few bifid and trifid scales present between the anterior and posterior arms of each side. Eighth segment with 2 ventral papillae, the same color as the body, appearing like short, broad-based cones, no sclerotized plaques.

Types.—Pupa, in collection of J. Romeo de León, Guatemala City; collected from a stream in the high region called María Tecúm, between Sololá and Totonicapán, Guatemala, 1940. Plesiotypes, 2 ♂♂ and 2 ♀♀, in collection of Herbert T. Dalmat, were also collected in the region of María Tecúm.

Genus GIGANTODAX Enderlein, 1925

GIGANTODAX AQUAMARENSIS (De León)

Simulium aquamarensis De León, Bol. Sanit. Guatemala, vol. 52, pp. 72-73, figs. 10-11, 1944 (original description, pupal respiratory apparatus).

Gigantodax aquamarensis (De León), Dalmat, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 50, 54, and 57, 1951 (salient characters are given that demonstrate its membership in this genus; distribution in Guatemala).

Male (pl. 22, figs. 10-12).—(First description of male.) 2.8 mm. long.

Head: Holoptic. Eyes reddish brown on the upper half, black beneath. Antenna 11-segmented, very slightly tapering, last segment blunt; scape, pedicel, and basal part of first flagellar segment yellow, the remainder brown. Palpi dark brown. Clypeus dark brown, gray-pruinose, irregularly covered with yellow hairs.

Thorax: Mesonotum rust brown, the prescutellar region gray-pruinose; short, narrow, yellow, scalelike hairs over entire mesonotum, longer and more numerous around the periphery; prescutellar region with long, yellow, erect hairs. Humeral angles brown, with yellow hairs. Scutellum shiny brown, darker along the midline, with very long yellow hairs. Postnotum dark brown on anterior half, light on posterior half, devoid of hairs. Pleura brown, with gray pruinosity. Stem of halter brown, its apex somewhat darker; the knob brown. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1.2; Sc pilose along basal six-sevenths; R_1 completely pilose, with spines also on distal third; R_{2+3} pilose along distal six-sevenths; Cu_2 almost straight; discal cell absent.

Legs: Leg 1, length, 2.8 mm.; coxa and trochanter brown; femur brown, its apex somewhat darker; tibia brown, basal three-fourths of basitarsus light brown, the apical fourth, as well as all of segments 2-5, dark brown. Leg 2, length, 2.6 mm.; coxa dark brown; trochanter brown; femur brown, with dark-brown apex; tibia light brown on basal three-fourths, dark on apical fourth; basal half of basitarsus and basal third of second tarsal segment light brown, the apical parts of these segments, as well as all of segments 3-5, dark brown. Leg 3, length, 3.5 mm.; coxa dark brown; trochanter brown; femur brown, with dark-brown apex; basal three-fourths of tibia, except for one margin, light brown, the apical fourth dark; tarsus dark brown; relation of basitarsus to second segment, 8.0 : 1; basitarsus long, narrow, parallel-sided; calcipala very large, wide, pointed at end; pedisulcus absent.

Abdomen: Tergite of segment 1 light brown, somewhat gray-pruinose, with short yellow hairs; pleurites light brown, with long yellow hairs that reach segment 5. Segment 2 dark brown, the anterior half white-pruinose, clothed with yellow hairs. Other segments dark brown, the posterior margin lighter, clothed with both short and long yellow hairs. Sternites dark brown, gray-pruinose, with yellow hairs.

Genitalia: Sidepieces (pl. 22, fig. 10) longer than wide, somewhat cylindrical in shape; the basal and apical margins at angle to each other; with concavity on dorsal surface near middle of apical end; dorsal opening occupying more than half of dorsal surface of sidepiece. Clasper (pl. 22, fig. 10) conical in shape, about three-fourths the length of sidepiece; apex rounded, with two terminal spines, one distal to the other; basal opening extending along less than half of clasper. Body of adminiculum (pl. 22, fig. 11) almost square in shape, slightly longer than wide, the apical corners rounded; with concavity at middle of apical margin; longitudinal keel extending entire length of body along middle of ventral surface; entire body of adminiculum clothed with short hairs, longer on keel-like structure; basal processes short, broad, poorly sclerotized, each with a spurlike process directed posteriorly. Adminicular arms (pl. 22, fig. 12) small, with 2 teeth, 1 very long, the other about three-fourths its length; lateral plate minute, irregular in shape.

Female (pl. 28, figs. 127-129, and pl. 35, fig. 272).—(First description of female.) 2.9 mm. long.

Head: Dichoptic; elongate. Eyes black, shiny; fronto-ocular triangle very small, its height about equal to its base. Antenna 610 μ long, 11-segmented, slightly tapering, the apex blunt; segment $3<1+2$, $3<4+5$, $3=11$; scape and pedicel yellow, flagellum brown, its apex very dark. Palpi dark brown to black. Frons, clypeus, and occipital region black, gray-pruinose, with short and long yellow hairs. Cornuae of buccopharyngeal apparatus sclerotized, wide, bifurcate, the two branches pointed; median space hyaline, smooth.

Thorax: Mesonotum reddish brown, with slight gray pruinosity especially in the prescutellar region; short, narrow, yellow, scalelike hairs over entire mesonotum, long ones on the periphery; long yellow hairs in prescutellar region. Humeral angles brown, with yellow hairs. Scutellum shiny brown, with long yellow hairs. Postnotum velvety brown, with gray pruinosity. Pleura brown, with slight gray pruinosity; pre-alar cluster composed of yellow hairs. Stem and knob of halter brown, with white pruinosity. Wings, 3.0 mm. long and 1.3 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal four-fifths; R_1 completely pilose, also with a few spines on distal third; R_{2+3} pilose except for basal sixth; Cu_2 straight; discal cell usually absent; at times it is indicated, but not completely closed.

Legs: Leg 1, length, 2.8 mm.; entire leg brown. Leg 2, length, 2.6 mm.; coxa and trochanter brown; femur brown, with very small dark-brown apical ring; tibia brown with very small light-brown basal ring; tarsus light brown. Leg 3, length, 3.3 mm.; coxa, trochanter, and femur brown, the femur with a dark-brown apical ring; tibia brown with light-brown basal ring; tarsus brown; relation of basitarsus to second tarsal segment, 8.1 : 1; calcipala very large, almost covering entire second segment; pedisulcus absent; claw with well-developed heel and with short, lance-shaped structure emerging at base (pl. 35, fig. 272).

Abdomen: Tergite of segment 1 light brown with short yellow hairs; pleurites brown, with very long yellow hairs reaching segment 4. Segment 2 dark brown, somewhat white-pruinose, covered with yellow hairs. All other segments dark brown, lightly covered with gray pruinosity, clothed with short yellow hairs. Sternites tan.

Genitalia: Cercus (pl. 28, fig. 127) somewhat rectangular in shape, its height about 1.75 times its length (width). Anal lobe (pl. 28, fig. 127) almost circular in shape, the posterior margin somewhat straightened and the dorsal extremity strongly tapered to form a pointed prolongation. Genital rod (pl. 28, fig. 129) with large, oval, basal dilatation, the rod itself rather short; apical expansions of arms of genital fork broad, membranous, with basally directed, slender prolongation from near the middle of the outer margin. Ovipositor (pl. 28, fig. 128) triangular in shape, with numerous hairs at apex.

Pupa (pl. 36, fig. 279, and pl. 39, fig. 319).—(First description of pupa other than respiratory apparatus.) Granulosity on entire thorax; 4 simple hairlike trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Granulosity on dorsum of all segments; spines on segments 1-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 1 with 8 simple spines in transverse row across the middle, the row divided by median separation; segment 2 with 16 spines in transverse row three-fourths the distance from the anterior margin, with median separation; segments 3 and 4 each with 16 spines in transverse row somewhat before the posterior margin, with median separation, the inner three spines on either side of the midline larger than the others; segments 6 and 7 each with uninterrupted transverse row just behind the anterior margin, segment 6 with 50 spines, segment 7 with 40 spines; segment 8 with 42 spines in uninterrupted row behind the anterior margin and with other transverse row of 6 long spines, posterior to the longer row, divided by median space. Ventral surface of abdominal segments: Completely covered wtih granulosity; all spines anteriorly directed; all transverse rows are situated somewhat in front of the posterior margin of the respective segment; segment 3 with 4 simple spines in transverse row, the spines well separated from each other, with median space; segment 4 with 12 simple spines in transverse row, with median separation; segments 5 and 6 each with 8 simple spines in transverse row, with median separation, the outer spine on either side of the row smaller than the others; segment 7 with similar transverse row to that of segment 3, the spines being somewhat heavier; outer margin on either side of segment 9 with 1 bifid and 6 simple long hairs. Terminal spines very well developed, cone-shaped, pointed.

Respiratory apparatus (pl. 36, fig. 279) of each side arising near the anterior corners of the thorax; composed of 12-15 expanded filaments, somewhat saclike, tapered toward the apex, which branch as follows: 1-3-3-1-1-3-2; six to eight of the filaments have very much narrowed extensions from their apices; filaments without superficial segmentation, but completely wrinkled in all directions and with microscopic spicules. Maximum length, 1.1 mm.; average diameter, 140 μ.

Cocoon (pl. 39, fig. 319): Length of base, 3.0 mm.; maximum width, 1.4 mm.; maximum height, 1.8 mm. Cocoon of wall-pocket type, without collar; case composed of soft, loose threads to which particles of mud and sand have attached; cocoon with ventral surface convex, in profile, the anterior aperture appearing perpendicular to the anterior section of the base; rim around anterior aperture not thickened. Cocoon covering only three-fourths of abdomen; attached along entire base except for a very small anterior section.

Larva (pl. 40, fig. 359, and pl. 42, fig. 396).—(First description of larva.) Total length, 5.0 mm. Length of head capsule 1.1 times its width. Width of thorax 1.3 times that of head. First 4 abdominal segments about equal to thorax in width; segments 5-7 expanded, greatest at segment 6 which is 1.3 times the width of segments 1-4. Body seems to gradually widen from head through the seventh abdominal segment, posterior to which it again tapers; abdomen oval in cross section, wider than high; in profile, the ventral surface of segments 6-8 slopes upward and the dorsal surface slopes downward. General color gray to tan, with definite darkened collar across anterior end of thorax and with ventral surface of pseudopod also darkened; no dark patches on ventrolateral regions of segments 6 and 7.

Head: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 359. Each cephalic fan with 34-40 pectinate branches, the hairs on these branches close together, simple, and fine, intermixed at regular intervals with heavier, longer hairs. Mandible with 11 teeth on its inner margin; the 3 apical teeth larger than any of the others, the second and third appearing to emerge from a common base; the most basal tooth is somewhat removed from any of the others which are contiguous to one another and of variable length. Antenna 340 μ long, 4-segmented, dark yellow, not reaching the end of the basal stalk of cephalic fan; segment 3 almost equal to length of segments 1 and 2 taken together; segment 1 with longitudinal striations. Submentum with 17 apical teeth arranged in groups of 3-3-1-3-1-3-3, all but the lateral groups of three somewhat extended from the apical margin; ventrolateral row with 7 hairs in irregular arrangement; all hairs appear bifid from their middle to the apex, the outer half also darker; lateral margin of submentum irregularly serrated. No occipital cleft (pl. 42, fig. 396).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 66-76 rows of hooks on its apex; postclypeal sclerites long and narrow, only lightly sclerotized, appearing to extend from the posterior junction of the frons-clypeus with the epicranial plates; inner end pointed. Posterior sucker with 126-134 rows of hooks. Anal gills composed of 3 short, digitate processes, somewhat expanded distally. Anterior arms of X-shaped sclerite more heavily sclerotized than the posterior arms; a small, triangular-shaped patch between the anterior and posterior arm of each side, each patch with a central clear area; posterior arms completely encircling the posterior sucker; no rectal scales. Eighth segment without ventral papillae or sclerotized plaques.

Types.—Pupa, in collection of J. Romeo de León; collected in a stream at Aguas Amargas, Zunil, Department of Quezaltenango, Guatemala, at 1,800 meters above sea level. Plesiotypes, 2 ♀♀, in collection of Herbert T. Dalmat, were collected in the type locality. Amongst the ♂♂ used for the above description, are 4Q-2 (4 slides) and R-6A (3 slides) which are also designated as plesiotypes; they are in the author's collection.

GIGANTODAX WRIGHTI Vargas, Martínez, and Díaz

Simulium (*Gigantodax*) *wrighti* VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 5, No. 1, pp. 37-41, figs. 1-7, 1944 (original description, photographs of ♂ and ♀ genitalia, posterior leg of ♀, and pupal respiratory apparatus; comparison of ♂ genitalia with those of *G. araucanium*).

Simulium (*Gigantodax*) *vargasi* DE LEÓN, Bol. Sanit. Guatemala, vol. 52, pp. 69-70, figs. 5-6, 1944 (pupal respiratory apparatus).

Gigantodax wrighti VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 165, figs. 138 and 147, 1946 (larva).—D'ANDRETTA AND D'ANDRETTA, JR., Pap. Avulsos Dept. Zool., São Paulo, vol. 8, No. 2, pp. 23-37, 32 figs., 1947 (redescription of ♀, ♂, and pupa).

Male (pl. 22, figs. 13-15).—3.5 mm. long.

HEAD: Holoptic. Eyes reddish brown above, black beneath. Antennae 710 μ long, 11-segmented; scape, pedicel, and first flagellar segment of same width, the remaining segments being somewhat narrower but about equal in width to each other, segment 11 blunt; segment $3<1+2$, $3=4+5$, $3>11$; scape and pedicel yellow, the flagellum brown with yellow pruinosity and short yellow hairs. Palpi dark brown. Clypeus dark brown, white-pruinose, and with yellow scalelike hairs and some longer yellow hairs.

THORAX: Mesonotum orange to brown, with white pruinosity in the prescutellar region, covered with narrow, yellow, scalelike hairs, the hairs in the prescutellar region and on most of periphery much longer. Humeral angles brown, white-pruinose, with yellow hairs. Scutellum rust brown, white-pruinose, with long yellow hairs. Postnotum rust brown, with white pruinosity, devoid of hairs. Pleura brown, with white pruinosity. Stem of halter light brown at base and darker at apex; the knob dark brown, flat. Wings, 3.8 mm. long and 1.7 mm. wide; relation of body length to wing, 1 : 1.1; Sc completely pilose; R_1 completely pilose, the distal half also spiny; hairs and spines arranged in a single row; R_{2+3} pilose along its distal five-sixths; Cu_2 straight; discal cell absent.

LEGS: Leg 1, length, 3.2 mm.; coxa brown; trochanter brown, the basal half somewhat lighter; femur brown with dark-brown apical ring; basal and apical thirds of tibia dark brown, the median third lighter; outer edge of median third also dark; tarsus brown. Leg 2, length, 3.0 mm.; coxa brown; trochanter brown, its apical half somewhat lighter; femur, tibia, and tarsus as on leg 1. Leg 3, length, 3.9 mm.; coxa and trochanter brown; femur as on leg 2; tibia brown with basal and apical dark-brown rings; tarsus brown; basitarsus with margins parallel to each other, its relation to second tarsal segment, 7.2 : 1; calcipala very well developed, almost covering entire second segment; pedisulcus absent.

Abdomen: Tergite of segment 1 brown, the posterior margin with fringe of yellow hairs; pleurites brown, with long yellow hairs that reach the third segment. Segment 2 brown, the anterior half and the lateral regions white-pruinose, clothed with short yellow hairs. Other segments dark brown, irregularly covered with short yellow hairs. Sternites light brown.

Genitalia: Sidepiece (pl. 22, fig. 13) somewhat cylindrical in shape, longer than wide, the basal margin at angle to apical margin; dorsal opening occupying more than half of dorsal surface of sidepiece; with concavity on dorsal surface near middle of apical end. Clasper (pl. 22, fig. 13) conical in shape, about half as long as sidepiece; apex rounded, with two terminal spines arranged so that one is distal to the other. Body of adminiculum (pl. 22, fig. 14) longer than wide, the apex rounded with median concavity; longitudinal, raised, keel-like structure which extends from the middle of apex halfway along the adminiculum where it divides in two, one branch entering each of the basal processes; with numerous minute spicules over entire adminiculum and with longer hairs at apical concavity and along longitudinal keel; basal processes extremely short, narrow, blunt, not well sclerotized; short winglike structure lateral to each basal process. Adminicular arms (pl. 22, fig. 15) composed of about 5 strong teeth, one of them more than twice the length of the others.

Female (pl. 28, figs. 130-132, and pl. 35, fig. 273).—3.6 mm. long.

Head: Dichoptic; elongate. Eyes shiny black; fronto-ocular triangle rather small, the height approximately equal to the base. Antenna 750 μ long, 11-segmented, hardly tapering, the apex blunt; segment $3<1+2$, $3<4+5$, $3>11$; scape and pedicel yellow, the flagellum light brown, somewhat darker near apex. Palpi dark brown to black. Vertex rather wide. Frons, clypeus, and occipital region dark brown, gray-pruinose, clothed with yellow scalelike hairs, some long yellow hairs, and very few black hairs. Cornuae of buccopharyngeal apparatus narrowly triangular in shape, very slightly sclerotized; median space hyaline, smooth, with concavity; median area is so pale that it is often almost invisible when mounted after clearing.

Thorax: Mesonotum rusty brown to orange, the prescutellar region slightly gray-pruinose; a single gray-pruinose longitudinal stripe, poorly defined, on either side of midline, slightly divergent posteriorly, that blends with white pruinosity of prescutellar region; short, narrow, yellow, scalelike hairs covering the mesonotum, much longer in prescutellar region and around the periphery. Humeral angles brown, with yellow scalelike hairs. Scutellum light brown, with long yellow hairs. Postnotum velvety brown, somewhat gray-pruinose, devoid of hairs.

Pleura brown, slightly gray-pruinose, the pre-alar cluster composed of yellow hairs. Halter with brown stem, darker at base, the knob brown, infuscate, and very large. Wings, 4.0 mm. long and 1.7 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along basal four-fifths; R_1 completely pilose, also with a few spines along distal third; R_{2+3} pilose except for small basal region, at times with a single basal hair; Cu_2 straight; discal cell absent.

Legs: Leg 1, length, 3.2 mm.; coxa and trochanter dark brown; femur brown, with very small apical dark ring; tibia light brown except for basal and apical dark rings and dark band along one margin; tarsus light brown. Leg 2, length, 3.0 mm.; coxa dark brown; trochanter light brown; femur light brown with dark-brown apical ring; tibia light brown with wide basal and apical dark rings; tarsus light brown. Leg 3, length, 4.0 mm.; coxa dark brown; trochanter light brown; femur light brown with very wide, dark apical ring; tibia light brown with basal and apical fourths almost black; basitarsus and second segment light brown, the other tarsal segments dark brown; relation of basitarsus to second tarsal segment, 7.4 : 1; calcipala very large, covering about two-thirds of second tarsal segment; pedisulcus absent, represented by slight indentation; claw with well-developed heel and with a secondary toothlike structure that emerges at the base, this structure being somewhat quadrangular, one of its apical angles prolonged (pl. 35, fig. 273).

Abdomen: Tergite 1 light brown. clothed with short yellow hairs; pleurites light brown with long yellow hairs that reach the third segment. Segment 2 brown on anterior half and dark brown on posterior half; somewhat gray-pruinose; with short yellow hairs. Other segments dark brown, with narrow light-brown band along posterior margin, covered with short yellow hairs. Sternites tan.

Genitalia: Cercus (pl. 28, fig. 130) rectangular in shape, the height slightly more than twice the length (width). Anal lobe (pl. 28, fig. 130) almost semicircular in shape, the dorsal extremity somewhat tapered, the ventral greatly expanded and extending under the cercus. Genital rod (pl. 28, fig. 132) with well-developed basal dilatation that is oval in shape; rod rather short; apical expansions of genital fork hyaline, very clear, like a broad, subquadrangular membrane, the outer apical angle prolonged into narrow structure that recurves toward the base; inner apical angle expanded into truncate structure. Ovipositor (pl. 28, fig. 131) triangular in form, small.

Pupa (pl. 36, fig. 280, and pl. 39, fig. 320).—Granulosity on entire thorax; 5 simple trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Granulosity over dorsum of all segments; spines on segments 1-4 are anteriorly directed, those on segments 6-8 are posteriorly directed; segment 1 with transverse row across its middle composed of 8 simple spines with median separation; segment 2 with 12 simple spines in transverse row three-fourths the distance from the anterior margin, with median separation; segments 3 and 4 each with 16 simple spines in transverse row, with median separation, the eight inner spines near the posterior margin, the other eight somewhat anterior to these in position; segments 6-8 each with uninterrupted transverse row just behind the anterior margin, segment 6 with 22 spines, segments 7 and 8 each with 30 spines. Ventral surface of abdominal segments: Completely covered with granulosity; all spines are anteriorly directed; segment 4 with 10 simple spines in transverse row just before the posterior margin, with median separation; the five spines on either side of the midline are arranged in two groups of two, and a single spine (innermost); segments 5-7 each with 6 simple spines in transverse row somewhat before the posterior margin, the spines evenly spaced, with median separation; outer margin on either side of segment 9 with 3 long simple hairs. Terminal spines very well developed, conical in shape, the apices pointed.

Respiratory apparatus (pl. 36, fig. 280) of each side arising near the anterior corners of the thorax; composed of 8 or 9 somewhat flattened ovoid processes that branch as follows: 1-1-4-2-1; four of the processes bear a narrow filament from the apex and one process has a filament emerging from the midregion; there can be much variation in the branching of the filaments but the appearance of the entire apparatus is unique; filaments without superficial segmentation, but with wrinkles in all directions and with microscopic spicules. Maximum length, 1.9 mm.; average width, 220 μ.

Cocoon (pl. 39, fig. 320): Length of base, 3.8 mm.; maximum width, 1.4 mm.; maximum height 1.6 mm. Cocoon of wall-pocket type, without collar; case composed of soft, loose threads that have sand and mud particles attached to them; rim around anterior aperture not thickened. Cocoon covering abdomen and three-fourths of thorax; attached along more than the posterior three-fourths of its base.

Larva (pl. 40, fig. 360, and pl. 42, fig. 397).—Total length, 7.4 mm. Length of head capsule 1.1 times its width. Width of thorax 1.5 times that of head. First 4 abdominal segments about 1.3 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.4 times width of segments 1-4; shape of body similar to that of *aquamarensis*. General color gray, the neck and ventral part of pseudopod darker; no dark patches on ventrolateral regions of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 360. Each cephalic fan with 26-30 pectinate branches, the hairs on these branches are simple, fine, rather long, and close together, intermixed with longer, heavier simple hairs at regular intervals. Mandible with 9-10 teeth along its inner margin; when there are 10 teeth, the basal two teeth are close to each other but separated from the rest; the apical two teeth are well separated from each other as well as from the middle group, the teeth of which are more or less contiguous to one another; none of the teeth are very well pointed or markedly longer than the others. Antenna 290 μ long, 4-segmented, reaching about three-fourths the way to the end of the basal stalk of the cephalic fan; segments 1 and 2 light brown, segment 3 much darker and much thinner than segments 1 and 2; segment 3 almost equal to length of segments 1 and 2 taken together; segment 1 with longitudinal striations. Submentum with 17 apical teeth arranged in groups of 3-3-1-3-1-3-3 as in *aquamarensis;* ventrolateral row with 5 hairs in straight line, the most-distal bifid along almost all its length, the other hairs simple; most-basal hair minute; lateral margin of submentum almost completely serrated, the toothlike processes not very deeply cut. No occipital cleft (pl. 42, fig. 397).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 58-62 rows of hooks on its apex. Postclypeal sclerites very long and wide, strongly tapered at inner extremity, not heavily sclerotized, with irregular edges that appear to extend from point of junction of epicranial plate and frons-clypeus; well separated, longer than in any other Guatemalan species. Posterior sucker with 95-105 rows of hooks. Anal gills composed of 3 simple digitate processes, each longer than in *aquamarensis,* more rounded, and curving dorsally. Anterior arms of X-shaped sclerite very heavily sclerotized, broadening anteriorly, with posteriorly directed spur from midregion; no patch between arms; posterior arms completely encircle the posterior sucker; with 4 to 5 rows of rectal scales that are bifid or trifid, and with several trifid scales lateral to the expanded portion of the anterior arms. Eighth segment with 2 well-formed, conical, ventral papillae; no sclerotized plaques.

Types.—♂, in collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected in the Desierto de los Leones, D. F., Mexico, at 3,200 meters above sea level, March 5, 1944. Paratypes, 7 ♂♂ and 7 ♀♀, in collection with type ♂.

Genus SIMULIUM Latreille, 1802

SIMULIUM (NOTOLEPRIA) EXIGUUM* Roubaud

Simulium exiguum ROUBAUD, Bull. Mus. Nat. Hist. Nat., Paris, vol. 12, pp. 108-110, 1906 (original description, female).—VARGAS, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, fig. 15, 1942 (♀ genitalia); vol. 4, No. 4, figs. 1-9, 1943 (♂ genitalia and leg, ♀ leg, pupal cocoon and filaments.—LANE AND VULCANO, Rev. Ent., Rio de Janeiro, Brazil, vol. 14, No. 3, p. 437, fig. 14, 1943 (buccopharyngeal apparatus).—DAMPF, Canadian Ent., vol. 76, pp. 117-124, 6 figs., 1944 (existence of dichoptic as well as holoptic ♂♂; external features of ♀ and of both forms of ♂, with figures of head, thorax, and of profile of ♂ genitalia).—WYGODZINSKY, An. Inst. Med. Reg. Tucumán, Argentina, vol. 3, No. 2, pp. 214-217, figs. 54-56, 1951 (female).

Simulium (*Notolepria*) *exiguum* Roubaud, VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 171-172, fig. 153, 1946 (larva).

Male (pl. 22, figs. 16-18).—2.0 mm. long. The dimorphism in the males of this species described by Dampf (1944) is common in Guatemala. In those streams where dichoptic males emerge, almost 20 percent of the males are of that form. Dichoptic males have been found in 5 of 79 streams in which *exiguum* was collected, the localities being in different parts of the country. Since, outside of the facial characters, the principal difference is only one of size, the description below will concern itself with the normal holoptic form.

HEAD: Holoptic. Eyes black. Antenna 460 μ long, 11-segmented, hardly tapering, the eleventh segment wide and blunt; segment $3<1+2$, $3=4+5$, $3=11$; scape and pedicel brown, the flagellum black. Palpi dark brown to black. Clypeus black, white-pruinose, irregularly covered with short black hairs.

THORAX: Mesonotum velvety black, with bluish-white pruinosity on all parts according to the angle of the light source, without definite bands, stripes, or other patterns; with short, broad, appressed, golden-yellow, scalelike hairs over the mesonotum, more numerous on anterior fourth and in prescutellar region. Humeral angles black, with golden-yellow scales. Scutellum velvety black, with long black hairs and golden-yellow scalelike hairs. Postnotum velvety black, white-pruinose, devoid of hairs. Pleural regions dark brown to black, with shiny white pruinosity. Stem of halter dark brown, the knob brilliant yellow, cup-shaped. Wings, 1.9 mm. long and 0.85 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal fifth; R_1 spiny along the distal half, with occasional hairs among the spines; R_{2+3} pilose along distal six-sevenths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 1.9 mm.; entire leg light brown except the distal half of the basitarsus and tarsal segments 2-5, which are dark

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* See footnote 6, p. 68.

brown. Leg 2, length, 1.7 mm.; coxa dark brown; trochanter, femur, tibia, and tarsus light brown. Leg 3, length, 2.0 mm.; coxa dark brown; trochanter light brown; basal two-thirds of femur light brown, the apical third dark brown; tibia with basal half light brown, the apical half dark brown; basitarsus light brown with dark brown anterior edge; tarsal segments 2 and 3 light brown, 4 and 5 dark brown; relation of basitarsus to second tarsal segment, 5.3 : 1; calcipala well developed but not quite reaching the pedisulcus; pedisulcus well formed at middle of second tarsal segment.

Abdomen: Tergite of segment 1 dark brown to black, with short black hairs; pleurites of same color, with long black hairs that reach segment 4. Segment 2 dark brown to black, the anterior half and pleural regions white-pruinose, with short black hairs. All other segments dark brown to black, the pleural regions shiny white-pruinose, with short black hairs. Sternites brown, with gray pruinosity.

Genitalia: Sidepiece (pl. 22, fig. 18) wider than long, quadrangular in shape, with dorsal concavity near middle of apical margin; dorsal opening occupying about three-fourths of dorsal surface of sidepiece. Clasper (pl. 22, fig. 18) about half the length of sidepiece, conical in form, almost dome-shaped, the apex blunt and rounded, without terminal spine; basal aperture extending along at least one-half the length of clasper. Body of adminiculum (pl. 22, fig. 17) roughly triangular in shape, the apical angle rounded; basal margin broadly arched; minute spinelike hairs on ventral surface; basal processes short, well sclerotized, somewhat convergent, and blunt. Arms of adminiculum (pl. 22, fig. 16) with several teeth, somewhat concentrated near the apex; one long, broad tooth at the apex, directed in the opposite direction from the others; lateral plate narrow, with several wrinkles.

Female (pl. 28, figs. 133-135, and pl. 35, fig. 274).—1.8 mm. long.

Head: Dichoptic. Eyes black; no fronto-ocular triangle. Antenna 370 μ long, 11-segmented, very slightly tapering; segment $3<1+2$, $3<4+5$, $3=11$; scape and pedicel light brown, the flagellum black; the first two or three flagellar segments are also light brown at times. Palpi brown. Frons, clypeus, and occipital region black, bluish-white-pruinose, irregularly clothed with short black hairs. Cornuae of bucco-pharyngeal apparatus heavily sclerotized, tapering, the apex blunt; median space hyaline, broad.

Thorax: Mesonotum black, completely gray-pruinose, without longitudinal bands, stripes, or other designs; short, narrow, yellow, lustrous, scalelike hairs over entire mesonotum, denser along the periphery, arranged in packets; in prescutellar region these hairs are longer and single; short, fine, black hairs also over entire mesonotum. Humeral angles black, with yellow scalelike hairs. Scutellum black with long black hairs and with numerous golden-yellow scalelike hairs that almost encrust the lateral areas. Postnotum velvety dark brown, with white pruinosity, devoid of hairs. Pleura black, with bluish-white pruinosity. Stem of halter brown, the knob pale yellow. Wings, 1.9 mm. long and 0.85 mm. wide; relation of body length to wing, 1:1; Sc pilose along basal fifth; R_1 spiny along distal half, with a few hairs intermixed; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 1.7 mm.; entire leg light brown except the apical two-thirds of basitarsus, and segments 2-5, which are dark. Leg 2, length, 1.5 mm.; entire leg light brown except the coxa which is dark brown. Leg 3, length, 1.9 mm.; coxa dark brown; trochanter light brown; femur dark brown except for small, light-brown basal ring; basal third of tibia light brown, the apical two-thirds dark brown; tarsus light brown; relation of basitarsus to second tarsal segment, 5.1:1; calcipala well developed, just reaching the pedisulcus; pedisulcus well formed at middle of second segment; claw with minute subbasal tooth (pl. 35, fig. 274).

ABDOMEN: Segment 1 dark brown to black, with short black hairs sparsely distributed, the pleura with fringe of longer hairs that reach segment 2. Segment 2 black, the posterior half somewhat white-pruinose, with short, fine, black hairs. Other segments black with bloom of bluish-white pruinosity, sparsely covered with short, fine, black hairs. Sternites gray.

GENITALIA: Cercus (pl. 28, fig. 133) dome-shaped, its height not quite twice its length (width). Anal lobe (pl. 28, fig. 133) broad, its ventral extremity somewhat quadrangular, the dorsal extremity tapered. Genital rod (pl. 28, fig. 134) with very slight, if any, basal dilatation; apical expansions of arms of genital fork subtriangular in shape, with well-sclerotized outer basal angle, an arm of which appears to cross the expansion diagonally; arms broad and ribbonlike, forming an angle where they diverge. Ovipositor (pl. 28, fig. 135) very small, triangular in shape, the apex pointed.

Pupa (pl. 36, fig. 281, and pl. 39, fig. 321).—Granulosity on entire thorax; 3 arborescent trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Without granulosity; spines on segments 2-4 are anteriorly directed; segment 2 with 8 simple spines in transverse row across the middle, the row divided in two by median space; outermost spine on either side more separated from the adjacent spine than are any two other spines; anterior to the outermost spine on either end of the row are 2 other spines, the more posterior one very fine, the other one similar to the spines in the transverse row; segments 3 and 4 each with 8 simple spines in a transverse row somewhat before the posterior margin, with median separation. Other segments devoid of spines. Ventral surface of abdominal segments: All spines are anteriorly directed; segment 5 with 4 bifid spines in transverse row in front of the posterior margin, with median separation; segments 6 and 7 each with 4 spines in transverse row, with median separation, the two spines on either side of the midline more separated from each other than those on segment 5; the outer spines simple, the inner spines bifid. Terminal spines very small.

Respiratory apparatus (pl. 36, fig. 281) of each side arising a little behind the anterior margin of the thorax; composed of 6 filaments which branch at the same level as follows: 2-2-2; the respiratory apparatus not uncommonly has 8 filaments, such pupae usually being found in the streams from which dichoptic males are reared; filaments with superficial annulation and with microscopic spicules. Maximum length, 2.4 mm., slightly longer than the length of the cocoon; average diameter, 24 μ.

Cocoon (pl. 39, fig. 321): Length of base, 2.3 mm.; maximum width, 1.2 mm.; maximum height, 1.2 mm. Cocoon of wall-pocket type, without collar; texture of case parchmentlike, without visible threads; rim around anterior aperture slightly thickened. Cocoon covers abdomen and three-fourths of thorax; attached along the posterior half of its base.

Larva (pl. 40, fig. 361, and pl. 42, fig. 398).—Total length, 4.2-4.6 mm. Length of head capsule 1.2 times its width. Width of thorax 1.6 times that of head. First 4 abdominal segments 1.1 times the width of head; segments 5-7 expanded, greatest at segment 6 which is 1.7 times the width of segments 1-4; abdomen almost round in cross section; body with same general shape as larvae of the subgenus *Simulium*. General color brown gray; abdominal segments 1-4 with gray ring completely encircling them; eighth segment milky white, with no markings except that formed by the patch of rectal scales; ventrolateral dark patches at times present on segments 5-7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 361. Each cephalic fan with 27-33 nonpectinate branches. Mandible with 2 very close teeth on its inner margin, the distal one at least three times the length of the basal one; the basal tooth very minute and fine, almost like a spine. Antenna 250 μ long, 4-segmented, pale yellow, far surpassing the basal stalk of the cephalic fan; segments 1 and 2 so closely united that they almost appear as a single segment; segment 2 somewhat longer than segment 1; distinct angle often present at articulation of segments 2 and 3; segment 2 with an indication of superficial segmentation near its middle; no transverse striations or longitudinal wrinkles. Submentum with 9 triangular-shaped apical teeth, all very small, none very much longer than the others; ventrolateral row composed of 4 hairs in straight line, the most-distal hair trifid or 4-branched near its tip; at times there are 2 small additional hairs near the base; lateral margin of submentum with 2 to 3 toothlike processes, the most-apical well sclerotized and appearing to arise from the side of the outermost of the apical teeth. Occipital cleft very deep and wide, almost circular in appearance (pl. 42, fig. 398).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 28-30 rows of hooks on its apex; postclypeal sclerites very minute, usually absent. Posterior sucker with 68-72 rows of hooks. Each of the three main divisions of the anal gills with 2-5 projections, forming a hand-like structure. Posterior arms of X-shaped sclerite well sclerotized; anterior arms well sclerotized, each with narrow pigmented patch along entire outer margin; about 8 rows of rectal scales, each scale well developed, mainly single, some double, directed anteriorly; rectal scales forming dark band across the segment. Eighth segment without ventral papillae or sclerotized plaques.

Types.—♀, probably in the Museum of Paris; collected at Alto Sarare, Venezuela, 1899. In the British Museum (Natural History) there is a single specimen that was determined by Roubaud, and in the United States National Museum there are four ♀♀ from Sarare, Venezuela, that had been examined by Roubaud.

SIMULIUM (EUSIMULIUM) AUREUM (FRIES)

Simulia aureus Fries, Monographia Simuliarum sveciae, Lundae, vol. 1, No. 5, p. 16, 1824 (original description).

Simulium bracteatum Coquillett, Malloch, U. S. Dept. Agr. Bur. Ent. Techn. Ser., No. 26, p. 15, 38-39, 1914 (redescription of Coquillett's species; ♀, ♂, and pupa).—Jobbins-Pomeroy, U. S. Dept. Agr. Bull. 329 (Prof. Pap.), pp. 13-14, pl. 2, fig. 4; pl. 3, fig. 7; pl. 4, fig. 7; pl. 5, fig. 3; and text figs. 3, 4, and 6, 1916 (larva, figs. of ♂ genitalia, larva [rectal gills, antenna, submentum, and row of hooks of posterior sucker], and pupa).

Eusimulium aureum (Fries), Dyar and Shannon, Proc. U. S. Nat. Mus., vol. 69, art. 10, pp. 12-15, 48, figs. 24-26, 44, 1927 (♀ and ♂ genitalia; also described under *Eusimulium aureum bracteatum* and *Eusimulium bracteatum*).

Simulium (*Eusimulium*) *aureum* (Fries), Twinn, Canadian Journ. Res., sect. D, vol. 14, pp. 115-117, figs. 6A, 1-5, 1936 (♀, ♂, and pupa).—Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 166, 1946 (larva).

Simulium (*Eusimulium*) *donovani* VARGAS, Rev. Inst. Salubr. Enferm. Trop., vol. 4, No. 4, pp. 359-360, figs. 34-36, 1943 (female).
Simulium diazi DE LEÓN, Bol. Sanit. Guatemala, vol. 52, p. 70, fig. 7, 1944 (pupal respiratory filaments).

Male (pl. 22, figs. 19-21).—3.5 mm. long.

HEAD: Holoptic. Eyes very dark reddish brown above, black beneath. Antenna 500 μ long, 11-segmented, slightly tapering, the last segment pointed; segment $3=4+5$, $3=1+2$, $3>11$; completely black. Palpi dark brown at base, black apically. Clypeus black, yellowish-white-pruinose, with pale-yellow hairs.

THORAX: Velvety black, with white pruinosity covering entire mesonotum, dependent on position of light source; densely covered with long, narrow, brassy-yellow, scalelike hairs along the periphery; few such hairs on disc; long, yellow, erect hairs in the prescutellar region; along the anterior margin some of these hairs appear silvery. Humeral angles dark brown, with silvery pruinosity and short, yellow, scalelike hairs. Scutellum black, with very long yellow hairs and several appressed, yellow, scalelike hairs. Postnotum black, with silvery pruinosity that appears to be in W-shaped pattern, devoid of hairs. Pleura dark brown, gray-pruinose, all tufts pale yellow; prealar group composed of brassy-yellow hairs. Stem of halter dark brown, the knob tan to rose. Wings, 3.5 mm. long and 1.2 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal fifth; R_1 completely pilose, with spines also on distal half; R_{2+3} pilose except for small basal region; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.7 mm.; coxa dark brown; trochanter dark brown, its base somewhat lighter; femur light brown, the apex dark; basal and apical thirds of tibia dark brown, the middle light; tarsus black; tarsal segments 1-3 each with lance-shaped spur extending from its apex. Leg 2, length, 2.4 mm.; coxa and trochanter dark brown, femur and tibia as on leg 1; basitarsus brown on basal third, black on apical two-thirds; tarsal joints 2-5 black; basitarsus and second segment with apical spur. Leg 3, length, 2.8 mm.; coxa and trochanter dark brown; femur and tibia as on leg 1 and 2; basal three-fourths of basitarsus and basal third of second segment light brown, the remainder of these segments, as well as all of segments 3-5, dark brown to black; second joint with apical spur; relation of basitarsus to second segment, 4.5 : 1; calcipala well developed, not quite reaching the pedisulcus; pedisulcus formed one-third the distance from the base of second segment, not very deep; some very long hairs on tibia and basitarsus. On all legs, the light areas are clothed with silver to yellow hairs and the dark areas with black hairs.

ABDOMEN: Tergite of segment 1 dark brown, with yellow hairs; pleurites dark brown, with fringe of very long pale-yellow hairs that reach segment 5. Segment 2 dark brown, with bluish-white pruinosity on anterior half and on pleural regions, with yellow hairs on pleural regions. Segments 3-6 dark brown, white pruinosity along posterior margin and in pleural regions, clothed with rather long pale-yellow to bronze hairs; segments 7 and 8 dark brown, completely gray-pruinose, with short black hairs. Sternites dark brown, with central longitudinal black band, clothed with long, pale-yellow hairs.

GENITALIA: Sidepiece (pl. 22, fig. 19) almost conical in shape, much longer than wide, the apical margin greatly reduced; with dorsal concavity near middle of apical margin; dorsal opening occupying about half of dorsal surface of sidepiece. Clasper (pl. 22, fig. 19) somewhat snout-shaped, the base widely open, with bulge on outer margin; apex truncate, with a single, short terminal spine. Body of adminiculum (pl. 22, fig. 20) like the stem of an inverted Y, its length about three times its width, the apex pointed, very hairy; the basal processes appear as the arms of the inverted Y, very long, divergent, broad, expanded and blunt at their ends. Adminicular arms (pl. 22, fig. 21) with one long tooth at the apex and, at times, with a second shorter one; lateral plate wide, somewhat rectangular in shape, without wrinkles.

Female (pl. 29, figs. 136-138, and pl. 35, fig. 268).—2.9 mm. long.

HEAD: Dichoptic. Eyes black; base of fronto-ocular triangle 1.5 times the height. Antenna 500 μ long, 11-segmented, slightly tapering, the apical segment pointed; segment $3=1+2=4+5=11$; scape and pedicel light brown, the flagellum black. Palpi black. Frons, clypeus, and occipital region black, gray-pruinose, the frons with short, pale-yellow scalelike hairs, the clypeus with longer, erect, yellow hairs, and the occipital region with rather long, recumbent, scalelike hairs. Cornuae of buccopharyngeal apparatus long, narrow, sharply pointed, well sclerotized; the median space hyaline, smooth.

THORAX: Mesonotum black, with bloom of gray pruinosity; long, narrow, appressed, pale- to bronze-yellow scalelike hairs in broad band around the periphery, longer in the prescutellar region; shorter hairs of same type sparsely distributed on the midregion of scutum; some of the hairs near the anterior margin appear almost silvery. Humeral angles black, gray-pruinose, with long yellow hairs. Scutellum dark reddish brown, with long, yellow, erect hairs and several recumbent, yellow, scalelike hairs. Postnotum dark brown, with white pruinosity in the form of a W, and with 2 patches of recumbent, golden, scalelike hairs, one on either side of midline, on the posterior half of the postnotum. Pleura dark brown, with gray pruinosity; all tufts yellow, the pre-alar group more bronze. Stem of halter with stem brown at base, lighter at apex, the knob creamy yellow. Wings, 3.3 mm. long and 1.4 mm. wide; relation of body length to wing, 1:1.2; Sc pilose along basal two-thirds; R_1 completely pilose, the distal two-fifths with spines as well; R_{2+3} pilose except along an extremely short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.7 mm., coxa and trochanter light brown; femur light brown with apical dark ring; tibia light brown, the base and apex with dark rings, the basal one lighter than the apical; tarsus black. Leg 2, length, 2.5 mm.; coxa dark brown; trochanter light brown; femur and tibia as on leg 1; tarsus black, the basitarsus and segments 2 and 3 with apical spurs. Leg 3, length, 3.1 mm.; coxa dark brown; trochanter light brown; femur and tibia as on legs 1 and 2; basitarsus light brown on basal two-thirds with very small basal black band, the apical third black; segments 2-5 black; segments 2 and 3 with apical spur; relation of basitarsus to second segment, 4.6:1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed one-third the distance from the base of second segment; basal heel of claw well developed, claw with secondary, spear-shaped structure arising near the base (pl. 35, fig. 268).

Abdomen: Tergite of segment 1 light brown with rather long yellow hairs; pleurites brown, with fringe of very long pale-yellow hairs. Segment 2 with tergum brown, the pleura black, all with rather long yellow to bronze scalelike hairs. Other segments black, with dark-brown tergites, all densely covered with yellow scalelike hairs; some of these scalelike hairs appear almost silvery; hairs on segments 7 and 8 shorter than on other segments; plates of tergites 3-7 narrow. Sternites brown, with tan hairs.

Genitalia: Cercus (pl. 29, fig. 136) almost oval in shape, posterior margin slightly concave, its height more than twice its length (width). Anal lobe (pl. 29, fig. 136) smaller and narrower than the cercus, its anterior margin convex, posterior margin concave, curved around the cercus ventrally where it ends in blunted point; with long spines on ventral (anterior) margin only. Genital rod (pl. 29, fig. 138) not heavily sclerotized, without basal dilatation; apical expansions of arms of genital fork triangular in shape, the apical angle, outer basal angle, and the margin between the two well sclerotized; apical angle rather sharply pointed; arms of genital fork emerge close to one another, so that their inner margins are almost parallel. Ovipositor (pl. 29, fig. 137) somewhat conical in shape, tapered distally, the apex rounded.

Pupa (pl. 36, fig. 282, and pl. 39, fig. 322).—Granulosity on entire thorax; 6 rather heavy, simple trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Without granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in transverse row three-fourths the distance from the anterior margin, the row divided by a median separation; anterior to the outermost spine at each end of the row are 2 very fine spines; segments 3 and 4 each with 8 simple spines in transverse row somewhat before the posterior margin, with median space; transverse rows on segments 6-9 are situated behind the anterior margin and all have a median separation; segment 6 with 6 spines, segment 7 with 12 spines, and segments 8 and 9 with 18 spines. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed and the rows are situated somewhat before the posterior margin of the respective segment; segment 4 with a single simple spine on either side of the midline; segment 5 with 4 bifid spines in transverse row, with median separation; segments 6 and 7 with 4 spines in transverse row, with median separation, the outer spines simple, the inner ones bifid; distance between the two spines on either side of midline greater than that on segment 5. Terminal spines very small.

Respiratory apparatus (pl. 36, fig. 282) of each side arising a little behind the anterior margin of thorax; composed of 4 very long filaments that branch close to the base as follows: 2-2; filaments showing superficial segmentation and microscopic spicules. Maximum length, 4.6 mm., about equal to the length of cocoon; average diameter, 70 μ.

Cocoon (pl. 39, fig. 322): Length of base, 4.7 mm.; maximum width, 1.9 mm.; maximum height, 2.1 mm. Cocoon of wall-pocket type, without collar; case with parchmentlike texture, the threads well marked; rim around anterior aperture thickened. Cocoon covers abdomen and three-fourths of thorax; attached along the posterior half of its base.

Larva (pl. 40, fig. 362, and pl. 42, fig. 399).—Total length, 6.5-7.0 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times that of head. Width of first 4 abdominal segments equal to width of head; segments 5-7 expanded, greatest at segment 6 which is 1.6 times width of segments 1-4; shape of body about the same as in the subgenus *Simulium*. General color light brown; dorsum of thorax often gray, especially in younger larvae; venter of all segments with gray markings; ventrolateral patches usually not present on segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 362. Each cephalic fan with 37-50 nonpectinate branches. Mandible with 2 teeth on its inner margin, the basal tooth appearing to arise from the greatly expanded base of the more-distal tooth; distal tooth much larger than the other, both sharply pointed. Antenna 540-580 μ long, 4-segmented, surpassing the basal stalk of the cephalic fan; segment 3 shorter than segment 1 which is shorter than segment 2; segment 2 about 1.2 times segment 1; segments 1 and 3 light brown, segment 3 somewhat lighter than 1, segment 2 clear, almost transparent; segment 1 with some longitudinal wrinkles but no transverse striations. Submentum with 9 triangular-shaped apical teeth, the central tooth and the outermost tooth at each extremity longer than the others; all teeth rather sharp-pointed; ventrolateral row composed of 4 hairs in a straight line, at irregular intervals from one another, all hairs appearing simple; lateral margin of submentum with strongly marked serrations, about 7 in all, the apical two more heavily sclerotized than the others and appearing to emerge from the lateral margin of the outermost of the apical teeth. Occipital cleft very shallow, angular (pl. 42, fig. 399).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 18-22 rows of hooks on its apex; postclypeal sclerites rather small, like short bars, not very heavily sclerotized, greatly separated. Posterior sucker with 68-75 rows of hooks. Each of the three main divisions of the anal gills simple, like inflated fingers. Posterior arms of X-shaped sclerite well sclerotized, perpendicular to the longitudinal axis of body; anterior arms well formed, almost at right angles to posterior arms; a short, well-pigmented, narrow patch along the outer margin of each of the anterior arms, and a small patch between the two anterior arms at their point of convergence; numerous minute spicules, or granulosity, between the anterior and posterior arms of each side, also between the two anterior arms at their point of divergence; no rectal scales. Eighth segment with ventral papillae that are very slender and long, giving them a distinctive appearance; without sclerotized plaques.

Types.—Originally described from Europe; location of type unknown. Because of extensive distribution, specimens can be found in collections throughout Europe and the Western Hemisphere.

SIMULIUM (BYSSODON) BENJAMINI Dalmat

Simulium (*Byssodon*) *benjamini* Dalmat, Ann. Ent. Soc. Amer., vol. 45, No. 2, pp. 339-344, figs. 1-7, 1952(b) (original description, ♂, ♀, and pupa).

Male (pl. 22, figs. 22-24).—2.1 mm. long.

Head: Holoptic. Eyes very dark reddish brown; length of eyes almost equal to that of thorax. Antenna 330 μ long, 11-segmented, slender, the apical segments somewhat wider than the basal ones; segment $3<1+2$, $3<4+5$, $3>11$; scape, pedicel, and basal three segments of flagellum brown, the remaining segments dark brown. Palpi black. Clypeus black, white-pruinose, irregularly covered with short black hairs.

Thorax: Mesonotum velvety brown; 2 strong white-pruinose triangles, one on either side of the midline, the base contiguous with the anterior margin of scutum; posterior to each of these triangles, and somewhat more removed from the midline, is another white-pruinose triangle that is elongate, its base facing anteriorly and its apex reaching beyond the anterior half of the scutum; lateral margins of mesonotum, as well as the prescutellar region, also white-pruinose, these pruinose regions separated by area of base color; few long, narrow, yellow, scalelike hairs on prescutellar region and on the long white-pruinose triangles; anterior half of mesonotum sparsely clothed with short, lustrous, brown hairs. Humeral angles somewhat lighter than mesonotum in general, each with transverse patch of white pruinosity, and with a few yellow scalelike hairs. Scutellum triangular in shape, the angles sharp; velvety brown, with long black hairs along the outer margins. Postnotum velvety brown, with triangular patch of gray pruinosity, the apex pointing posteriorly. Pleura of mesothorax velvety brown, covered with shiny-white pruinosity; pre-alar group composed of yellow hairs. Stem of halter brown, the knob pale yellow to cream. Wings, 1.8 mm. long and 0.85 mm. wide; relation of body length to wing, 1.2 : 1; Sc pilose along its basal fifth (3 hairs); R_1 spiny and with a few hairs along its distal half; R_{2+3} pilose along its distal four-fifths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.0 mm.; coxa and trochanter dark brown; femur light brown on basal two-thirds, dark brown on apical third; tibia dark brown, its midregion somewhat lighter; tarsus dark brown. Leg 2, length, 1.7 mm.; coxa, trochanter, and femur dark brown, the femur somewhat lighter on its midregion; tibia black, with yellow basal ring; tarsal segments 1-3 yellow on basal half, brown apically; segments 4 and 5 brown. Leg 3, length, 2.1 mm.; coxa and trochanter dark brown; femur light brown on basal two-thirds, dark brown on apical third; tibia dark brown, with yellow basal ring; apical region of tibia with concentration of short hairs that are very close together; apex almost pointed; there is a rather distinct angle, the more apical region again tapering; basal two-thirds of basitarsus and of second tarsal segment tan, the remainder of these segments, as well as tarsal segments 3-5, dark brown; relation of basitarsus to second tarsal segment, 4.2 : 1; basitarsus with apical end truncate, the calcipala occupying about half its width; calcipala very well developed, surpassing the pedisulcus; pedisulcus well formed one-third the distance from the base of second tarsal segment.

ABDOMEN: Tergite and pleurites of segment 1 velvety brown, the pleurites with fringe of long brown hairs that reach segment 3, and the tergite with very short brown hairs. Segment 2 dark brown, completely white-pruinose, with short brown hairs. All remaining segments dark velvety brown, with short black hairs; pleural regions of segments 3, 5, 6, 7, and 8 white-pruinose; segment 9 completely gray-to tan-pruinose, with few short black hairs, finer than on other segments.

GENITALIA: Sidepiece (pl. 22, fig. 23) somewhat cylindrical in form, longer than wide, the apical margin very slightly shorter than the basal one; basal and apical margins parallel to each other; dorsal opening occupying about two-thirds of the dorsal surface of sidepiece. Clasper (pl. 22, fig. 23) 0.6 the length of sidepiece, conical in shape, the apex somewhat truncate, with a very short heavy terminal spine at the more basal of the apical angles; basal opening extending along one-third of clasper. Body of adminiculum (pl. 22, fig. 24) triangular in shape, wider than long, covered with numerous hairs, longer on apical margin; basal processes long and broad, as long as the body of adminiculum, the ends somewhat spatulate, pointed, and convergent. Adminicular arms (pl. 22, fig. 22) with about 6 long, sharp teeth, well spaced, arranged in linear fashion; lateral plate small, quadrangular, with numerous wrinkles that appear somewhat sclerotized.

Female (pl. 29, figs. 139-141, and pl. 35, fig. 275).—2.0 mm. long.

HEAD: Dichoptic. Eyes shiny black; height of fronto-ocular triangle 1.5 times the base. Antenna 400 μ long, 11-segmented, short and stubby, very slightly tapering, the apical segment pointed; segment $3<1+2$, $3>4+5$, $3<11$; scape, pedicel, and first flagellar segment yellow, the other segments light brown. Palpi dark brown to black. Frons, clypeus, and occipital region black, white-pruinose, covered with short black hairs. Cornuae of buccopharyngeal apparatus extremely broad, heavily sclerotized, the ends bifid; median space well sclerotized, with definite central concavity, and with about 23 teeth of variable size that are arranged as follows: 7 short, sharply pointed teeth along border of central concavity; at each end of concavity there is a projection composed of 3 very long, sharp teeth and 2 shorter teeth; between each projection and the closest cornua there are 3 minute teeth; the structure of the buccopharyngeal apparatus is sufficient to distinguish this species from all other Guatemalan species.

THORAX: Mesonotum dark brown to black, velvety; two stripes of shiny-white pruinosity, somewhat wider anteriorly, extending from anterior border to prescutellar depression which is similarly white-pruinose; wide band of white pruinosity along each lateral margin, separated from the pruinosity of prescutellar region; short, lustrous, dark-brown to black hairs sparsely distributed over scutum, more numerous on anterior half; very narrow, yellow, scalelike hairs present on prescutellar region and at the posterior angles. Humeral angles velvety brown, with white pruinosity and a few yellow scalelike hairs. Scutellum velvety brown, with long black hairs along the margins. Postnotum same color as mesonotum, with white pruinosity, devoid of hairs. Pleura dark brown to black, shiny white-pruinose; pre-alar group composed of a few yellow hairs. Stem of halter light brown, the knob cream to tan. Wings, 2.2 mm. long and 1.0 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along the basal half; R_1 spiny and pilose along the distal half, the hairs sparse and situated closer to the base; R_{2+3} pilose except for basal seventh; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.1 mm.; entire leg brown, the basal half of the trochanter and the midregion of the femur somewhat lighter. Leg 2, length, 1.9 mm.; coxa and trochanter dark brown; femur brown, the base and apex somewhat darker; tibia dark brown, with yellow basal ring; tarsal segments 1-3 yellow to tan on their basal two-thirds, darker apically; segments 4 and 5 dark brown. Leg 3, length, 2.3 mm.; coxa and trochanter dark brown; femur light brown on basal two-thirds, dark brown on apical third; tibia dark brown, with yellow basal ring, spindle-shaped, widest about three-fourths the distance from the base, at which point there is a distinct angle, the more apical region again tapering; apical region of tibia with concentration of short hairs that are very close together; apex almost pointed; basal half of basitarsus and of second segment yellow, the apical halves of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second segment, 5.0 : 1; basitarsus with apical end truncate, the calcipala occupying about half its width; last tarsal segment rather long; calcipala well developed, not quite reaching the pedisulcus; pedisulcus well formed at middle of second segment; claw with well-developed heel and with small subbasal tooth (pl. 35, fig. 275).

Abdomen: Tergite and pleurites of segment 1 dark brown, the pleura with long dark hairs that reach segment 3. Segment 2 dark brown, white-pruinose except for small patch at middle of posterior margin; with short black hairs. Segments 3-5 with very much reduced tergal plates; anterior and posterior margins of segments 3 and 4, and anterior margin of segment 5 white-pruinose; pleural regions with short black hairs. Segments 6-9 shiny brown, with short black hairs well distributed throughout. Sternites tan.

GENITALIA: Cercus (pl. 29, fig. 139) irregularly oval in shape, somewhat more expanded ventrally, with a heavily sclerotized band along its anterior margin. Genital rod (pl. 29, fig. 141) narrow, poorly sclerotized, with no basal dilatation; apical expansions of arms of genital fork wide, subquadrangular in shape, with heavily sclerotized bar extending diagonally across it; with well-formed submedian tooth on outer margin. Ovipositor (pl. 29, fig. 140) triangular in shape, its base greater than its length.

Pupa (pl. 36, fig. 283, and pl. 39, fig. 323).—Granulosity on entire thorax; 4 simple and 2 bifid trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Without granulosity; all spines on segments 2-4 are anteriorly directed, those on segments 7 and 8 are posteriorly directed; segment 2 with 8 simple spines in transverse row across its middle, the row divided in two by a median space; anterior to the outermost spines on either end of the row are 2 other similar spines; segments 3 and 4 each with 8 simple spines in transverse row somewhat before the posterior margin, with median separation; segment 7 with 12 simple spines in anterior row along the anterior margin, with median space; segment 8 with 22 simple spines in transverse row slightly behind the anterior margin, with median separation. Ventral surface of abdominal segments: Without granulosity; all spines are anteriorly directed, and all transverse rows are situated three-fourths the distance from the anterior margin of the respective segment; segment 5 with 4 trifid spines in transverse row, with median separation; segments 6 and 7 each with 4 trifid spines in transverse row, with median separation, the distance between the two spines on either side of the midline greater than on segment 5. Terminal spines absent.

Respiratory apparatus (pl. 36, fig. 283) of each side arising slightly behind the anterior margin of thorax; composed of very short basal trunk from which branch 8 thin filaments, grouped as follows: 3-3-2; the filaments of each of the groups of three branch off close to one another; filaments with superficial segmentation and with microscopic spicules. Maximum length, 2.5 mm., about equal to the length of cocoon; average diameter, 20 μ.

Cocoon (pl. 39, fig. 323): Length of base, 2.6 mm.; maximum width, 1.1 mm.; maximum height, 1.0 mm. Cocoon of wall-pocket type, without collar; rim around anterior aperture thickened; case with parchmentlike texture, the threads visible. Cocoon covering abdomen and half of thorax; attached along slightly more than the posterior half of the base.

Larva.—Not available.

Types.—Holotype (♂), 4 slides, and allotype (♀), 5 slides, in collection of United States National Museum. Holotype collected from the Río Sakchá, Poptúm, El Petén, Guatemala, November 11, 1948. Allotype collected from a stream in Cobán, Alta Verapaz, Guatemala, November 19, 1944. Paratypes, 3 ♀♀, 4 ♂♂, and 2 pupae, in collection of Herbert T. Dalmat.

SIMULIUM (LANEA*) CALLIDUM (Dyar and Shannon)

Eusimulium callidum Dyar and Shannon, Proc. U. S. Nat. Mus., vol. 69, art. 10, p. 16, fig. 41, 1927 (original description, ♀).

Simulium callidum (Dyar and Shannon), Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, pp. 231-232, figs. 1 and 8, 1942 (♂ and ♀ genitalia).—Vargas, ibid., vol. 4, No. 4, figs. 28-29, 1943 (pupa).

Simulium (*Eusimulium*) *callidum* (Dyar and Shannon), Bequaert, *in* Strong, Sandground, Bequaert, and Ochoa, Contr. No. 6, Dept. Trop. Med. and Inst. Trop. Biol. and Med., Harvard Univ., pp. 210-212, fig. 98, 1934 (♂, ♀, and pupa).—Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 166-167, 1946 (larva).

Male (pl. 23, figs. 25-27).—3.3 mm. long.

Head: Holoptic. Eyes with upper region shiny reddish brown, the lower region black. Antenna 450 μ long, 11-segmented, slightly tapering; segment 3 = 1 + 2; scape and pedicel light brown, flagellum darker. Palpi brown, the base slightly lighter than the rest. Clypeus with silver pruinosity and few long black hairs.

Thorax: Mesonotum yellowish to orange, with 2 rather narrow longitudinal bands of white pruinosity, one on either side of midline, extending posteriorly for one-third the scutum; bands curved in form of comma so that the concavity is along the outer margin; very few yellow scalelike hairs around the periphery, never in packets, seldom visible; short, fine, black hairs over entire mesonotum, somewhat longer in prescutellar region. Humeral angles silvery-pruinose, with fine black hairs and a few golden scalelike hairs. Scutellum light yellowish brown, with several long, strong, black hairs and with some slender, appressed, black hairs as well as a few yellow scalelike hairs. Postnotum brown, with silvery pruinosity. Pleura yellow, silvery-pruinose in parts; pre-alar group primarily black, with 1 to 2 yellow hairs intermixed. Stem of halter brown, the knob tan. Wings, 3.2 mm. long and 1.4 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal fifth; R_1 with spines along distal three-fifths, with 3 to 4 hairs amongst the spines; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

* See footnote 6, p. 68.

Legs: Leg 1, length, 3.1 mm.; coxa yellow; trochanter and femur light brown; tibia brown with its anterior margin and apical fourth darker; tarsus dark brown. Leg 2, length, 1.8 mm.; coxa dark brown; trochanter light brown; femur very hairy, light brown, with anterior margin and very small apical region dark brown; tibia brown on basal third, dark brown on apical two-thirds, very hairy; basal half of basitarsus brown, the apical half black; tarsal segments 2-5 black; basitarsus and second segment with several apical spines. Leg 3, length, 3.4 mm.; coxa dark brown; trochanter light brown; femur light brown with its apical fourth and posterior margin dark brown; very hairy, with apical spines; tibia black with brown basal ring, very hairy, with 2 apical spines; basitarsus reddish brown, very hairy, tarsal segments 2-5 black; relation of basitarsus to second segment, 5.4:1; calcipala well developed, overlapping the pedisulcus; pedisulcus formed on basal third of second segment.

Abdomen: Tergite of segment 1 yellow, with short black hairs; pleurites yellow, with very long black hairs that reach beyond the third segment. Segment 2 yellowish brown, with short black hairs. Other segments velvety black, the pleura brown, with short black hairs; pleura of segments 6 and 7 with patch of silvery pruinosity. Sternites black.

Genitalia: Sidepiece (pl. 23, fig. 25) cylindrical in shape, twice as long as it is wide; dorsal opening occupying less than half of the dorsal surface of sidepiece. Clasper (pl. 23, fig. 25) almost rectangular in shape, much longer than wide, shorter than sidepiece, the distal end broader than the base; outer apical angle rounded and somewhat extended, the inner apical angle pointed, with a single short terminal spine at its apex. Body of adminiculum (pl. 23, fig. 26) shield-shaped, slightly longer than wide, the apex somewhat pointed; ventral surface with numerous short hairs; basal processes short, narrow, ending in point, strongly sclerotized. Arms of adminiculum (pl. 23, fig. 27) with about 24 teeth arranged in linear fashion, long and short ones intermixed; lateral plate elongate.

Female (pl. 29, figs. 142-144, and pl. 35, fig. 259).—3.1 mm. long.

Head: Dichoptic. Eyes dark reddish brown; height of fronto-ocular triangle 1.5 times the base. Antenna 450 μ long, 11-segmented, slightly tapering; segment $3=4+5$, $3=$ or $<1+2$, $3=11$, scape and pedicel light brown, flagellum dark brown. Palpi black. Frons and clypeus brown, white-pruinose, with short black hairs. Occipital region dark brown, with many black hairs and some that appear lighter in color. Cornuae of buccopharyngeal apparatus narrow, blunt, sclerotized; median space slightly sclerotized, smooth, without teeth.

Thorax: Mesonotum yellow to orange, with narrow band of silver pruinosity on either side of midline, broad at the anterior margin, extending to white pruinosity of prescutellar region; the band of either side is curved with convexity extended laterally, thereby forming a lyre-shaped structure; yellow coloration along the midline and along the anterior limit of the prescutellar region; golden scalelike hairs along the periphery of mesonotum, more pronounced in the prescutellar region; short black hairs evenly covering the anterior half of mesonotum, few on posterior half, numerous on prescutellar region. Humeral angles silvery-pruinose. Scutellum pale yellow, with long, strong, black hairs and with some golden-yellow scalelike hairs. Postnotum brown, with white pruinosity, devoid of hairs. Pleura yellow, evenly white-pruinose. Stem of halter brown, the knob yellow, cup-shaped. Wings, 3.1 mm. long and 1.3 mm. wide; relation of body length to wing, 1:1; Sc pilose along basal three-fourths; R_1 completely pilose, its distal half also with spines; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.8 mm.; coxa and trochanter pale yellow; femur pale yellow, its distal third somewhat darker; tibia light brown; tarsus black. Leg 2, length, 2.7 mm.; coxa brown; trochanter yellow; femur and tibia yellow with apical brown band; basal half of basitarsus yellow, the apical half dark brown; tarsal segments 2-5 dark brown. Leg 3, length, 3.4 mm.; coxa brown; trochanter yellow; femur yellow with apical fourth dark; tibia yellow on basal half, dark brown on apical half, with 2 apical spines; basal half of basitarsus and of tarsal segment 2 yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second tarsal segment, 4.6:1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed on basal third of second segment; claw with submedian tooth (pl. 35, fig. 259).

Abdomen: Tergite of segment 1 yellow, with white pruinosity; pleurites pale yellow, with very long reddish-brown hairs. Tergite of segment 2 yellow in front, brown behind; pleurites velvety brown. Segment 3 pale in middle, remainder velvety black. Other segments velvety brown, the pleurites with some yellow pruinosity. Short black hairs over entire abdomen. Sternites white-pruinose.

Genitalia: Cercus (pl. 29, fig. 142) with height almost equal to length (width), the posterior angles rounded. Anal lobe (pl. 29, fig. 142) high, its height about three times its length (width), tapered at both ends, with slight protuberance near middle which curves under cercus. Genital rod (pl. 29, fig. 144) with slight basal dilatation; apical expansions of arms of genital fork irregularly triangular in shape, the apical angle strongly tapered, the other two angles blunt; inner basal angle hyaline, outer angle, which emerges at about the middle of the expansion, somewhat sclerotized. Ovipositor (pl. 29, fig. 143) small, elongate, the apex somewhat expanded.

Pupa (pl. 36, fig. 284, and pl. 39, fig. 324).—Granulosity on central part of thorax; 4 arborescent trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with 8 simple, hairlike spines in transverse row, crossing the segment about three-fourths the distance from anterior margin, the row divided in two by a median space; anterior to the outermost spine on either side of the row are 2 hairs, the most-anterior heavier; segments 3 and 4 with 8 simple spines in a transverse row across the middle of the segments, the row being divided by median space; segment 7 with 8 simple spines in transverse row on anterior margin, with median separation, and with about 10 comblike groups of spines lateral to each end of the row; segment 8 with 19-24 simple spines in transverse row across anterior margin, with median separation, and with combs lateral to both ends of the row; segment 9 with what appears to be a band of posteriorly directed denticles along the anterior margin, divided in two by a median space. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single simple spine on either side of the midline, about three-fourths the distance from the anterior margin; segment 5 with transverse row of 4 bifid spines, crossing about three-fourths the distance from the anterior margin, divided in two by median space; segments 6 and 7 with 4 spines in a transverse row about three-fourths the distance from the anterior margin, the outer spines simple, the inner spines bifid; the two spines on either side of the midline are more separated than those on segment 5, the distance between them approximately equal to that of the median space. Terminal spines very small, ending in point.

Respiratory apparatus (pl. 36, fig. 284) of each side emerging just behind the anterior margin of thorax; composed of 8 filaments which branch as follows: 3-3-2; all filaments curve in one direction to give the effect of a fan; with superficial annulations and with microscopic spicules. Maximum length of filaments, 2.7 mm., about 0.65 times the length of the cocoon; diameter, 40-60 μ.

Cocoon (pl. 39, fig. 324): Length of base, 4.1 mm.; maximum width, 2.0 mm.; maximum height, 1.5 mm. Cocoon wall-pocket type, without collar; texture of case parchmentlike, the threads visible; rim around anterior aperture thickened. Cocoon covering abdomen and thorax; attached along a little more than half its base.

Larva (pl. 40, fig. 363, and pl. 42, fig. 400).—Total length, 5.7-6.1 mm. Width of head capsule equal to the length. Width of thorax 1.6 times that of head. Width of first four abdominal segments 1.2 times that of head; segments 5-7 expanded, greatest at segment 6 which is 1.4 times width of segments 1-4; cross section and general shape equal to that of larvae in the subgenus *Simulium*. General color smoke gray with slight green coloration in some regions; black patches on ventrolateral regions of segments 6 and 7 present, but not very distinctly marked.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 363. Each cephalic fan with 30-32 pectinate branches, the hairs on these branches short, heavy, close together, with somewhat longer, bifid hairs interspersed at regular intervals. Mandible with 2 flattened teeth on its inner margin that appear to arise as branches from the same base; apical tooth much longer and broader than the other. Antenna 400 μ long, 4-segmented, just surpassing the basal stalk of cephalic fan; segments 1-3 subequal in length; segments 1 and 2 dark brown, 3 and 4 lighter in color; segment 1 with longitudinal striations. Submentum with 9 apical teeth, shaped like half of a hexagon, the central tooth and the outermost tooth on either side larger than the others; ventrolateral row composed of 7 hairs in straight line, the hairs bifid and trifid; lateral margin of submentum serrated, with about 8 toothlike processes. Occipital cleft deep, dome-shaped, the apex pointed (pl. 42, fig. 400).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 38-42 rows of hooks at its apex; postclypeal sclerites small, but well sclerotized. Posterior sucker with 105 rows of hooks. Anal gills with 3 main divisions each with usually 5 fingerlike processes, some longer than others; at times, there are as many as 24 processes in all, the central division on such specimens having 14; the lateral divisions may have up to 7 processes. Anterior and posterior arms of X-shaped sclerite heavily sclerotized, the anterior arms short and completely obscured by wedge-shaped patches that start at the union with the posterior arms; patches much larger than on *downsi;* approximately 10 rows of rectal scales, posteriorly directed, each with from 1-5 denticles at tip; small, round protuberance on either side, just posterior to anal opening and lateral to it, covered with numerous spines; row of simple spines behind each posterior arm. Two extremely small ventral papillae on eighth segment, hardly visible; no plaques.

Types.—♀ (U.S.N.M. No. 28667) in the collection of the United States National Museum; collected in Córdoba, Veracruz, Mexico.

SIMULIUM (LANEA) COLVINI Dalmat

Simulium (*Lanea*) *colvini* DALMAT, Ann. Ent. Soc. Amer., vol. 45, No. 2, pp. 344-347, figs. 8-14, 1952(b) (original description, ♂, ♀, and pupa).

Male (pl. 23, figs. 28-30).—2.4 mm. long.

HEAD: Holoptic. Eyes light reddish brown. Antenna 430 μ long, 11-segmented, slightly tapering; segment $3=1+2$, $3>4+5$, $3>11$; scape and pedicel yellow, flagellum light brown. Palpi black. Clypeus black with white pruinosity and with few, irregularly distributed, short black hairs.

THORAX: Mesonotum yellow to orange; on either side of midline there is a white-pruinose triangle, its base contiguous to the anterior margin of mesonotum, its apex extending posteriorly to the prescutellar region which is also white-pruinose; a few long, narrow, yellow scalelike hairs on dorsum, more numerous on anterior half and in prescutellar region, never in packets; short black hairs over entire mesonotum. Humeral angles yellow, covered with white pruinosity. Scutellum light yellow to white, with yellow scalelike hairs and with long black hairs. Postnotum light yellow, velvety, with white pruinosity, devoid of hairs. Pleura tan, with white pruinosity. Stem of halter brown, the knob tan. Wings, 1.9 mm. long and 0.94 mm. wide; relation of body length to wing, 1.3:1; Sc pilose along basal third to sixth (3 hairs on dorsal surface); R_1 completely pilose, with spines as well as hairs along distal two-thirds; R_{2+3} pilose except for very short basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.2 mm.; coxa, trochanter, and femur light brown; tibia light brown with the posterior edge darkened; tarsus black. Leg 2, length, 1.9 mm.; coxa bluish black; trochanter, femur, and tibia yellow; basitarsus yellow, the apical half appearing black owing to large number of heavy black hairs; tarsal segments 2-5 black. Leg 3, length, 2.3 mm.; coxa brown to bluish black; trochanter yellow; femur yellow with apex black; basal half of tibia yellow, the apical half black; basal two-thirds of basitarsus and basal half of second segment yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.3:1; calcipala well developed, reaching pedisulcus; pedisulcus very small, on basal third of second segment.

ABDOMEN: Tergite of segment 1 yellow, with both short black hairs and short yellow hairs; pleurites yellow, partially white-pruinose, with long yellow hairs and with some short black ones. Segment 2 yellow, partially white-pruinose, with few short black hairs. Tergites of segments 3 and 4 black; those of segments 5 and 6 with anterior half yellow and posterior half black; pleura of segments 4-6 yellow with white pruinosity; other segments black. Sternites tan, white-pruinose, with central black patch.

Genitalia: Sidepiece (pl. 23, fig. 28) almost square, the length and width being equal; dorsal opening very large, following general contours of sidepiece itself, covering approximately five-sixths of its dorsal surface. Clasper (pl. 23, fig. 28) less than one-half the length of sidepiece, the apex truncate with one heavy terminal spine arising on distal end, somewhat removed from the inner apical angle; well-marked opening on basal half of clasper. Body of adminiculum (pl. 23, fig. 30) circular; apex somewhat prolonged to form a crown which is covered with long hairs; hairs on remainder of body of adminiculum shorter and appressed; basal processes sclerotized, pointed, with spurlike extensions near the apices. Adminicular arms (pl. 23, fig. 29) usually with 10 teeth, the distal five being long, the others noticeably shorter; lateral plate small, quadrangular, hyaline, with numerous wrinkles that appear somewhat sclerotized.

Female (pl. 29, figs. 145-147, and pl. 35, fig. 265).—1.9 mm. long.

Head: Dichoptic. Eyes yellowish brown; height of fronto-ocular triangle about equal to its base. Antenna 510 μ long, 11-segmented very slightly tapering; segment $3<1+2$, $3<4+5$, $3<11$; scape and pedicel yellow, the flagellum light brown. Palpi brown. Frons and clypeus black with white pruinosity. Occipital region black, with short yellow scalelike hairs. Cornuae of buccopharyngeal apparatus very wide, shovel-like, heavily sclerotized, with expansive membrane; median space hyaline, with numerous very small sclerotized teeth.

Thorax: Mesonotum velvety yellow; on either side of midline there is a longitudinal stripe of white pruinosity that extends from the anterior margin into the prescutellar region which is also white-pruinose; stripes of both sides parallel to one another; wide band of white pruinosity on each of the lateral margins of mesonotum; few long, narrow, yellow, scalelike hairs on anterior half of mesonotum, in the prescutellar region, and on lateral margins above the wing insertion; short black hairs along the periphery and on the anterior fourth. Humeral angles light yellow, white-pruinose, and with yellow hairs. Scutellum light yellow, with short, yellow, scalelike hairs and with long black ones. Postnotum with anterior half dark brown, the posterior half light yellow; with light-yellow to white pruinosity, devoid of hairs. Pleura yellow, with white pruinosity. Stem of halter with dark-brown base and tan apex, knob tan. Wings, 2.4 mm. long and 0.97 mm. wide; relation of body length to wing, 1 : 1.3; Sc pilose along basal half; R_1 completely pilose, also with spines along distal two-thirds; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.3 mm.; entire leg light brown except the tarsus which is black. Leg 2, length, 2.0 mm.; coxa bluish black; trochanter light brown; femur light brown with bluish-black apex; tibia tan with blackish cast; basitarsus tan with black cast apically; tarsal segment 2 with basal half light brown, apical half black; segments 3-5 black. Leg 3, length, 2.4 mm.; coxa and trochanter light brown; femur light brown with somewhat darkened apical end; basal half of tibia light brown, the apical half black with numerous black hairs; basal two-thirds of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.8 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed at basal third of second segment; small claw with almost no basal heel, but with small subbasal tooth (pl. 35, fig. 265).

Abdomen: Tergum of segment 1 pale yellow, with short yellow hairs; pleurites pale yellow, with long tan hairs that reach the third segment. Segment 2 pale yellow. Segments 3-6 yellowish, with gray pruinosity, each segment with large velvety-black patch in middle of dorsal surface and with 1 or 2 small patches lateral to the median one; segments 7 and 8 pale yellow. Sternites tan.

Genitalia: Cercus (pl. 29, fig. 145) somewhat higher than long (wide), with few long, strong hairs and numerous short, spinelike hairs. Anal lobe (pl. 29, fig. 145) rather narrow (short), extending beneath the cercus, with posteriorly directed, ventral, fingerlike projection which is more heavily sclerotized than the rest of the anal lobe and contains many very short hairs and some rather long ones. Genital rod (pl. 29, fig. 147) with small, bulblike basal dilatation; apical expansions of arms of genital fork triangular in shape, the inner basal angle broad and blunt, the apical angle tapered and pointed; both these angles sclerotized along the arms; a rather long, heavily sclerotized, toothlike process arising from middle of outer margin; margin sclerotized between this process and the apical angle. Ovipositor (pl. 29, fig. 146) small, 32 μ long by 8-10 μ at widest point, somewhat lyre-shaped.

Pupa (pl. 36, fig. 285, and pl. 39, fig. 325).—Granulosity on entire thorax; 5 bifid trichomes on either side of midline, all on anterior half of thorax. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple, hairlike spines in a transverse row, crossing the segment about three-fourths the distance from the anterior margin, the row divided in two by a median space; anterior to the outermost spine on either extremity are 2 hairs, the most anterior one somewhat heavier; segments 3 and 4 each with a transverse row of 8 simple spines, crossing the segment somewhat before the posterior margin, the row divided in two by a median space; segment 6 with 24 spines in transverse row that crosses about one-fourth the distance from the anterior margin, with median separation, and with comblike groups of minute spines lateral to both ends of the row; segment 7 with a row of 18 spines, with median separation, crossing along anterior margin, and with combs lateral to each end of the row; segment 8 with 30 spines in an uninterrupted row across the anterior margin, and with combs lateral to the both ends; segment 9 with 15-18 spines in transverse row, with median space, crossing along the anterior margin, without combs. Ventral surface of abdominal segments: No granulosity; all spines anteriorly directed; segment 4 with a single bifid spine on either side of midline, near middle of segment, with median space; segment 5 with transverse row of 4 bifid spines, with median separation; segment 6 with 4 spines in transverse row, the outer spines simple, the inner bifid; segment 7 with 4 spines in transverse row, the outer spines simple, the inner spines trifid; the transverse rows on segments 5-7 cross the segment along the posterior margin; the two spines on either side of the midline of segments 6 and 7 are more separated than those on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines very small, the apices blunt.

Respiratory apparatus (pl. 36, fig. 285) of each side arising in the region of the humeral angles, just behind the anterior margin of the thorax; composed of 8 filaments which branch as follows: 3-3-2; all filaments have superficial annulations and microscopic spicules. Maximum length, 2.6 mm., about 0.74 times the length of cocoon; average diameter, 20 μ.

Cocoon (pl. 39, fig. 325): Length of base, 3.5 mm.; maximum width, 2.2 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, without collar; lateral margins of base extended to form winglike structures; rim around anterior aperture not thickened, with slight anteriorly directed prolongation from dorsal margin; texture of case parchmentlike, in the matrix of which loose threads are visible. Cocoon covering abdomen and half of thorax; attached along the posterior half of its base.

Larva (pl. 40, fig. 364, and pl. 42, fig. 401).—Total length, 4.4-4.8 mm. Length of head capsule 1.2 times its width. Width of thorax

1.4 times that of head. Width of first four abdominal segments 1.2 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.6 times width of segments 1-4; cross section and profile the same as that of other species in the subgenus *Lanea*. General color yellow to tan, with greenish transverse bands around the abdominal segments; ventrolateral dark patches present on segment 7, at times on segment 6 as well.

Head: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 364. Each cephalic fan with 45-49 pectinate branches, the hairs on these branches stout, bifid, well separated, not intermixed with other types of hairs. Mandible with 2 short, triangular-shaped teeth on its inner margin, the teeth close together but still separated from each other; more distal tooth just slightly larger than the other. Antenna 390 μ long, 4-segmented, light yellow, just surpassing the basal stalk of the cephalic fan; segment $3>2>1$; base of antenna rather long; no transverse striations. Submentum with 9 apical teeth, somewhat like a half of a hexagon in shape, the central tooth and the outermost tooth on each side somewhat larger than the others; ventrolateral row composed of 4 stout hairs in straight line, bifid or trifid near the tips; lateral margin of submentum with 7 well-formed toothlike serrations. Occipital cleft dome-shaped, the sides somewhat parallel to one another (pl. 42, fig. 401).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 32 rows of spines at its apex; postclypeal sclerites small, not very well sclerotized. Posterior sucker with 63-65 rows of hooks. Anal gills composed of 3 main divisions, each with 5-8 somewhat spatulate, fingerlike processes arising close to one another, forming a handlike structure; each process bluntly rounded at tip. Anterior and posterior arms of X-shaped sclerite well sclerotized; anterior arms each with wedge-shaped expansion along the outer margin which almost reaches the extremity of the arm; expansions of both sides joined by a median patch between the two anterior arms at the point where they join with the posterior ones; posterior arms extending almost to the lateral margins; no rectal scales. Two ventral papillae on segment 8, well developed, somewhat pointed; no sclerotized plaques.

Types.—Holotype (♂), 4 slides, and allotype (♀), 5 slides, in collection of United States National Museum; both collected from a stream between Malacatán and Ayutla, Department of San Marcos, Guatemala, July 18, 1951. Paratypes, 5 ♂♂, 4 ♀♀, 19 pupae, and 16 larvae, in collection of the author.

SIMULIUM (LANEA) DOWNSI Vargas, Martínez, and Díaz

Simulium (*Lanea*) *downsi* VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 126-129, 167, figs. 41-44, 128, 1946 (original description, ♂, ♀, pupa, and larva).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 54-57, 1951 (presence in Guatemala and distribution).

Male (pl. 23, figs. 31-33).—2.7 mm. long.

HEAD: Holoptic. Eyes dark reddish brown. Antenna 440 μ long, 11-segmented, very slightly tapering; segment $3<1+2$, $3<4+5$, $3>11$; scape and pedicel yellow, flagellum brown. Palpi brown. Clypeus brown, white-pruinose, with few black hairs principally on the margins.

THORAX: Mesonotum yellow to orange, with 2 wide bands of white pruinosity, one on either side of midline, that extend from the anterior margin slightly more than one-third the way back, their anterior end wider than the posterior; short, yellow, scalelike hairs over entire mesonotum, more numerous around periphery, never in packets; short black hairs sparsely distributed over entire mesonotum, longer on prescutellar region but not as long as those found in the same region of most other species. Humeral angles yellow, white-pruinose, with yellow scalelike hairs. Scutellum pale yellow with yellow scalelike hairs and with long, strong black hairs. Postnotum dark brown, midline yellow, with white pruinosity, devoid of hairs. Pleura brown, white-pruinose. Stem of halter brown, the knob yellow, cup-shaped. Wings, 2.2 mm. long and 0.9 mm. wide; relation of length of body to wing, 1.2:1; Sc pilose along basal fourth; R_1 spiny along apical half, with a single hair sometimes present among the more basal spines; R_{2+3} pilose along its apical five-sixths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.3 mm.; coxa, trochanter, and femur yellow; basal three-fourths of tibia yellow, apical fourth dark brown; its posterior edge along basal half also brown; tarsus black. Leg 2, length, 2.0 mm.; coxa brown; trochanter and femur yellow; tibia yellow, the posterior edge on apical half brown; basal two-thirds of basitarsus yellow, the remainder, as well as all of tarsal segments 2-5, dark brown. Leg 3, length, 2.3 mm.; coxa brown; trochanter yellow; femur yellow on basal three-fourths, its apical fourth brown; tibia with basal half yellow, apical half black; basal half of basitarsus and of second segment yellow, their apical halves, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.6:1; calcipala well developed, nearly reaching the pedisulcus; pedisulcus well developed on basal third of second segment.

ABDOMEN: Tergite of segment 1 yellow with short black hairs; pleurites yellow with long dark hairs reaching segment 5. Segment 2 yellow, the pleurites somewhat darker, with narrow band of white pruinosity along anterior margin, with short black hairs. Segment 3 yellow. All other segments brown, covered with short black hairs; pleurites with zones of lighter pruinosity. Sternites yellow gray.

GENITALIA: Sidepiece (pl. 23, fig. 31) somewhat conical in shape, longer than wide, the apex broader than the base; dorsal opening occupying less than half the sidepiece. Clasper (pl. 23, fig. 31) shorter than the sidepiece, somewhat rectangular in shape, the distal end broader than the base; outer apical angle rounded and somewhat protruding, inner apical angle rather sharp-pointed, with one terminal spine at very apex. Body of adminiculum (pl. 23, fig. 33) somewhat pyramidal in shape, its apex rounded; short spines and longer hairs over entire surface; basal processes short, slender, the tips pointed and sclerotized, forming angle with the outer basal angles of the body of adminiculum. Adminicular arms (pl. 23, fig. 32) with about 15 teeth, the basal one long, narrow, and sharply pointed, the more-apical ones short and blunt; lateral plate long, slender, somewhat sclerotized.

Female (pl. 29, figs. 148-150, and pl. 35, fig. 260).—2.4 mm. long.

HEAD: Dichoptic. Eyes black; base of fronto-ocular triangle equal to the height. Antenna 430 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3=4+5$, $3>11$; light brown, the flagellum being somewhat darker than the scape and pedicel. Palpi black. Frons and clypeus black, white-pruinose, with few black hairs and some tan ones. Occipital region black, covered with both black and tan hairs. Cornuae of buccopharyngeal apparatus well sclerotized, very wide, and bifurcated at ends; median space very slightly sclerotized, and somewhat serrate along its margin.

THORAX: Mesonotum yellow to orange, with 2 narrow bands of white pruinosity, well separated, one on either side of midline, extending from the anterior margin to the posterior region where it unites with the white pruinosity of the prescutellar area; lateral margins also white-pruinose; long, narrow, yellow, scalelike hairs over entire mesonotum, more numerous on periphery; short black hairs over entire mesonotum, somewhat longer on prescutellar region. Humeral angles yellow, white-pruinose, with yellow hairs. Scutellum pale yellow, with some appressed, yellow, scalelike hairs and several long, strong, black hairs. Postnotum dark brown, white-pruinose, devoid of hairs. Pleura yellow, white-pruinose. Stem of halter tan; the knob pale yellow, almost white, cup-shaped. Wings, 2.6 mm. long and 1.0 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along basal three-fourths; R_1 completely pilose and with spines on apical half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.5 mm.; coxa, trochanter, and femur yellow; basal four-fifths of tibia yellow, the apical fifth black; tarsus black. Leg 2, length, 2.1 mm.; coxa dark brown; trochanter yellow; femur and tibia yellow; basal half of basitarsus and of second segment yellow, the apical halves, as well as all of tarsal segments 3-5, black. Leg 3, length, 2.7 mm.; coxa dark brown; trochanter yellow; basal three-fourths of femur yellow, the rest dark brown; basal half of tibia yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.5 : 1; calcipala well developed, almost reaching the pedisulcus; pedisulcus well developed at middle of second segment; claw without extension of heel and without secondary tooth or spur (pl. 35, fig. 260).

Abdomen: Tergite of segment 1 yellow, with some short tan hairs; pleurites yellow, with long hairs reaching segment 3. Segment 2 yellow with some short tan hairs on tergite. Segments 3-7 with 5 longitudinal rows of black areas on a yellow field, one row central, which does not extend to the seventh segment, and two rows on either side of the central one, these reaching segment 7; last two segments yellow, shiny, with pruinosity; all segments with short black hairs. Sternites yellow.

Genitalia: Cercus (pl. 29, fig. 148) almost oval in shape, higher than long (wide). Anal lobe (pl. 29, fig. 148) high, with tapering ventral prolongation; a short prolongation curving somewhat around the ventral surface of cercus. Genital rod (pl. 29, fig. 150) without basal dilatation; apical expansions of arms of genital fork triangular in shape, the apical angle strongly tapered and pointed, the other two angles blunt and arising at different levels. Ovipositor (pl. 29, fig. 149) very small, membranous, irregularly quadrangular in shape.

Pupa (pl. 36, fig. 286, and pl. 39, fig. 326).—Granulosity pronounced on central region of thorax, very sparse on posterior part; 3 to 4 bifid hairs on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple hairlike spines in transverse row across middle of the segment, the row divided into two by a median space; anterior to the outermost spines on either side of the row are 2 hairs, the most-anterior heavier; segments 3 and 4 with 8 simple spines in a transverse row across the middle of the segments, the row being divided by a median space; segment 6 with 18-20 simple spines in transverse row across anterior margin, divided by median space; segment 7 with 14-16 spines in transverse row along anterior margin, divided by median space, and with about 15 comblike groups of spines on each side, lateral to the row of spines; segment 8 with 16-30 simple spines in an uninterrupted row across the anterior margin and with numerous comblike groups lateral to each end of the row; segment 9 with 4-12 (usually 10) simple spines in a transverse row across anterior margin, divided by median space, and with several comblike groups lateral to the row. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single simple spine on either side of midline; segments 5-7 with 4 spines in transverse row across posterior margin; all spines on segment 5 are bifid; on segments 6 and 7 the two outer spines are simple, the inner one bifid; the two spines on either side of the midline of segments 6 and 7 are more separated than those on segment 5, the distance between them approximately equal to that of the median space. Terminal spines small, flattened, conical, the apex sclerotized.

Respiratory apparatus (pl. 36, fig. 286) of each side arising just posterior to anterior margin of thorax; composed of 8 filaments which branch as follows: 3-3-2; filaments with superficial annulations and with microscopic spicules. Maximum length of filaments, 2.5 mm., about 0.7 times the length of the cocoon; average diameter, 40 μ.

Cocoon (pl. 39, fig. 326): Length of base, 3.5 mm.; maximum width, 2.0 mm.; maximum height, 1.6 mm. Cocoon wall-pocket type, without collar; texture of case parchmentlike, spongy, with threads visible; rim around anterior aperture thickened. Cocoon covering abdomen and two-thirds of thorax; attached along the posterior half of its base.

Larva (pl. 40, fig. 365, and pl. 42, fig. 402).—Total length, 5.3-5.5 mm. Length of head capsule 1.1 times its width. Width of thorax 1.6 times width of head. First 4 abdominal segments slightly wider than head capsule; segments 5-7 noticeably expanded, reaching the greatest width at segment 6 which is 1.7 times the width of segment 1; posterior segments tapered; body with same general shape as that of larvae in subgenus *Simulium*. General color tan to yellow, with a large black patch on the ventrolateral areas of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 365. Each cephalic fan with 36-42 pectinate branches, the hairs on these branches simple, interspersed at regular intervals with stronger, longer hairs that are also simple. Mandible with two flattened teeth on its inner margin, the teeth appearing to emerge from the same base; both teeth sharp-pointed, the distal one longer and broader. Antenna 360 μ long, 4-segmented, light brown, just passing the basal stalk of cephalic fan; segment 2 longer than segment 1; segment 1 with longitudinal striations. Submentum with 9 triangular-shaped apical teeth, the central tooth and the outermost tooth on either side larger than the others; ventrolateral row composed of 4 hairs, arranged in a straight line; hairs short, some bifid or trifid; lateral margin of submentum serrated, with about 6 toothlike indentations. Occipital cleft dome-shaped, the apex somewhat pointed (pl. 42, fig. 402).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 30-36 rows of hooks at its apex; postclypeal sclerites minute, hardly visible. Posterior sucker with 60-61 rows of hooks. Anal gills composed of 3 main branches, each with from 4-6 projections which extend as fingers from a glove. Anterior and posterior arms of X-shaped sclerite well sclerotized, the anterior arms with a triangular-shaped extension on the outer margin and with a small rectangular membranous patch between them near the point of divergence; no rectal scales. Two very small ventral papillae on segment 8; no plaques.

Types.—Holotype (♂) and allotype (♀), part mounted on slides, the rest on pins, and numerous paratype ♂♂, ♀♀, and pupae in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected on the Finca El Rosario, Soconusco, Chiapas, Mexico, August 18, 1942.

SIMULIUM (LANEA) DUGESI Vargas, Martínez, and Díaz

Simulium (*Lanea*) *dugesi* Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 129-131, 167-168, figs. 45-48, 1946 (original description, ♂, ♀, pupa, and larva).

Male (pl. 23, figs. 34-36).—1.8 mm. long.

Head: Holoptic. Eyes reddish brown on top, black on ventral half. Antenna 11-segmented, tapers markedly; scape and pedicel brown, flagellum black. Palpi dark brown to black. Clypeus black, with white pruinosity and with several short black hairs.

Thorax: Mesonotum velvety dark reddish brown; on each side of midline is a large triangle of silver-gray pruinosity, the base contiguous with the anterior margin of the scutum; from the posterior apex of the triangle extends a silver-pruinose band which joins with the silver pruinosity of the prescutellar region; in appearance, the silver-pruinose designs look like funnels; several long, narrow, golden, scalelike hairs irregularly distributed on mesonotum, some almost copper-colored, not in packets; several tan hairs in prescutellar region, not long. Humeral angles velvety dark brown, with white pruinosity. Scutellum dark velvety brown, with some yellow scalelike hairs and some long black ones. Postnotum dark velvety brown, with white pruinosity, devoid of hairs. Pleura dark brown to black, with white pruinosity. Stem of halter yellow to brown, the knob white. Wings, 1.9 mm. long and 0.94 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal sixth (3 hairs); R_1 spiny and pilose along distal half; R_{2+3} pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.1 mm.; coxa light brown; trochanter and femur yellow; tibia yellow on basal half, black on apical half; tarsus black. Leg 2, length, 1.8 mm.; coxa black; trochanter and femur yellow; tibia yellow on basal half, brown on apical half; basitarsus yellow with brown apex; tarsal segments 2 and 3 yellow on basal half, brown on apical half; segments 4 and 5 dark brown. Leg 3, length, 2.2 mm.; coxa black; trochanter yellow; femur black except for small basal area that is dark brown; tibia yellow on basal two-fifths, black on apical three-fifths; basal two-thirds of basitarsus and basal half of second segment yellow, the apical portions of these segments, as well as all of tarsal segments 3-5, black; relation of basitarsus to second segment, 4.1 : 1; calcipala well developed, reaching halfway to pedisulcus; pedisulcus well developed at middle of second segment.

ABDOMEN: Tergite of segment 1 black with short black hairs; pleurites black with long black hairs reaching the fourth segment. Segment 2 velvety black with white pruinosity on the pleural regions and with short black hairs. Other segments velvety black; segment 5 with white pruinosity on pleurites and segment 6 having it both on tergite and pleurites; all segments with short black hairs. Sternites tan.

GENITALIA: Sidepiece (pl. 23, fig. 34) somewhat conical in shape, longer than wide; apical end shorter than base; dorsal opening occupying less than half of dorsal surface of sidepiece. Clasper (pl. 23, fig. 34) almost rectangular in shape, the inner apical angle extended to form a prolongation at the tip of which there is a single terminal spine. Body of adminiculum (pl. 23, fig. 36) triangular, the apical end sharply extended, its apex rounded; ventral surface covered with numerous hairs; basal processes short, at definite angle to the body of adminiculum, well sclerotized, pointed, with slight posteriorly directed spur on lateral margin of each. Arms of adminiculum (pl. 23, fig. 35) with about 12 teeth, five of which are sharply pointed and form a domelike apex, the others distributed along the rest of the arm; lateral plate rectangular, slender.

Female (pl. 29, figs. 151-153).—1.9 mm. long.

HEAD: Dichoptic. Eyes dark reddish brown; fronto-ocular triangle small, the base 1.6 times the height. Antenna 410 μ long, 11-segmented, broad, slightly tapering; segment $3<1+2$, $3<4+5$, $3=11$; scape, pedicel, and first flagellar segment yellowish, the remainder dark brown. Palpi brown. Frons, clypeus, and occipital region black, with gray-white pruinosity and with short tan hairs. Cornuae of buccopharyngeal apparatus heavily sclerotized, dark, pointed; median space hyaline, with 5-6 rows of strong teeth.

Thorax: Mesonotum dark brown to black, completely covered with gray pruinosity except for a fairly wide copper-brown longitudinal band down the midline, which extends to almost the prescutellar region; short, narrow, golden-yellow, scalelike hairs irregularly distributed over mesonotum; no erect black hairs. Humeral angles brown with slight yellowish cast and with gray pruinosity. Scutellum yellowish brown, with a few long yellow hairs and very few scalelike ones. Postnotum dark brown, partially gray-pruinose. Pleura dark brown, with gray-white pruinosity, some areas with yellowish cast. Stem of halter yellow, the knob white. Wings, 2.2 mm. long and 1.0 mm. wide; relation of body length to wing, 1 : 1.2; Sc pilose along basal sixth (3 hairs); R_1 pilose and spiny along apical two-fifths, some spines thick, others very fine; R_{2+3} completely pilose; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.1 mm.; coxa, trochanter, femur, and tibia yellow; tarsus black. Leg 2, length, 1.8 mm.; coxa light brown; trochanter and femur yellow; tibia yellow except for dark-brown patch on anterior face; basitarsus and segments 2-3 yellow, segments 4 and 5 dark brown. Leg 3, length, 2.4 mm.; coxa brown; trochanter and femur yellow; tibia yellow on basal half, dark brown apically; basal four-fifths of basitarsus and basal half of second segment yellow, the remainder of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second segment, 3.6 : 1; calcipala well developed, reaching only halfway to pedisulcus; pedisulcus well developed almost at middle of second segment; claw without any secondary tooth or spur (pl. 35, fig. 261).

Abdomen: Segment 1 tan, with white pruinosity, the tergite with short yellow hairs, the pleurites with long tan hairs. Tergite of segment 2 dark brown; pleural regions tan, white-pruinose, with long yellow hairs. Segments 3-8 each with 3 dark-brown patches, one central and the other two lateral; base color tan, covered with gray pruinosity; golden-yellow hairs on all these segments, but shorter than on segment 2. Sternites tan, pruinose, with yellow hairs.

Genitalia: Cercus (pl. 29, fig. 151) twice as high as it is long (wide), the posterior angles well rounded. Anal lobe (pl. 29, fig. 151) about twice as high as cercus, anterior and posterior margins rounded, posterior-ventral angle with small prolongation that curves under the cercus. Genital rod (pl. 29, fig. 153) hardly dilated at its base; apical expansions of arms of genital fork triangular in shape, the apical angle strongly tapered and pointed; a long toothlike extension near the base from the outer margin; all hyaline. Ovipositor (pl. 29, fig. 152) very small, much longer than wide, its apex pointed.

Pupa (pl. 36, fig. 287, and pl. 39, fig. 327).—Granulosity dense on entire thorax; 4 bifid trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with 8 simple, hairlike spines in transverse row across the middle, the row divided into two by a median space; anterior to the outermost spine on either side of the row are 2 hairs; segments 3 and 4 with 8 simple spines in a transverse row somewhat before the posterior margin, the row divided by a median space; segment 7 with 10 simple spines in transverse row behind the anterior margin, with median separation, and with comblike groups of spines lateral to both ends of the row; segment 8 with 24 simple spines in transverse row behind the anterior margin, with median separation, and with combs lateral to both ends of the row; segment 9 with 24 spines in irregular transverse row behind the anterior margin, not interrupted by median space, with combs lateral to both ends of the row; on either side of midline, near the posterior end of the ninth segment, is a single short, heavy spine. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with 1 bifid spine on either side of midline, about three-fourths the distance from the anterior margin; segment 5 with transverse row of 4 bifid spines, about three-fourths the distance from the anterior margin, divided by median space; segments 6 and 7 with 4 spines in a transverse row about three-fourths the distance from the anterior margin, the outer spines simple, the inner spines bifid; the two spines on either side of the midline are more separated than those on segment 5, the distance between them approximately equal to that of the median space. Terminal spines very small, pointed.

Respiratory apparatus (pl. 36, fig. 287) of each side arising just behind the anterior margin of thorax; composed of 8 filaments which branch as follows: 3-3-2; with poorly marked superficial annulations and with microscopic spicules. Maximum length of filaments, 1.9 mm., about 0.65 times the length of the cocoon; average diameter, 16 μ.

Cocoon (pl. 39, fig. 327): Length of base, 2.9 mm.; maximum width, 1.8 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, without collar; texture of case parchmentlike, the threads visible; rim around anterior aperture thickened. Cocoon covering abdomen and half of thorax; attached along posterior half of its base.

Larva (pl. 40, fig. 366, and pl. 42, fig. 403).—Total length, 4.6 mm. Length of head capsule 1.1 times its width. Width of thorax 1.1 times that of head. Abdominal segments 1-4 slightly narrower than head or thorax; segments 5-7 expanded, at greatest width 1.3 times that of segments 1-4; in profile, like other species of subgenus *Lanea;* in dorsal view, dumbbell-shaped. General color, greenish gray to tan, with black, comma-shaped patches on ventrolateral areas of segments 6-8.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 366. Each cephalic fan with 42 pectinate branches, the hairs on these branches all small, bifid, well separated, not interspersed with other forms of hairs. Mandible with 2 flattened teeth on its inner margin that appear to arise as branches from the same base; apical tooth longer and broader than the other. Antenna 310 μ long, 4-segmented, very clear yellow, passes the basal stalk of the cephalic fan; segment $1>2<3<4$; segments 1 and 2 with longitudinal striations. Submentum with 9 apical teeth, each in form of a half-hexagon, the central tooth and the outermost tooth on either side larger than the others; ventrolateral row composed of 3 hairs in straight line, though not equidistant from one another, the hairs bifid near their apices; lateral margin of submentum deeply serrated, with four toothlike processes. Occipital cleft dome-shaped, with small, nipplelike, apical concavity (pl. 42, fig. 403).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 20-25 rows of hooks at its apex; postclypeal sclerites absent. Posterior sucker with 71-72 rows of hooks. Anal gills with only 3 main divisions that are fleshy and somewhat tapering, no branching. Anterior arms of X-shaped sclerite with apical winglike expansions along both margins, the posterior arms long and well sclerotized; no rectal scales. Two minute ventral tubercles on eighth segment; no pigmented plaques.

Types.—Holotype (♂) and allotype (♀), part mounted on slides, the rest on pins, as well as paratype ♂♂, ♀♀, and pupae, in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected in Río Guayalejo, Xicoténcatl, Tamaulipas, Mexico, March 28, 1944.

SIMULIUM (LANEA) HAEMATOPOTUM Malloch

Simulium haematopotum MALLOCH, U. S. Dept. Agr. Bur. Ent. Techn. Ser., No. 26, pp. 62-63, 1914 (original description, female).—VARGAS, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, pp. 233-234, figs. 2 and 9, 1942 (♂ and ♀ genitalia).

Simulium (*Lanca*) *haematopotum* Malloch, VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 168, fig. 121, 1946 (larva).

Male (pl. 23, figs. 37-39).—2.0 mm. long.

HEAD: Holoptic. Eyes dark brown, shiny. Antenna 390 μ, 11-segmented, slightly tapering; segment $3=1+2=4+5$, $3>11$; brown, the tip black. Palpi black. Clypeus black, white-pruinose, irregularly covered with short black hairs.

THORAX: Mesonotum velvety black; 2 large triangles of white pruinosity, one on either side of midline, the base on the anterior margin, extending slightly more than one-third the length of the mesonotum; lateral margins and prescutellar region also white-pruinose; long, narrow, dark-yellow, scalelike hairs around periphery and on midline, not in packets; row of short tan hairs in prescutellar region. Humeral angles black, white-pruinose, with scalelike hairs. Scutellum very dark brown, with some scalelike hairs and a few long black hairs. Postnotum velvety black, white-pruinose. Pleura dark brown with white pruinosity. Stem of halter brown, the knob bright yellow. Wings, 2.2 mm. long and 1.1 mm. wide; relation of body length to wing, 1:1.1; Sc pilose along its basal fourth; R_1 spiny along its distal half, with at most 2 hairs among the spines; R_{2+3} pilose except for small basal portion; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.2 mm.; coxa, trochanter, and femur light brown; tibia light brown with small apical black ring; tarsus black. Leg 2, length, 1.8 mm.; coxa black; trochanter brown; femur light brown; tibia dark brown; basitarsus and tarsal segments 2 and 3 light brown; segments 4 and 5 black. Leg 3, length, 2.2 mm.; coxa black; trochanter light brown; femur black with light-brown basal ring; tibia light brown on basal half, the apical half black; basal two-thirds of basitarsus and basal half of second segment light brown, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5:1; calcipala well developed, but not reaching pedisulcus; pedisulcus formed at middle of second segment, not deeply incised.

ABDOMEN: Tergite of segment 1 black with short black hairs; pleurites black with long black hairs that reach the fourth segment. Segment 2 black, the pleurites partially white-pruinose, with short black hairs. Other segments black with short black hairs. Sternites tan.

GENITALIA: Sidepiece (pl. 23, fig. 37) somewhat longer than wide, almost square in shape; dorsal opening occupying approximately half of sidepiece. Clasper (pl. 23, fig. 37) shorter than sidepiece, with broad base, somewhat rectangular in shape, the inner apical angle greatly expanded to form a snoutlike structure, at the very end of which there is a single very long, strongly pointed terminal spine. Body of adminiculum (pl. 23, fig. 38) somewhat triangular in shape, broader than long, the apex pointed; with concavity at center of basal margin; covered with numerous hairs that are more numerous near the apex; basal processes short, sclerotized, rather broad at base, tapering to point at apex; appear as gradual extensions of body of adminiculum, not at strong angle to it. Adminicular arm (pl. 23, fig. 39) with numerous rather long, pointed teeth, extending along entire arm, somewhat shorter near apex; lateral plate rectangular, long, very slightly sclerotized.

Female (pl. 30, figs. 154-156, and pl. 35, fig. 262).—2.0 mm. long.

HEAD: Dichoptic. Eyes black; fronto-ocular triangle very small, its base equal to twice its height. Antenna 410 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3=4+5=11$; scape and pedicel light brown, flagellum gradually darkening from its base to apex. Palpi very dark brown. Frons and clypeus black, white-pruinose, with short tan hairs along their lateral margins. Occipital region black, white-pruinose, with short black hairs. Cornuae of buccopharyngeal apparatus heavily sclerotized and broad, except for apices which are sharply pointed; median space sclerotized, with central concavity, and with 2 irregular rows of large, strong teeth.

THORAX: Mesonotum velvety black, with a very wide longitudinal band of white pruinosity on either side of the midline, extending from the anterior margin to the white pruinosity of the prescutellar region with which it blends; the band on each side of the midline tapers somewhat, being wider in front, and the distance between the two bands is about equal to the width of any one of the bands; lateral margins of mesonotum also white-pruinose; long, narrow, yellow, scalelike hairs distributed over entire surface of mesonotum; some short black hairs on mesonotum, slightly longer in prescutellar region. Humeral angles black, white-pruinose, with yellow scalelike hairs. Scutellum dark brown, shiny, with several yellow scalelike hairs and a few long black hairs. Postnotum velvety dark brown, with white pruinosity, devoid of hairs. Pleura dark brown, with white pruinosity. Stem of halter light brown, the knob tan to white. Wings, 2.2 mm. long and 1.0 mm. wide; relation of body length to wing, 1:1.1; Sc pilose along the basal fourth; R_1 spiny along apical three-fifths; R_{2+3} pilose except for short basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.1 mm.; coxa, trochanter, femur, and tibia yellow; tarsus black. Leg 2, length, 1.8 mm.; coxa brown; trochanter and femur tan; tibia tan with large black patch on outer face; basitarsus and tarsal segments 2 and 3 tan, the remainder black. Leg 3, length, 2.5 mm.; coxa brown; trochanter yellow; femur with basal fourth yellow, apex black, and median portion dark brown; tibia with basal half yellow, apical half dark brown; basal three-fourths of basitarsus and basal half of second segment yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.8:1; calcipala well developed, almost reaching the pedisulcus; pedisulcus very deeply incised; basal heel somewhat developed, but without secondary spur or tooth (pl. 35, fig. 262).

Abdomen: Tergite of segment 1 black, with white pruinosity and several short yellow hairs; the pleurites similarly colored and clothed, with the addition of long tan hairs that reach the fourth segment. Segment 2 dark brown with gray pruinosity. Segments 3-6 with wide black median band, the sides gray-pruinose; segments 7 and 8 with short golden hairs. Sternites tan.

Genitalia: Cercus (pl. 30, fig. 154) dome-shaped, somewhat higher than long (wide), with few long, strong hairs and numerous minute, scalelike hairs. Anal lobe (pl. 30, fig. 154) both high and rather long (wide), with fingerlike prolongation that curves under the cercus; similar investiture to that of cercus. Genital rod (pl. 30, fig. 156) with basal dilatation hardly noticeable; apical expansions of arms of genital fork triangular in shape, the inner basal and apical angles rounded and hyaline; at middle of outer margin there is a very heavily sclerotized and pigmented toothlike projection; the heavily pigmented patch extends from base of this projection across the expansion to its inner margin. Ovipositor (pl. 30, fig. 155) very small, with heavily pigmented group of spines.

Pupa (pl. 36, fig. 288, and pl. 39, fig. 328).—Granulosity very sparse and poorly marked on thorax; 2 bifid trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with 8 simple, hairlike spines in transverse row, crossing the segment about three-fourths the distance from anterior margin, the row divided in two by a median space; anterior to the outermost spine on either side of the row are 2 hairs, the most anterior heavier; segments 3 and 4 with 8 simple spines in a transverse row somewhat in front of posterior margin, the row being divided by median space; segment 7 with 8-18 simple spines in transverse row behind the anterior margin, with median separation; segment 8 with 24-26 simple spines in an uninterrupted transverse row one-fourth the distance from the anterior margin, and with comblike groups of spines lateral to each end of the row; segment 9 with 14 simple spines in transverse row along anterior margin, with median space. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single simple spine on either side of the midline halfway back from the anterior margin; segment 5 with transverse row of 4 bifid spines, crossing about three-fourths the distance from the anterior margin, interrupted by median space; segments 6 and 7 with 4 spines in transverse row about three-fourths the distance from the anterior margin, the outer spines simple, the inner one bifid; the two spines on either side of the midline are more separated than those on segment 5, the distance between them approximately equal to that of the median space. Terminal spines very short, conical.

Respiratory apparatus (pl. 36, fig. 288) of each side arising just behind the anterior margin in the region of the humeral angles; composed of 8 filaments which branch as follows: 3-3-2; all filaments have superficial annulations and microscopic spicules. Maximum length of filaments, 1.8 mm., about 0.5 times length of cocoon; average diameter, 28 μ.

Cocoon (pl. 39, fig. 328): Length of base, 3.5 mm.; maximum width, 1.4 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, without collar, but with lateral margins of base connected at anterior end by narrow band; usually with anteriorly directed extension of case from dorsal margin of anterior aperture; texture of case parchmentlike, threads not visible; rim around anterior aperture not thickened. Cocoon covering abdomen and half of thorax; attached along posterior half of base.

Larva (pl. 40, fig. 367, and pl. 42, fig. 404).—Total length, 4.4-4.6 mm. Length of head capsule 1.1 times the width. Width of thorax 1.4 times that of head. Width of abdominal segments 1-4 equal to 1.1 times that of head; segments 5-7 expanded, 1.7 times width of abdominal segments 1-4; cross section and general shape the same as other species of the subgenus *Lanea*. Tan to yellow, with grayish-green transverse band across the abdominal segments, the bands interrupted at the middle of dorsum; band of same color forming collar just posterior to head capsule; ventrolateral patches not usually visible on segments 6 and 7.

Head: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 367. Each cephalic fan with 27-28 pectinate branches, the hairs on these branches extremely fine, short, somewhat separated, simple, not intermixed with other kinds of hairs. Mandible with 2 teeth on its inner margin, separated from each other but very close together, the more basal one very sharply pointed and needlelike. Antenna 330 μ long, 4-segmented, yellow, far surpassing the basal stalk of the cephalic fan; segment $1<3<2>1$; clear area between segments 2 and 3; no transverse striations. Submentum with 9 apical teeth, shaped like half of a hexagon, all of approximately the same length; ventrolateral row composed of 3 to 5 hairs in a straight row, the apical three bifid at their ends, the basal hairs simple; lateral margin of submentum with 4 toothlike processes, two of them near the apical teeth, the other two more basal. Occipital cleft dome-shaped, the apex pointed (pl. 42, fig. 404).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 34 rows of hooks at its apex; postclypeal sclerites rarely visible. Posterior sucker with 78-82 rows of hooks. Anal gills with 3 fleshy main divisions, at times each of these with 1 to 3 fingerlike projections. Anterior and posterior arms of X-shaped sclerite well sclerotized; anterior arms with wedge-shaped membranous expansion on the outer margin, the arms extending only slightly beyond these; posterior arms rather long; no rectal scales. Two rather small ventral papillae on eighth segment, no plaques.

Types.—♀ (U.S.N.M. No. 15414) in the collection of the United States National Museum; collected in Santa Lucrecia, Veracruz, Mexico.

SIMULIUM (LANEA) JACOBSI Dalmat

Simulium (*Lanea*) *jacobsi* Dalmat, Ann. Ent. Soc. Amer., vol. 46, No. 1, pp. 40-42, figs. 9-11, 1953 (original description, larva).

In giving the original description of this species, the author mentioned his desire to find further examples so that the adult and pupa could be described. Unfortunately, sufficient opportunity to collect in the same locality did not arise and the description of the larva is all that is available at present. It is hoped that future workers will have the opportunity to make further collections of this species.

Larva (pl. 40, fig. 368, and pl. 42, fig. 405).—Total length, 4.6 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times that of head. First 4 abdominal segments 1.3 times width of head; segments 5-7 expanded, greatest width at segment 6 which is about 1.4 times that of segments 1-4; segment 8 sharply tapering. General color white, with transverse purple bands across posterior half of abdominal segments 1-8, these interrupted on segments 5-7 by longitudinal white lines that cross through the transverse bands giving a striped appearance to that region of the abdomen; without dark patches on the ventrolateral regions of segments 6 and 7.

Head: Frons-clypeus (pl. 40, fig. 368) pale yellow with a very dark, irregularly triangular design on its posterior half, the design not interrupted by nonpigmented regions although clearly marked areas of contrasting intensity of color are visible; epicranial plates (pl. 40, fig. 368) of each side with 2 extensive dark areas along the posterior margin, each with 3 or 4 small markings within, those in the more lateral area appearing somewhat lighter than the surrounding region. Each cephalic fan with 31-33 nonpectinate branches. Mandible with 2 flattened teeth on its inner margin, these being close together but not appearing to arise from a common base; more distal tooth about twice the length of the other. Antenna 275 μ long, 4-segmented, transparent yellow, just reaching the apex of the basal stalk of cephalic fan; segment 2 divided into two near its midregion giving the antenna the appearance of having 5 segments; segments 1 and 2 about equal in length, either of these longer than segment 3; segment 1 with longitudinal striations. Submentum with 9 apical teeth, all of almost equal size, blunt, their lateral margins parallel; ventrolateral row composed of 3 fairly short, stout hairs, the middle one trifid near its apex, the basal one simple; lateral margin of submentum with 4 toothlike structures, the most apical one separated from the other three and appearing to emerge from the lateral margin of the outermost of the apical teeth; 4 small hairs emerging from ventral surface of median plate. Occipital cleft dome-shaped, the apex with a slight concavity (pl. 42, fig. 405).

Thorax and Abdomen: Light cream color with purple collar near anterior margin; pseudopod (thoracic proleg) with 20-25 rows of hooks at its apex; postclypeal sclerites in form of small, heavily pigmented circles that are well separated from each other. Posterior sucker with 80-84 rows of hooks. Anal gills in form of 3 very broad, conical structures that taper considerably from their base to apex; on the ventral surface of the middle trunk there is a single, short, fingerlike projection emerging from near the midregion; from near the same region of the right trunk, and extending to its apex, emerge 2 long projections; from the left trunk 3 such fingerlike projections emerge and also extend to its apex; thus the anal gills have 9 branches in all. The X-shaped sclerite is simple, well sclerotized, with no pigmented patches between the arms; no rectal scales. No ventral papillae or plaques on eighth segment.

This larva has been placed in the subgenus *Lanea* because it possesses the following combination of characteristics: Mandible with 2 teeth on its inner margin; occipital cleft well formed and not reaching submentum; antennae 4-segmented (rather than 5-segmented, with further superficial divisions of second segment); posterior sucker with fewer than 150 rows of hooks; antennae lacking transverse striations; and rectal scales absent. *Simulium* (*L.*) *jacobsi* appears closest to *S.* (*L.*) *samboni* and *S.* (*L.*) *haematopotum* but can easily be distinguished from them by the completely dark patterns of the frons-clypeus, the nonpectinate condition of the branches of the cephalic fans, the color patterns on the thorax and abdomen, and the absence of ventral tubercles on the eighth segment of the abdomen.

Type.—Larva (2 slides), in collection of the United States National Museum; collected in the Río Michatoya, Finca El Llano, Palín, Department of Escuintla, Guatemala, June 22, 1951.

SIMULIUM (LANEA) SAMBONI Jennings

Simulium samboni Jennings, Proc. Ent. Soc. Washington, vol. 17, pp. 199-200, 1915 (original description, ♀ and ♂).—Fairchild, Ann. Ent. Soc. Amer., vol. 33, No. 4, pp. 704-705, figs. 8, 9, 24, and 31, 1940 (♀, ♂, and pupa).—Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, p. 240, fig. 6, 1942 (♂ genitalia).

Simulium (*Lanea*) *samboni* Jennings, Vargas and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 9, No. 4, p. 343, figs. 60-61, 1948 (larva).—Dalmat, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 55-57, 1951 (presence and distribution in Guatemala given).

Male (pl. 23, figs. 40-42).—2.2 mm. long.

Head: Holoptic. Eyes dark reddish brown. Antenna 480 μ long, 11-segmented; segment $3>1+2$, $3>4+5$, 3 twice 11; scape and pedicel light brown, flagellum darkening toward apex. Palpi dark brown to black. Clypeus dark brown, partially white-pruinose.

Thorax: Mesonotum yellow to orange, with 2 longitudinal wedge-shaped patches of white pruinosity, the bases on the anterior margin, one on either side of the midline, extending somewhat more than one-fourth the way back; wide band of white pruinosity on the lateral margins; short, narrow, golden, scalelike hairs over entire mesonotum, more numerous along anterior margin and in prescutellar region, never in packets; short black hairs over entire mesonotum. Humeral angles pale yellow, white-pruinose, with yellow scalelike hairs. Scutellum pale yellow, with some yellow, scalelike hairs and a few long black hairs. Postnotum velvety brown, its midline yellow, with white pruinosity. Pleura pale yellow, with white pruinosity. Stem of halter dark brown, the knob yellow. Wings, 2.2 mm. long and 1.1 mm. wide; relation of body length to wing, 1:1; Sc pilose along its basal third; R_1 completely pilose, its distal half also with spines; R_{2+3} pilose except for minute basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.2 mm.; coxa, trochanter, and femur yellow; tibia tan on anterior edge, dark brown on posterior edge; tarsus dark brown to black. Leg 2, length, 1.9 mm.; coxa dark brown; trochanter and femur yellow; tibia yellow, sometimes longer than femur; basitarsus and basal half of second tarsal segment yellow, apical half of the latter, as well as all of segments 3-5, black. Leg 3, length, 2.3 mm.; coxa brown; trochanter yellow; femur yellow with small dark apical patch; tibia yellow on basal half, black on apical half; basal two-thirds of basitarsus and basal half of second segment yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second tarsal segment, 4:1; calcipala well developed, almost reaching pedisulcus; pedisulcus rather well formed on basal third of second segment.

Abdomen: Tergite of segment 1 yellow, with short yellow hairs; pleurites yellow, with long yellow hairs that reach segment 4. Segment 2 yellow, the anterior margin white-pruinose, with short black hairs. Segment 3 yellow. Segment 4 black. Segments 5-8 with anterior half yellow and posterior half black; at times, these segments appear almost entirely black, with very little yellow. All segments with short black hairs. Sternites tan.

Genitalia: Sidepiece (pl. 23, fig. 40) cylindrical in shape, somewhat tapered toward the apex; about 1.5 times the length of clasper; dorsal opening occupying more than half of dorsal surface of sidepiece, rounded. Clasper (pl. 23, fig. 40) short and wide, the length almost equal to the width, the inner apical angle tapered, somewhat rounded, with 2 well-developed terminal spines, one closer to the apex than the other. Body of adminiculum (pl. 23, fig. 42) almost crescent-shaped, the apex with slight concavity; with numerous hairs over entire surface, especially near the midline; basal processes short, well sclerotized, pointed, with spurlike structures near the apices. Arms of adminiculum (pl. 23, fig. 41) with about 10 spines arranged in a whorl, the spines not sharp-pointed; lateral plate narrow, somewhat quadrangular, wrinkled.

Female (pl. 30, figs. 157-159, and pl. 35, fig. 264).—2.0 mm. long.

Head: Dichoptic. Eyes black; fronto-ocular triangle very small, its height about equal to the base. Antenna 530 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3<11$; scape and pedicel light brown, the flagellum gradually darkening from its base to apex. Palpi brown, its apex black. Frons black, white-pruinose, with a single row of short tan hairs along each margin. Clypeus black, white-pruinose, irregularly covered with short tan hairs. Occipital region dark brown, white-pruinose, irregularly clothed with yellow scalelike hairs and short black ones. Cornuae of buccopharyngeal apparatus sclerotized, with winglike expansions; median space somewhat sclerotized, with several rather long, well-developed, sharply pointed teeth along entire extent.

THORAX: Mesonotum orange; 2 narrow longitudinal stripes of white pruinosity, one on either side of midline, extending from transverse row of white pruinosity, situated along the anterior margin of mesonotum, to prescutellar depression which is also white-pruinose; the longitudinal stripes are wider at the anterior margin and they curve outward near their posterior limit; narrow band of white pruinosity along lateral margins; short, narrow, yellow, scalelike hairs along the periphery, more in the prescutellar region; short black hairs on dorsum, principally along anterior and posterior margins. Humeral angles pale yellow, with white pruinosity. Scutellum yellow, darker near midline, with white pruinosity. Postnotum brown on anterior half, yellow on posterior half, with white pruinosity, devoid of hairs. Pleura light brown, partially white-pruinose. Stem of halter brown, the knob pale yellow. Wings, 2.1 mm. long and 1.0 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal two-thirds; R_1 completely pilose, with spines also along distal half; R_{2+3} pilose except for a very short basal section (long enough for only one hair); Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.2 mm.; coxa, trochanter, and femur yellow; tibia yellow with brown apical ring; tarsus black. Leg 2, length, 1.9 mm.; coxa dark brown; trochanter, femur, tibia, and basitarsus yellow; tarsal segment 2 yellow on basal half, black on apical half; tarsal segments 3-5 black. Leg 3, length, 2.4 mm.; coxa dark brown at base, light brown at apex; trochanter yellow; femur yellow with brown apical ring; tibia yellow on basal half, brown on apical half; basal two-thirds of basitarsus and basal half of second tarsal segment yellow, the remainder of these segments, as well as all of segments 3-5, dark brown to black; relation of basitarsus to second segment, 4 : 1; calcipala well developed, long and slender, surpassing the pedisulcus; pedisulcus well formed at middle of second segment; claw with basal heel very slightly developed, without secondary spur or tooth (pl. 35, fig. 264).

ABDOMEN: Tergite of segment 1 yellow, with short yellow hairs; pleurites yellow, with long yellow hairs reaching segment 3. Segment 2 yellow with short black hairs. Segments 3-6 yellow with black median patch and with one or two smaller dark patches on each side of the median one; this gives the appearance of longitudinal rows of spots; segments 7 and 8 yellow, with white pruinosity. Sternites tan, with a few long black hairs on last segment.

Genitalia: Cercus (pl. 30, fig. 157) dome-shaped, the height about equal to length (width). Anal lobe (pl. 30, fig. 157) rather narrow, of about equal width (length) throughout, except at the ventral portion where it becomes greatly narrowed to form a pointed structure; with slight projection on posterior margin that curves under the cercus. Genital rod (pl. 30, fig. 159) with practically no basal dilatation; apical expansions of arms of genital fork triangular in shape, the inner basal angle almost 90 degrees; apical angle sharply pointed, well sclerotized; near the middle of the outer margin there is a very short, sclerotized, toothlike projection, the margin also sclerotized between the base of this projection and the apical angle. Ovipositor (pl. 30, fig. 158) short, lanceolate, somewhat broadened at apex.

Pupa (pl. 36, fig. 289, and pl. 39, fig. 329).—Granulosity on entire thorax; 5 bifid hairs on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple, hairlike spines in a transverse row across its middle, the row divided in two by a median space; anterior to the outermost spine on either extremity are 2 hairs, the most anterior somewhat heavier; segments 3 and 4 each with a transverse row of 8 simple spines, crossing the segment somewhat before the posterior margin, the row divided in two by a median space; segments 6 and 7 with transverse row of 22 simple spines, with median separation, and with comblike groups of minute spines lateral to each end of the row; segment 8 with uninterrupted row of 25-30 spines and with combs lateral to each end of the row; segment 9 with 8 spines in uninterrupted row, without combs; all rows of spines on segments 6-9 are across the anterior margins. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single simple spine on either side of midline near middle of segment; segment 5 with transverse row of 4 bifid spines, a little before the posterior margin, with median separation; segments 6 and 7 with transverse row of 4 spines about three-fourths the way back from the anterior margin, the two outer spines simple, the two inner spines either bifid or trifid; the 2 spines on either side of the midline of segments 6 and 7 are more separated than those on segment 5, the distance between them approximately equal to that of the median space. Terminal spines very small, pointed.

Respiratory apparatus (pl. 36, fig. 289) of each side arising behind the anterior margin of thorax; composed of 8 filaments which branch as follows: 3-3-2; all filaments very thin, with superficial annulations and with microscopic spicules. Maximum length, 1.9 mm., about 0.6 the length of the cocoon; average diameter, 20 μ.

Cocoon (pl. 39, fig. 329): Length of base, 3.1 mm.; maximum width, 2.2 mm.; maximum height, 1.7 mm. Cocoon of wall-pocket type, without collar; texture of case parchmentlike in the matrix of which are seen loose threads; rim around anterior aperture well thickened; cocoon with small, lateral, winglike expansions. Cocoon covering abdomen and two-thirds of thorax; attached along posterior half of base.

Larva (pl. 40, fig. 369, and pl. 42, fig. 406).—Total length, 5.0-5.2 mm. Length of head capsule 1.2 times its width. Width of thorax 1.4 times that of head. First 4 abdominal segments 1.1 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.7 times the width of abdominal segments 1-4; cross section and profile like those of other species in the subgenus *Lanea*. General color creamy white, with numerous greenish-yellow markings; abdominal segments 1-4 each with a yellow transverse band; segments 5-7 appear all yellow; dark-brown dorsolateral patches on segment 7, hardly visible on segment 6.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 369. Each cephalic fan with 37-39 pectinate branches, the hairs on these branches fine, short, and close together, intermixed at intervals with longer bifid hairs. Mandible with 2 rather slender, long, pointed teeth on its inner margin, the teeth well separated, the distal tooth about twice the length of the other. Antenna 340 μ long, 4-segmented, light brown, just passing the basal stalk of the cephalic fan; segments 1 and 2 subequal, each shorter than segment 3; pale band at base of segment 3; no transverse striations. Submentum with 9 triangularly shaped apical teeth, the central one longer than the others; ventrolateral row composed of 3 bifid or trifid hairs in straight line; lateral margin of submentum with 4 toothlike serrations, the most apical two heavily sclerotized like the apical teeth. Occipital cleft dome-shaped, broad, almost semicircular (pl. 42, fig. 406).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 34 rows of hooks at its apex; postclypeal sclerites medium-sized, fairly well pigmented. Posterior sucker with 73-75 rows of hooks. Anal gills with 3 main divisions, each with 3-4 fingerlike projections; one projection in each group longer than the others, somewhat club-shaped. Anterior and posterior arms of X-shaped sclerite well sclerotized; anterior arms with wedge-shaped expansions along the outer margins that almost reach the extremity of the arms; large green patch in front of the anterior arms and between them; on either side, between the anterior and posterior arm, can be seen several long, simple spines; no rectal scales. Two ventral papillae on eighth segment well developed, pointed; no sclerotized plaques.

Types.—Holotype ♂, and ♀ (U.S.N.M. No. 19996), in collection of the United States National Museum; reared from pupae collected in a small tributary of the Comacho River, Empire, Canal Zone, Panama, October 4, 1913.

SIMULIUM (LANEA) TRIVITTATUM Malloch

Simulium trivittatum Malloch, U. S. Dept. Agr. Bur. Ent. Techn. Ser., No. 26, p. 30, 1914 (original description, female).—Dyar and Shannon, Proc. U. S. Nat. Mus., vol. 69, art. 10, pp. 37-38, figs. 78, 79, 115, and 116, 1927 (♂ and ♀ genitalia).—Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 4, No. 4, figs. 19-26, 1943 (♂ genitalia, posterior legs of ♂ and ♀, and pupa).

Simulium (Lanea) trivittatum Malloch, Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 169-170, fig. 127, 1946 (larva). —Dalmat, Amer. Midl. Nat., vol. 52, No. 1, pp. 175-196, 1954 (presence in Guatemala).

Male (pl. 23, figs. 43-45).—The only male reared from pupae collected in Guatemala was dissected prior to preparing a description of the external characters. Therefore, a description can be given of only the wings, legs, and genitalia since these were mounted on slides.

Wings: 2.6 mm. long and 1.2 mm. wide; Sc pilose along basal third; R_1 with hairs and spines on distal half, the spines more numerous than the hairs; R_{2+3} pilose except for short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.8 mm.; coxa, trochanter, and femur yellow; tibia yellow on basal half, brown on apical half; tarsus dark brown to black. Leg 2, length, 2.0 mm.; coxa, trochanter, and femur yellow; basal half of tibia and basitarsus yellow, the apical half brown; tarsal segments 2-5 dark brown to black. Leg 3, length, 2.9 mm.; coxa brown; trochanter yellow; femur and tibia yellow with apical dark ring; basitarsus yellow on basal two-thirds, black on apical third; tarsal segments 2-5 black; relation of basitarsus to second segment, 3.2:1; calcipala well developed, not reaching pedisulcus; pedisulcus well formed one-third the distance from the base of second tarsal segment.

Genitalia: Sidepiece (pl. 23, fig. 43) somewhat cylindrical in shape, the apical margin shorter than the basal one, longer than wide; dorsal opening occupying somewhat more than half of dorsal surface of sidepiece. Clasper (pl. 23, fig. 43) almost twice as long as it is wide, apex wider than base; outer apical angle rounded, the inner apical angle pointed, somewhat prolonged, with a single terminal spine. Body of adminiculum (pl. 23, fig. 44) semicircular, the apex somewhat pointed, the base with slight concavity; entire ventral surface clothed with short and long hairs, the longer ones closer to apex; basal processes short, well sclerotized, pointed. Adminicular arms (pl. 23, fig. 45) with about 20 teeth arranged along distal half of arm, more numerous near apex; lateral plate narrow, somewhat quadrangular in shape.

Female (pl. 30, figs. 160-162, and pl. 35, fig. 266).—2.5 mm.

HEAD: Dichoptic. Eyes reddish brown with gray pruinosity; base of fronto-ocular triangle 1.8 times the height. Antenna 500 μ long, 11-segmented, slightly tapering beyond segment 5; segment $3<1+2$, $3<4+5$, $3=11$; scape and pedicel yellow, flagellum dark brown. Palpi brown, with gray pruinosity. Frons coppery red with gray pruinosity and with dark-brown hairs. Clypeus coppery red with silvery scales near its midregion. Occipital region coppery red with long yellow hairs along entire periphery.

THORAX: Mesonotum very dark reddish brown; 2 longitudinal bands of white pruinosity, wider at the anterior margin, where they originate, extending to prescutellar region which is also white-pruinose; lateral margins also white-pruinose; the longitudinal bands divide the mesonotum into 3 reddish-brown vittae; short, narrow, yellow, scalelike hairs over entire surface of mesonotum, somewhat longer in prescutellar region; short black hairs over entire mesonotum. Humeral angles very dark reddish brown with white pruinosity. Scutellum light yellow, with white pruinosity, and with long black hairs and golden scalelike hairs. Postnotum reddish brown, gray-pruinose, devoid of hairs. Pleura reddish brown with white pruinosity. Stem of halter brown, the knob white. Wings, 2.9 mm. long and 1.3 mm. wide; relation of body length to wing, 1 : 1.2; Sc pilose along its basal three-fifths; R_1 with both spines and hairs along distal half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.9 mm.; coxa, trochanter, and femur yellow; tibia yellow with dark apical ring; tarsus reddish brown. Leg 2, length, 2.5 mm.; coxa reddish brown; trochanter yellow; femur yellow with dark apical ring; basal half of tibia and basitarsus yellow, the apical half brown; tarsal segments 2-5 dark brown. Leg 3, length, 3.2 mm.; coxa dark reddish brown; trochanter yellow; femur yellow on basal fourth, dark brown on apical three-fourths, with numerous black hairs; tibia yellow on basal half, dark brown on apical half; basal three-fifths of basitarsus and basal half of second segment yellow, the remainder of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second segment, 4.4:1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed one-fourth the distance from the base of second segment; claw small, with almost no heel and with no secondary tooth or spur (pl. 35, fig. 266).

Abdomen: Tergite and pleurites of segment 1 reddish brown with white pruinosity, the tergite with short yellow hairs, the pleurites with long yellow hairs that extend back to the more posterior segments. Segment 2 reddish brown, with white pruinosity and short yellow hairs. Segments 3-6 yellow, each with a median dorsal dark-brown patch and 2 similar patches on either side of the median one, giving the appearance of 5 longitudinal rows of 4 patches each; the yellow base color between the patches has white pruinosity; segment 7 yellow, with a single, less-pronounced patch on either side near the lateral margin, the remainder of segment white-pruinose; segment 8 completely covered by white pruinosity; segments 3-8 invested with short black hairs that are evenly distributed, longer on segments 7 and 8. Sternites white-pruinose with black hairs.

Genitalia: Cercus (pl. 30, fig. 160) somewhat higher than long (wide), the posterior angles well rounded. Anal lobe (pl. 30, fig. 160) high and narrow (short), about three times the height of the cercus; ventral portion strongly tapered to a point, with a median projection from the posterior margin that curves somewhat beneath the cercus. Genital rod (pl. 30, fig. 162) with very slight oval dilatation; apical expansions of arms of genital rod irregularly triangular in shape, hyaline, the apical angle fairly sharp-pointed, the inner basal angle very broad and protruding; outer basal angle rather acute and small, arising on the outer margin between the apical and inner basal angles. Ovipositor (pl. 30, fig. 161) small, narrow, very short, the apex membranous and somewhat expanded; with riblike structures from base along half the length.

Pupa (pl. 36, fig. 290, and pl. 39, fig. 330).—Granulosity well marked on central part of thorax; 5 simple trichomes on either side of midline, all but one close to the lateral margin. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7 and 8 are posteriorly directed; segment 2 with 8 simple, hairlike spines in a transverse row about three-fourths the distance from the anterior margin, the row divided by a median space; anterior to the outermost spine on either extremity are 2 fine hairs; segments 3 and 4 each with a transverse row of 8 simple spines, each row divided in two by a median space, crossing the segment somewhat before the posterior margin; segment 7 with 16 spines in a transverse row somewhat behind the anterior margin, with median separation, and with several comblike groups of minute spines lateral to both ends of the row; segment 8 with uninterrupted row of 30 simple spines across the anterior margin and with numerous combs lateral to both extremities. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single long, simple spine on either side of midline at middle of segment, with separation between the spines of either side; segment 5 with transverse row of 4 bifid spines, with median separation, somewhat in front of the posterior margin; segments 6 and 7 each with transverse row of 4 spines about three-fourths the distance from the anterior margin, with median separation, the outer spines simple, the inner spines bifid; the 2 spines on either side of the midline of segments 6 and 7 are more separated than those of segment 5, the distance between them being approximately equal to that of the median space. Terminal spines very small, ending in points.

Respiratory apparatus (pl. 36, fig. 290) of each side arising in the region of the humeral angles, just behind the anterior margin of the thorax; composed of 8 filaments which branch as follows: 3-3-2; all filaments with well-marked superficial annulation, and with granulosity; no microscopic spicules. Maximum length, 1.8 mm., about 0.64 times the length of the cocoon; average diameter, 24 μ.

Cocoon (pl. 39, fig. 330): Length of base, 2.8 mm.; maximum width, 1.5 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, without collar; no winglike extensions from lateral margins of base; rim around anterior aperture thickened; texture of case parchmentlike, granular, threads not visible. Cocoon covering abdomen and two-thirds of thorax; attached along the posterior half of its base.

Larva.—No specimens available.

Types.—♀ (U.S.N.M. No. 15408), in collection of the United States National Museum; collected in Tampico, Tamaulipas, Mexico.

SIMULIUM (LANEA) VERACRUZANUM Vargas, Martínez, and Díaz

Simulium (*Lanea*) *veracruzanum* VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 133-136, 170, figs. 53-57 and 155, 1946 (original description, ♂, ♀, pupa, and larva).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 55-57, 1951 (presence and distribution in Guatemala).

Male (pl. 24, figs. 46-48).—3.0 mm. long.

HEAD: Holoptic. Eyes very dark reddish brown, almost black. Antenna 440 μ long, 11-segmented, black; segment $3>1+2$, $3>4+5$, $3>11$. Palpi black. Clypeus black, white-pruinose, irregularly covered with long black hairs.

THORAX: Mesonotum black; two very large triangles of white pruinosity, their bases on the anterior margin of mesonotum, extending posteriorly so that their apices join with the white pruinosity of the prescutellar region; distance between the two triangles equal to at least width of one of the triangles; lateral margins of mesonotum also white-pruinose; long, narrow, yellow, scalelike hairs around periphery, dull brown in midregion; few tan hairs on anterior margin and in prescutellar region. Humeral angles brown, white-pruinose, with yellow scalelike hairs. Scutellum brown to black, shiny, with a few long black hairs and several yellow scalelike hairs. Postnotum velvety black, white-pruinose. Pleura dark brown, evenly white-pruinose. Stem of halter dark brown to black, the knob yellow. Wings, 2.6 mm. long and 1.0 mm. wide; relation of length of body to wing, 1.2 : 1; Sc pilose along basal third; R_1 spiny and pilose along distal half; R_{2+3} pilose along distal five-sixths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.7 mm.; coxa, trochanter, and femur brown; tibia with basal three-fourths tan, the apical fourth black; tarsus black. Leg 2, length, 2.4 mm.; coxa black; trochanter and femur dark brown; tibia tan on its basal three-fourths, black on apical fourth; basitarsus tan on basal two-thirds, black on apical third; tarsal segments 2-5 black. Leg 3, length, 2.9 mm.; coxa, trochanter, and femur black; basal half of tibia tan, apical half black; basal half of basitarsus and of second tarsal segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.8 : 1; calcipala well developed, almost reaching the pedisulcus; pedisulcus well developed on basal third of second segment.

ABDOMEN: Tergite of segment 1 black, with short black hairs; pleurites black, with long black hairs reaching segment 4. Segment 2 black, anterior half of tergite white-pruinose, with short, black hairs. Other segments black, clothed with short black hairs; pleura of segment 6 white-pruinose. Sternites tan.

GENITALIA: Sidepiece (pl. 24, fig. 46) somewhat cylindrical in shape, longer than wide; dorsal opening occupying approximately half of dorsal surface of sidepiece. Clasper (pl. 24, fig. 46) somewhat flattened, its length equal to about twice its width; outer distal angle rounded, the inner distal angle somewhat prolonged, with a single stout terminal spine. Body of adminiculum (pl. 24, fig. 47) wider than long, the apex prolonged, dome-shaped; narrow, winglike expansions along lateral margins; entire ventral surface covered with both short and long hairs, the longer ones more prevalent at the apex; basal processes rather short, well sclerotized, pointed. Arms of adminiculum (pl. 24, fig. 48) with numerous (about 35) teeth, both long and short, extending along its entire length; lateral plate long, somewhat rectangular in shape, wrinkled, slightly sclerotized.

Female (pl. 30, figs. 163-165, and pl. 35, fig. 263).—2.5 mm. long.

HEAD: Dichoptic. Eyes very dark reddish brown; fronto-ocular triangle very small, its base 1.5 times its height. Antenna 420 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3=4+5$, $3=11$; scape and pedicel light brown, flagellum dark brown to black. Palpi black. Frons black, white-pruinose, with one irregular row of black hairs along the lateral margins. Clypeus black, white-pruinose, irregularly covered with short black hairs. Occipital region black with a few long black hairs. Cornuae of buccopharyngeal apparatus sclerotized, hornlike, sharply pointed; median space hyaline, with long thin teeth on lateral margins.

THORAX: Mesonotum velvety black, with 2 very wide longitudinal stripes of white pruinosity which extend, one on either side of midline, from the anterior margin to the white pruinosity of the prescutellar region; bands widest at anterior margin, with more than the width of one band between them; lateral margins yellow, with white pruinosity; long, narrow, brilliant-yellow, scalelike hairs along the periphery and on the longitudinal bands; short black hairs on all of mesonotum. Humeral angles yellow, with white pruinosity. Scutellum dull yellow, with a few long black hairs and with some yellow scalelike hairs. Postnotum velvety brown, with white pruinosity. Pleura yellow to brown, with white pruinosity. Stem of halter light brown, the knob yellow. Wings, 2.7 mm. long and 1.2 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along basal two-thirds; R_1 pilose and spiny on distal half; R_{2+3} pilose except for very short basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.6 mm.; coxa, trochanter, and femur light brown; basal four-fifths of tibia tan, the apical fifth dark brown; tarsus black. Leg 2, length, 2.4 mm.; coxa brown; trochanter light brown; femur light brown with small dark-brown apical ring; tibia tan on basal two-thirds, dark brown on apical third; basal half of basitarsus tan, apical half black; tarsal segments 2-5 black. Leg 3, length, 2.9 mm.; coxa dark brown; trochanter light brown; femur light brown on basal third, dark brown on apical two-thirds; basal half of tibia light brown, apical half black; basal two-thirds of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 3.9 : 1; calcipala well developed, reaching only halfway to pedisulcus; pedisulcus well developed at middle of second segment; claw without tooth or spur (pl. 35, fig. 263).

Abdomen: Tergite of segment 1 tan, the anterior and posterior margins white-pruinose, with yellow hairs; pleurites tan, with long tan hairs that reach the third segment. Anterior half of segment 2 tan, the posterior half black, clothed with black hairs; pleura white-pruinose. Segments 3-6 yellow to light brown, with white pruinosity, each segment with 3 black patches, one median and one on either side; these segments clothed with short dark-brown hairs; segments 7 and 8 brown, without dark patches. Sternites tan.

Genitalia: Cercus (pl. 30, fig. 163) dome-shaped, its height about equal to the length (width). Anal lobe (pl. 30, fig. 163) broad except for the ventral projection which is very long, narrow, and pointed. Genital rod (pl. 30, fig. 165) with basal dilatation; apical expansions of arms of genital fork narrowly triangular in shape; the inner basal angle is very large, shaped like a beak, hyaline; the apical angle is rather broadly pointed; a short, well-sclerotized tooth extending from the middle of the outer margin; at times this tooth is absent, the apical angle is very sharply pointed, and the distal half of the outer margin is well sclerotized (pl. 30, fig. 165). Ovipositor (pl. 30, fig. 164) short, appearing like a group of spikes within a membrane.

Pupa (pl. 36, fig. 291, and pl. 39, fig. 331).—Granulosity on entire thorax; 5 bifid and 2 simple trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-8 are posteriorly directed; segment 2 with 8 simple spines in transverse row across the middle of the segment, the row divided in two by a median space; outermost spines very fine and hairlike; anterior to the outermost spine on either extremity are 2 hairs, both very fine; segments 3 and 4 with 8 simple spines in a transverse row across the middle of the segment, divided by median space; segment 6 with transverse row of 6 spines across the anterior margin, with median space, and with comblike groups of spines lateral to each end of the row; segment 7 with 20 simple spines in transverse row across the anterior margin, with median separation, and with combs lateral to each end of the row; segment 8 with 13-29 simple spines in similar transverse row, with combs lateral to each end of the row. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single simple spine on either side of the midline at middle of segment; segment 5 with transverse row of 4 bifid or trifid spines, somewhat before the posterior margin, with median separation; segment 6 with transverse row before the posterior margin, composed of 4 spines, the outer two simple, the inner two trifid or bifid; segment 7 with transverse row somewhat before the posterior margin, the outer two simple or bifid, the inner two bifid; the two spines on either side of the midline of segments 6 and 7 are more separated than those on segment 5, the distance between them approximately equal to that of the median space. Terminal spines extremely small, the apices rounded.

Respiratory apparatus (pl. 36, fig. 291) of each side arising just behind the anterior margin of the thorax, in the region of the humeral angles; composed of 8 filaments which branch as follows: 3-3-2; all filaments have superficial annulations and microscopic spicules; upon gross examination the filaments appear very long and slender, all of them close together. Maximum length of filaments, 3.9 mm., about 1.2 times the length of the cocoon; average diameter, 24 μ.

Cocoon (pl. 39, fig. 331): Length of base, 3.3 mm.; maximum width, 1.5 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, without collar; texture of case parchmentlike, the loose threads appearing to be held in a somewhat gelatinous-appearing matrix; rim around anterior aperture thickened. Cocoon covering abdomen and half of thorax; attached along posterior half of base.

Larva (pl. 40, fig. 370, and pl. 42, fig. 407).—Total length, 5.5-6.2 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times width of head. Abdominal segments 1-4 equal to width of head; segments 5-7 expanded, greatest at segment 6 which is 1.9 times width of segments 1-4; cross section and profile the same as for other species of the subgenus *Lanea*. General color yellowish gray; ventrolateral patches not visible on segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 40, figure 370. Each cephalic fan with 39-42 pectinate branches, the hairs on these branches all simple, heavy, short, rather close together except at the apices, not intermixed by longer or heavier hairs. Mandible with 2 separate teeth on its inner margin, the basal one about half the length of the more apical one, narrower and sharper. Antenna 300 μ long, 4-segmented, all segments very dark brown, just surpassing the basal stalk of the cephalic fan; segment 1 shorter than segments 2 or 3, segment 2 somewhat longer than 3; no transverse striations. Submentum with 9 apical teeth, shaped like half of a hexagon, all of approximately the same length; ventrolateral row composed of 3-5 hairs in a straight line, the most-apical two hairs more separated from each other than any of the others, bifid and trifid; lateral margin of submentum with 7 toothlike structures; two of these are well sclerotized, arising just posterior to the outermost of the apical teeth; 4 others, also near the apex, are more like serrations; the most basal toothlike process, also appearing like a serration of the lateral margin, is far removed from the more apical four. Occipital cleft dome-shaped, broad, the apex with convexity (pl. 42, fig. 407).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 28-34 rows of hooks at its apex; postclypeal sclerites light brown, small, but clearly visible. Posterior sucker with 68-70 rows of hooks. Anal gills consisting of 3 main divisions, each with from 3 to 6 fingerlike projections. Anterior arms of X-shaped sclerite short, poorly sclerotized, completely covered by wedge-shaped patches that extend along the outer margins from the union with the posterior arms to the anal orifice; patches longer and narrower than those of *callidum;* the patches of both anterior arms are bridged by a median patch; posterior arms well developed and heavily sclerotized; no rectal scales. Two extremely minute ventral papillae on eighth segment, hardly visible on some specimens; no sclerotized plaques.

Types.—Holotype (♂) and allotype (♀), part on slides, the rest on pins, and paratype ♂♂, ♀♀, and pupae in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected from the Río Sedeño, Veracruz, Mexico, August 1945.

SIMULIUM (DYARELLA) ACATENANGOENSIS Dalmat [10]

Simulium (*Dyarella*) *acatenangoensis* DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 31-38, figs. 1-8, 1951 (original description, ♂, ♀, and pupa).

Male (pl. 24, figs. 49-51).—3.4 mm. long.

HEAD: Holoptic. Eyes dark reddish brown. Antenna 11-segmented, only slightly tapering; scape and pedicel reddish yellow, the flagellum dark brown; clothed with short yellow hairs; segment $3<4+5$, $3=1+2$, $3>11$. Palpi reddish brown at base, black along the remainder of their length. Clypeal region white-pruinose. Occipital region with white, erect hairs.

THORAX: Mesonotum velvety black, with reddish cast in dried specimens; when viewed from above, with the head directed forward and downward, and with the light source from in front at a 45° angle to the specimen, there is seen on either side of the midline a narrow longitudinal band of white pruinosity which begins a very short distance behind the anterior margin of the notum and extends two-thirds of its length; the posterior ends of the two bands blend into a posterior patch of the same color, thus forming a white U; very narrow dark line running along midline; humeral angles white-pruinose; perimeter of mesonotum and, at times, the entire mesonotum with numerous golden-yellow, appressed scales, these longer

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[10] See footnote 6, p. 68.

in prescutellar region, never in regular groups; fine black hairs evenly spaced over entire mesonotum, these being longer and stouter in prescutellar region. Scutellum yellowish to reddish brown, with golden-yellow scales on both sides, the scales being so numerous that the entire structure appears golden; several long, slender, erect, black hairs also present. Postnotum yellowish brown, with triangular patch of grayish pruinosity on either side of the midline, contiguous with the anterior margin; devoid of hairs. Pleura evenly gray-pruinose. Halteres with brown stem and yellow knob. Wings, 3.5 mm. long; Sc pilose along basal third; R_1 pilose along slightly more than its distal half, the hairs intermixed with stouter spines; R_{2+3} simple, pilose except for small basal region which is bare; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.6 mm.; coxa and trochanter yellow; femur yellow, with very small dark patch apically on dorsal and ventral sides; tibia with small basal yellow ring, followed by black ring, then a central dark-brown region, and finally a terminal black ring; tarsus completely black. Leg 2, length, 3.1 mm.; coxa dark brown, trochanter yellow; femur yellow with apical dark-brown ring; tibia same as for leg 1; tarsus with all segments black except the basal half of basitarsus and a very minute basal section of second tarsal segment, which are yellow. Leg 3, length, 3.7 mm.; coxa and trochanter with same coloration as on leg 2; femur yellowish brown with dark-brown apical ring; tibia broad, dark brown except for very small yellow basal section and a black ring adjacent to it; tarsus with same color pattern as on leg 2; relation of basitarsus to second joint, 4.7:1; calcipala and pedisulcus well developed.

Abdomen: Tergite of first segment light brown, the pleurites black and completely clothed with very long, tan-colored hairs; second segment black, the tergite covered with white pruinosity; all other tergites velvety black with median patch of gray pruinosity, and clothed with short black hairs, evenly distributed over the surface; segment 7 with gray pruinosity along anterior margin of the pleurites. Sternites brown with central longitudinal black band.

Genitalia: Sidepiece (pl. 24, fig. 49) almost square, very slightly wider than long; dorsal opening large, quadrangular, with its angles directed toward each of the margins of the sidepiece. Clasper (pl. 24, fig. 49) much longer than wide, with large bulge on inner margin; well-marked opening on interior face at base; apex of clasper somewhat truncate; 2 apical spines, one more terminal than the other, arise along an oblique line, apparently formed by a large concentration of short spinelike hairs. Body of adminiculum (pl. 24, fig. 50) much wider than long, the basal prolongations wide, hyaline, ending in a flat, spatulate plate with fingerlike extensions; ventral surface of body of adminiculum clothed with short hairs, more numerous toward the posterior margin; central region of adminiculum inflated, more so on the ventral surface than on the dorsal, to form a tubelike structure which extends posteriorly beyond the apical margin of the body of the adminiculum, the extension being longer than the body of the adminiculum itself; in cross section this tube is approximately oval at its base and apex, but toward its midregion it is constricted near the dorsal surface, thereby giving it an hourglass appearance; tube with apical indentation from which extend rather long, curled hairs; similar hairs present along lateral margins; very short hairs completely clothe the ventral surface of tube and also the apical part of the dorsal surface. Adminicular arms (pl. 24, fig. 51) with teeth along distal half, the apex with the teeth so grouped as to form a dome; the lateral plate subquadrangular, wrinkled.

Female (pl. 30, figs. 166-168, and pl. 35, fig. 237).—3.7 mm. long.

HEAD: Dichoptic. Antenna 630 μ long, 11-segmented, only slightly tapering; scape and pedicel yellow, the flagellum dark brown; segment $3=1+2=4+5$, $3>11$. Palpi orange-brown at base, the remainder dark brown. Eyes dark brown to black. Fronto-ocular triangle 154 μ high, 67 μ at base. Frons, clypeus, fronto-ocular triangle, and occipital region reddish brown, completely invested with grayish-white pruinosity, clypeal hairs short, silvery; hairs of frons and occipital region black. Buccopharyngeal apparatus with cornuae greatly expanded and heavily sclerotized, the dorsal margin serrate along its entire length; border of median space hyaline with pale teeth in a single row.

THORAX: Mesonotum clear, dark, rust brown, with short, black, appressed hairs sparsely distributed throughout; when viewed from above, with the head directed forward and downward, and with the light source from in front at a 45° angle to the specimen, 2 wedge-shaped, white-pruinose patches are visible, contiguous with the anterior margin, one on either side of the midline; the posteriorly directed angle of each patch is elongated to form a longitudinal band, also white-pruinose, which extends three-fourths the length of the mesonotum to just before the prescutellar depression, there uniting with the gray-pruinose patch which clothes the posterior fourth of the mesonotum; extending along the midline, from the anterior margin also to the posterior fourth of the mesonotum, is a very narrow, white-pruinose line; narrow, appressed, silvery-white scales rather evenly distributed on anterior fourth of notum and on its lateral margins;

small transverse region, immediately posterior to anterior fourth, with golden-yellow scales, shorter than the silvery-white ones; posterior fourth with few silvery scales, longer than those on other parts of the notum. Postnotum reddish brown, covered with silvery pruinosity, and devoid of hairs or scales. Scutellum dark brown, with numerous silvery scales, similar to those on posterior part of mesonotum, and with several long, fine, black hairs. Pleura evenly gray-pruinose. Halteres with tan stem and pale-yellow knob. Wings, 3.7 mm. long; relation of body to wing, 1:1; Sc pilose at least along basal half, usually with a single hair near apical extremity; R_1 pilose only along distal half; R_{2+3} simple, pilose except for small bare region at base; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.9 mm.; coxa and trochanter yellow; femur yellow except for minute brown patch on ventral surface near the apex; tibia pale yellow on basal two-thirds of ventral face, the same region on dorsal face black; apical third completely black; tarsus black. Leg 2, length, 3.4 mm.; coxa dark brown, trochanter yellow; femur yellow with apical dark ring; tibia with apical half black, the basal half divided into light, dark, and light patches; basal two-thirds of basitarsus and basal fourth of second tarsal segment yellow, the apical parts of these segments, and all other tarsal segments, black. Leg 3, length, 4.1 mm.; with same color patterns as on leg 2; relation of basitarsus to second joint, 6:1. Calcipala well developed, reaching only halfway to pedisulcus; pedisulcus well developed one-third distance from base of second segment; heel well developed with strong secondary spur just apical to it (pl. 35, fig. 237).

ABDOMEN: Tergites of first and second segments light brown with white pruinosity, all others velvety black; pleural regions of first segment black with posterior fringe of yellow hairs. Second through seventh segment with tan-pruinose pleura; eighth segment with pleura black. Sternites evenly tan-pruinose.

GENITALIA: Cercus (pl. 30, fig. 166) higher than long (wide), posterior margin rounded, clothed with many strong hairs and numerous minute, spinelike hairs. Anal lobe (pl. 30, fig. 166) ribbonlike, with ventral extremity curved around border of cercus and with a similar investiture of hairs as on cercus. Genital rod (pl. 30, fig. 168) with short basal dilatation, triangular in shape; apical expansions triangular; the interior basal angle with a secondary hollow, conical, heavily sclerotized spur extending from it at an angle; outer basal angle pronounced but with apex blunted; the apical angle heavily sclerotized and rather sharply pointed; hyaline, winglike expansions on outer margin of each of the 2 triangles near its apex; 2 branches of genital fork unite on horizontal plane. Ovipositor (pl. 30, fig. 167) well developed, lance-shaped, ending in a distinct point.

Pupa (pl. 37, fig. 292, and pl. 39, fig. 332).—Entire thorax with granulosity; on each side of midline there are 3 simple trichomes. Dorsal surface of abdominal segments: Granulosity on posterior half of segment 1 and on anterior half of segment 2; second segment with 6 anteriorly directed simple spines in a transverse row about three-fourths the distance back from anterior margin, the row being divided into two by a median space; segments 3 and 4 with similar rows, each composed of 8 spines. Ventral surface of abdominal segments: Fifth segment with 4 anteriorly directed spines in transverse row, just anterior to posterior margin of segment, the spines divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but the two spines on each side of median space are more separated than on segment 5 so that the distance between them is approximately equal to that of median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 292) of each side emerging just behind the anterior margin of thorax, composed of 8 tubular filaments, arranged in groups of 2-1-1-2-1-1; the branching is so close to the base that all filaments appear to emerge individually. Maximum length of filaments, 3.0 mm., about 0.54 times as long as cocoon; average diameter, 70 μ; filaments with microscopic spicules.

Cocoon (pl. 39, fig. 332): Length of base, 4.5 mm.; greatest length, 5.6 mm.; greatest width, 2.2 mm.; height, without festoons, 2.1 mm.; with festoons, 2.6 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; lateral margins not extended to form "wings." Extending from the rim around the anterior aperture are several ribbonlike festoons, those of each side being united; the number of festoons varies somewhat, but there are usually 4-5, the two most dorsal ones emerging very close to one another. Cocoon covering abdomen and one-half of thorax.

Larva (pl. 40, fig. 371, and pl. 42, fig. 408).—Total length, 9.6-11.0 mm. Length of head capsule 1.3 times its width. Width of thorax and of first 4 abdominal segments only slightly wider than head. Abdominal segments 5-7 expanded, segment 7 about 1½ times width of segment 1. In general, there appears to be a progressive widening from anterior to posterior end. In profile, the dorsum of the larva is straight, while on the ventral surface the posterior segments, starting with the sixth and ending at posterior sucker, slope dorsal at a distinct angle. General color, smoky gray with greenish hue on dorsum of abdominal segments and on ventral surface of thoracic and first two abdominal segments.

HEAD: Light orange brown. Design on frons-clypeus (pl. 40, fig. 371) dark brown, composed of 4 elongated patches in form of cross; epicranial plate of each side with approximately 6 darkened patches, the arrangement of these shown on plate 40, figure 371. Each cephalic fan with 51-55 pectinate branches, the fine hairs on these rather close, simple, long, accentuated at regular intervals by somewhat longer, stouter hairs. Mandible with 2 broad flattened teeth on its inner margin, the more-distal longer and rounded at apex; more-proximal tooth about one-third the length of distal and more pointed than it; at times, only the longer tooth is present. Antenna 450 μ long, light brown to yellow; 4-segmented, the second segment with 2-3 superficial indentations appearing to divide it into 3-4 parts; segments 1, 2, and half of 3 reaching the apex of stalk of cephalic fan. Submentum with 9 apical teeth, the median one and the two external ones longer than the others; teeth triangular in shape, pointed; ventrolateral row irregular, composed of 9-11 stout hairs, the three most apical ones trifid, the fourth bifid, and the others bifid or simple; lateral margin of submentum with 6 teeth in regular order. Occipital cleft, triangular in shape (pl. 42, fig. 408).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 50-60 rows of hooks at its apex; postclypeal sclerites small, heavily sclerotized, well separated from each other. Posterior sucker with 350-360 rows of hooks. Anal gills composed of 3 main branches, each with 12 fingerlike projections, some shorter than others, the entire middle group somewhat longer than the others. The X-shaped sclerite is simple, well sclerotized, without pigmented patches; no rectal scales or spines, but with very small tuberculated hairs sparsely distributed between anterior and posterior arms of each side. No ventral papillae or sclerotized plaques on the eighth segment.

Remarks.—*Simulium* (*D.*) *acatenangoensis* appears quite similar to *S.* (*D.*) *virgatum* Coq. (Coquillett, 1902; Stone, 1948), *S.* (*D.*) *rubicundulum* Knab (Vargas, 1942), and *S.* (*D.*) *mathesoni* Vargas (1943). It can be readily distinguished from *virgatum* as follows: The abdomen of the female *virgatum* is light brown with all the segments at least partially gray-pruinose above, while that of *acatenangoensis* is black with only the tergites of the first two segments bearing white pruinosity. The apical angle of the expansion of the genital fork of *acatenangoensis* is more acute and much more heavily sclerotized than in *virgatum*. The outer basal angle of the former is more elongate with the tip blunt. The base color of the abdomen of the male *acatenangoensis* is completely black and the sternites are light brown with a median, longitudinal black band, while the abdomen of *virgatum* is dark rusty brown and the sternites are all light tan-pruinose. The sidepiece of *acatenangoensis* appears almost square; the clasper has its outer margin well curved and its apex rather blunt, usually with 2 spines. *S. virgatum* has the sidepiece rectangular; the clasper is rather straight along its outer margin and the apex is rounded with usually 1 spine. The median prolongation of the adminiculum is shorter and narrower, and the basal prolongations are broad and spatulate in this species, while in *virgatum* the basal prolongations are long, narrow, and pointed. *S. virgatum* is a larger species. The pupal filaments are arranged in 2 groups of 2 filaments and 4 single ones, while in *virgatum* they are arranged in 2 groups of 3 filaments, and with only 2 single ones.

S. acatenangoensis can most easily be distinguished from *rubicundulum* by the following characteristics of the latter species: The apical margin of the adminiculum is straight with a very long, slender median prolongation emerging perpendicular to it. The clasper is not as curved on its outer margin as that of *acatenangoensis* and it bears only 1 apical spine. The mesonotum of the female is evenly clothed with golden-yellow scalelike hairs. The outer basal angle of the expansion of the genital fork is almost 90°. The pupal filaments are arranged like those of *virgatum*.

S. acatenangoensis appears closest to *S. mathesoni,* but the following points of difference will establish their individuality: The abdomen of the female *mathesoni* is dark brown with the posterior margins of segments 2 through 7 being gray-pruinose. The sternites of the abdomen of the male *mathesoni* are evenly pruinose rather than being shiny light brown with a median, longitudinal, black band, as in *acatenangoensis*. The hind femur of the male *mathesoni* is yellow, with subbasal and apical dark-brown rings, and the basitarsus is almost completely yellow; in *acatenangoensis* the femur lacks the subbasal dark ring, and the basitarsus is yellow only on its basal half. The pedisulcus of the same leg is much deeper in *acatenangoensis*. The adminiculum of *acatenangoensis* has the median prolongation narrower, the lateral margins of the latter being parallel rather than converging toward the apex. The body of the adminiculum of *acatenangoensis* is narrower and the basal prolongations are longer. The latter structures are broad and hyaline, each ending in a spatulate plate with fingerlike extensions; in *mathesoni* these are narrower, more heavily sclerotized, each ending in a rather sharp point. The arms of the adminiculum of *acatenangoensis* have the teeth at the apex concentrated to form a dome-shaped structure, while in *mathesoni* the teeth are more dispersed. The clasper of the former species has 2 apical spines instead of 1. The genital rod of the same species has the basal dilatation short, forming almost an equilateral triangle, while in *mathesoni* the dilatation is more elongate and oval.

The material used for comparison with *acatenangoensis* is the following:

Simulium (*Dyarella*) *virgatum* Coquillett: One male, one female, and their cocoons collected in Hutto, Tex. These were lent to the author by the U. S. National Museum at the request of Dr. Alan Stone. Descriptions and drawings of Stone (1948).

Simulium (*Dyarella*) *rubicundulum* Knab: Several males, females, and their cocoons collected on the Finca El Vergel, Chiapas, Mexico, and given to the author by Dr. Luis Vargas. Also hundreds of specimens collected in various parts of Guatemala and reared in the Onchocerciasis Laboratory. Drawings of male and female genitalia by Vargas (1942).

Simulium (*Dyarella*) *mathesoni* Vargas: One male, one female, and their cocoons collected in Gulatao, Oaxaca, Mexico, and given to the author by Dr. Luis Vargas. Also several specimens collected in Guatemala and reared in the Onchocerciasis Laboratory, some of which were compared with the type by Dr. Vargas. Drawings of male genitalia and cocoon by Vargas (1943).

After studying the above material the author does not concur in the synonymy of Stone (1948) in which *rubicundulum* Knab and *mathesoni* Vargas are considered as being the same as *virgatum* Coquillett. Each of these species, as well as *acatenangoensis,* is believed to be distinct, the latter species being very close to *mathesoni.* In the same paper by Stone, *hippovorum* Malloch is also considered a synonym of *virgatum* Coquillett.

Types.—Holotype (♂), 3 slides, and allotype (♀), 4 slides, and 4 paratypes (2 ♂♂, 2 ♀♀) in collection of the United States National Museum; holotype and allotype collected from the Río Ladrillera, Finca La Esperanza Pérez, Acatenango, Department of Chimaltenango, Guatemala, November 25, 1948. Remaining paratypes (5 ♀♀ and 4 ♂♂) in the collection of Herbert T. Dalmat.

SIMULIUM (DYARELLA) ARDENI Dalmat

Simulium (*Dyarella*) *ardeni* DALMAT, Ann. Ent. Soc. Amer., vol. 46, No. 1, pp. 35-40, figs. 1-8, 1953 (original description, ♂, ♀, and pupa).

Male (pl. 24, figs. 51A-51C).—3.2 mm. long.

HEAD: Holoptic. Upper half of each eye light brown, with dark reddish-brown median patch; lower half dark reddish brown. Antenna 730 μ long, 11-segmented, tapering; segment $3=1+2$, $3<4+5$, 3>11; scape and pedicel and part of third segment yellow, the rest of flagellum dark brown; all segments with gray pruinosity. Palpi light brown with gray pruinosity and several black hairs. Clypeus dark reddish brown with gray pruinosity and long tan hairs. Occipital region black with gray pruinosity and black hairs.

Thorax: Mesonotum dark reddish brown, with a very narrow black line extending from anterior margin to prescutellar region; on either side of median line there is a very broad band of white pruinosity, the area covered by the two together occupying about one-half the scutum; prescutellar region with long, black hairs; individual golden-yellow scalelike hairs distributed over entire mesonotum, these being formed in groups of 2 or 3, as well as singly, in prescutellar region. Humeral angles yellow with gray pruinosity and golden-yellow scalelike hairs. Pleura dark reddish brown to black with gray pruinosity; pre-alar group formed by both yellow and black hairs; cluster of 8 to 10 short black hairs on mesepimeron; small group of black hairs on metepisternum, just posterior to spiracle. Scutellum light brown with gray pruinosity, long black hairs and several golden-yellow scalelike hairs. Postnotum black with gray pruinosity; no hairs. Stem of halter brown; the knob light tan. Wings, 3.1 mm. long and 1.2 mm. wide; relation of length of body to wing, 1 : 1; Sc pilose on basal fourth; R_1 with spines and hairs along apical three-fifths, these beginning a short distance from point of branching of R_{2+3}; R_{2+3} simple, pilose along apical three-fifths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.9 mm.; coxa, trochanter, and femur yellow; tibia black, its midregion somewhat lighter; tarsus black. Leg 2, length, 3.6 mm.; coxa dark brown; trochanter yellow; femur yellow with black apical ring; tibia dark brown to black with somewhat lighter midregion, a small white ring at extreme base; basitarsus with basal two-thirds yellow, apical third black; segments 2 through 5 black. Leg 3, length, 4.2 mm.; coxa dark brown to black; trochanter yellow; femur yellow with black apical ring; tibia brown with dark patches at base and apex and with very light-tan ring at extreme base; basitarsus yellow with very small darkened area at extreme apex; segments 2 and 3 yellow, 4 and 5 black; relation of basitarsus to second joint, 3.9 : 1; calcipala well developed and somewhat pointed, almost reaching pedisulcus; pedisulcus well formed, deep, situated one-third distance from base of second tarsal segment.

Abdomen: Tergite and pleurites of segment 1 black, the tergite with light-brown patch at its middle, its lateral regions with long brown hairs. Tergite of segment 2 dark brown to black, the anterior margin light brown. Other segments black, the pleural regions with gray pruinosity. All segments with short brown hairs. Sternites tan-pruinose.

GENITALIA: Sidepiece (pl. 24, fig. 51A) somewhat rectangular in shape, approximately 1.3 times wider than long, the dorsal opening occupying about one-half its surface. Clasper (pl. 24, fig. 51A) 2.6 times longer than wide, 1.7 times the length of sidepiece; margins of clasper sinuous, well-marked opening on inner surface at base; apical region much narrower than rest of clasper, the apex itself rounded; terminal spine single, pointed, a distance from the apex. Both sidepiece and clasper with numerous long, stout, spinelike hairs. Body of adminiculum (pl. 24, fig. 51B) irregularly rectangular, much wider than long, the apical margin with marked concavity from which arise numerous hairs which are longer than any others on adminiculum; sides of adminiculum with small hyaline expansions; on ventral surface of body of adminiculum, passing longitudinally along midline, is a low keel which has numerous very short hairs on its ridge and somewhat longer hairs laterally; remainder of ventral surface with very few hairs, none on lateral expansions; basal prolongations with their ends well sclerotized and spatulate. Adminicular arms (pl. 24, fig. 51C) with about 28 pointed teeth, parallel to one another and perpendicular to the long axis of the arm; lateral plate triangular, somewhat sclerotized, and wrinkled.

Female (pl. 30, figs. 169-171, and pl. 35, fig. 267).—4.0 mm. long.

HEAD: Dichoptic. Eyes reddish brown; height of fronto-ocular triangle 2.1 times the base. Antenna 750 μ in length, 11-segmented, slightly tapering; segment $3<1+2$ or $4+5$, $3=11$; scape and pedicel yellow, the flagellum brown. Palpi brown with black hairs. Clypeus coppery red, with gray pruinosity and golden-yellow hairs. Frons dark reddish brown to black with gray pruinosity and with short, fine, black hairs. Occipital region black, with numerous black hairs and a few white ones. Cornuae of buccopharyngeal apparatus narrow, only slightly indented, with corrugatedlike impressions; border of median space hyaline, smooth, without teeth.

THORAX: Mesonotum dark reddish brown, completely gray-pruinose; small, fine, black hairs and very short, golden-yellow scalelike hairs distributed over entire mesonotum, the scalelike hairs never in groups and somewhat longer in prescutellar region; long, erect, black hairs on prescutellar region. Scutellum tan, with long, erect, black hairs, shorter recumbent black ones, and several golden-yellow scalelike hairs. Postnotum black with gray pruinosity, devoid of hairs. Pleura black with gray pruinosity. Stem of halter tan, the knob white and ovoid in shape; mesepimeron with cluster of yellow and black hairs; group of short white hairs on metepisternum, arising from yellow patch behind spiracle. Wings, 3.8 mm. long and 1.6 mm. wide; relation of body to wing, 1.1 : 1; Sc pilose on basal fourth; R_1 pilose on apical three-fourths, also with spines on all but short basal portion of pilose area; R_{2+3} pilose except for short basal region; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 4.4 mm.; coxa and trochanter yellow; femur yellow with dark apical patch; tibia yellow with apical fourth dark brown and with dark patch on outer surface of basal fourth; all tarsal segments dark brown. Leg 2, length, 3.8 mm.; coxa dark brown; trochanter yellow; femur yellow with dark-brown apical ring; tibia yellow with dark rings at base and apex, and with a dark longitudinal patch on its outer aspect which extends from the apical ring toward the base, reaching across three-fourths the length of the tibia; basitarsus with basal two-thirds yellow, apical third dark brown; segments 2 through 5 dark brown. Leg 3, length, 4.6 mm.; coxa dark brown; trochanter yellow; femur yellow with dark-brown apical ring; tibia and basitarsus as on leg 2; second tarsal segment with basal third yellow, apical two-thirds dark brown; segments 3 through 5 dark brown; relation of basitarsus to second joint, 4 : 1. Calcipala well developed, reaching pedisulcus; pedisulcus well formed, deep, situated one-fourth the distance from base of second segment; heel of claw developed into pointed structure, no secondary claw (pl. 35, fig. 267).

Abdomen: Tergite of segment 1 tan with very light, long hairs on lateral areas; pleurites yellow. Segment 2 tan with posterior margin brown, completely covered with tan pruinosity. Segments 3 through 5 black with central brown patch and with posterior margins tan-pruinose; pleurites on each side of these segments yellow with one small brown patch; segments 6 through 8 black with tan pruinosity. All segments with short black hairs. Sternites tan-pruinose, with short black hairs.

Genitalia: Cercus (pl. 30, fig. 169) higher than long (wide), posterior margin rounded, clothed with many heavy hairs and with several minute, spinelike ones. Anal lobe (pl. 30, fig. 169) somewhat crescentlike, a large, membranous, very hairy structure extending from it ventrally. Genital rod (pl. 30, fig. 171) without basal dilatation, or, at most, base very slightly expanded; arms of genital fork triangular in outline, the outer and apical angles heavily sclerotized. Ovipositor (pl. 30, fig. 170) large, triangular in outline, 240 μ long, by 120 μ wide at base.

Pupa (pl. 37, fig. 293, and pl. 39, fig. 333).—Entire thorax with granulosity; on each side of midline of thorax are 6 trichomes, one arborescent, three trifid, one bifid, and one simple. Dorsal surface of abdominal segments: Segment 1 with granulosity on anterior and posterior margins which seems to be composed of small triangular-shaped spines, grouped as in combs but not contiguous to one another. Segment 2 with 6 anteriorly directed simple spines in a transverse row about three-fourths the distance back from anterior margin, the row being divided into two by a median space; on either side of this row there are 3 hairs; entire surface covered with minute spines as on segment 1; segments 3 and 4 with transverse rows, somewhat before posterior margins, composed of 8 spines, each row also divided by median space; anterior fourth of segment 3 covered by small, straight spines, formed in groups of twos and threes; segment 4 with wide band of similar spines, in groups of 2 to 6, extending from middle of segment to row of heavier spines; segments 5-9 with band of minute straight spines along anterior margins, these in groups of 2 to 6. Ventral surface of abdominal segments: Fifth segment with 4 anteriorly directed spines in transverse row across its middle, the spines divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but the two spines on each side of median space are more separated than on segment 5, so that the distance between them is approximately equal to that of median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 293) of each side arising somewhat posterior to anterior margin in region of humeral angles, composed of 10 tubular filaments arranged in groups of 4-4-2. Maximum length of filaments, 1.2 mm., about 0.24 times as long as cocoon; average diameter, 40 μ; filaments smooth, without microscopic spicules.

Cocoon (pl. 39, fig. 333): Length of base, 3.6 mm.; greatest length, 5.0 mm.; greatest width, 1.9 mm.; height, 2.0 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; lateral margins not extended to form "wings." No festoons or prolongations from rim of anterior aperture, but with 2 or 3 ribbonlike markings near dorsal aperture which are woven into the cocoon itself. Cocoon covering abdomen and posterior fourth of thorax.

Larva.—None available.

The male of *Simulium* (*D.*) *ardeni* appears closest to *S.* (*D.*) *yepocapense* Dalmat on the basis of the wide mesonotal bands of white pruinosity. However, it can easily be distinguished from the latter by the color of the hind femur, tibia, and basitarsus, and by the form of the clasper. In *ardeni* the femur is yellow with a black apical ring; the tibia is yellow with dark rings near base and apex; in *yepocapense* both femur and tibia are black, except for a small, yellow, basal region on each. The basitarsus of *ardeni* is yellow with a very small darkened area at apex; that of *yepocapense* has the basal half yellow, the apical half black. In *ardeni* the clasper is narrowed considerably near the apex and the terminal spine is at a distance from the apex, while in *yepocapense* the clasper is broad at the apex, and the spine is almost terminal.

The female of *ardeni* most resembles *S.* (*D.*) *earlei* Vargas, Martínez, and Díaz insofar as they both have the mesonotum devoid of white-pruinose longitudinal bands and both have R_1 pilose on distal half to three-fifths only. However, the mesonotum of *earlei* has the base color light brown, and is clothed with silvery-white scalelike hairs, these in groups of 2 and 3 near the anterior margin; the mesonotum of *ardeni* has the base color dark reddish brown and is clothed with golden-yellow scalelike hairs, these never appearing in groups. The median space of the buccopharyngeal apparatus of *earlei* has several wide, scalelike teeth, while that of *ardeni* is smooth, without teeth.

The pupa of *ardeni* is similar to those of *pulverulentum* Knab and *yepocapense* Dalmat, but can be distinguished by the characteristic ramification of the pupal filaments. The cocoon of *ardeni* is larger than that of *pulverulentum*, and the collar of the cocoon is much higher than that of *yepocapense*.

Types.—Holotype (♂), on 7 slides, and allotype (♀), on 6 slides, in the collection of the United States National Museum; collected from the Río Tzunutz, San Pedro Carchá, Department of Alta Verapaz, Guatemala, November 16, 1944. Paratypes (1 ♂, 4 pupae, and 4 pupal exuvia) in the collection of Herbert T. Dalmat; collected with the holotype and allotype.

SIMULIUM (DYARELLA) EARLEI Vargas, Martínez, and Díaz

Simulium (*Dyarella*) *earlei* VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 118-120, 177-178, figs. 16-21, 1946 (original description, ♂, ♀, pupa, and larva).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 54-57, 1951 (presence in Guatemala).

Male (pl. 24, figs. 52-54).—4.0 mm. long.

HEAD: Holoptic. Eyes light brown. Antenna 660 μ long, 11-segmented, slightly tapering, the last segment rather blunt; segment $3=1+2=11$; scape and pedicel brown, flagellum very dark brown. Palpi dark reddish brown. Clypeus white-pruinose, with long black hairs.

Thorax: Mesonotum shiny rust brown, covered with white pruinosity except for 1 median and 2 lateral longitudinal lines which show the base color; black hairs over entire mesonotum, somewhat longer on prescutellar region; yellow scalelike hairs all around periphery of mesonotum, in small groups along the anterior margin. Humeral angles dark brown with gray pruinosity. Pleura dark brown, with light pruinosity. Scutellum shiny rust brown, with few black hairs on either side. Postnotum shiny rust brown, without hairs. Stem of halter dark brown and hairy, the knob tan. Wings, 3.8 mm. long and 1.6 mm. wide; relation of body length to wing, 1.1 : 1; Sc pilose on basal third; R_1 with hairs and spines on distal half; R_{2+3} pilose on distal three-fourths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 4.1 mm.; coxa, trochanter, and femur tan; tibia and tarsus dark brown. Leg 2, length, 3.4 mm.; coxa dark brown; trochanter tan; basal two-thirds of femur light brown, apical third dark brown; basal halves of tibia and basitarsus light brown, apical halves dark; second through fifth tarsal joints black. Leg 3, length, 4.2 mm.; coxa brown, trochanter light brown; femur dark brown with basal light ring; tibia dark brown; basal halves of basitarsus and second segment tan, the remainder dark brown to black; tarsal segments 3 through 5 black; relation of basitarsus to second joint, 2 : 1; calcipala well developed, straight and wide, almost reaching pedisulcus; pedisulcus well developed, deep, on basal third of second segment.

Abdomen: Anterior half of first tergite brown, posterior half black; pleura of this segment with black anterior half, the posterior half white-pruinose, clothed with long brown hairs that reach the fourth segment. Remaining segments velvety black, the pleura white-pruinose, invested with short black hairs. Sternites tan, with dark-brown region along midline.

Genitalia: Sidepiece (pl. 24, fig. 52) irregularly quadrangular in shape, its outer margin 1.5 times as long as the inner margin; somewhat wider than long; dorsal opening large, approximating the contour of the sidepiece. Clasper (pl. 24, fig. 52) slightly more than twice as long as wide, sinuous, with long bulge near distal end of outer margin and smaller bulge near base of inner margin; well-marked opening at base; narrower than rest of clasper, rounded; terminal spine single, near edge of clasper. Both sidepiece and clasper with numerous long, stout, spinelike hairs. Body of adminiculum (pl. 24, fig. 53) irregularly quadrangular, its width about 1.5 times its length, the apex with depression; on ventral surface of adminiculum, passing longitudinally along midline, is a very low keel, tentshaped, which is clothed with numerous hairs; remainder of ventral surface with few hairs; basal prolongations with their ends well sclerotized and spatulate, a membrane on the inner margin of each which reaches the body of the adminiculum. Adminicular arms (pl. 24, fig. 54) with about 35 very long teeth arranged in linear form, perpendicular to the long axis of the arm; lateral plate rectangular, wide, somewhat sclerotized.

Female (pl. 31, figs. 172-174, and pl. 35, fig. 238).—4.0 mm. long.

HEAD: Dichoptic. Eyes black; height of fronto-ocular triangle 1.7 times the base. Antenna 750 μ long, 11-segmented, very slightly tapering, widest at third segment, last segment blunt; segment $3<1+2$, $4+5$, or 11; scape and pedicel tan, the flagellum light brown, becoming dark toward the apex. Palpi light brown near base and dark brown toward apex. Frons brown, with white pruinosity and a row of hairs along its periphery. Clypeus brown, with white pruinosity and several rows of tan hairs on lateral margins. Occipital region brown, with white pruinosity and numerous black hairs. Cornuae of buccopharyngeal apparatus slightly sclerotized, large, flattened; median space hyaline, with many wide, scalelike teeth in irregular rows.

THORAX: Mesonotum shiny, copper-colored, completely white-pruinose, with no definite stripes or designs; narrow, minute, silvery scalelike hairs widely scattered over entire mesonotum, arranged in groups of 2-3 along anterior margin, somewhat longer in prescutellar region; short black hairs evenly distributed over entire mesonotum, long black hairs in prescutellar region. Humeral angles white-pruinose, anterior region covered with tan-colored hairs. Scutellum shiny light brown, anterior margin somewhat darker, invested with several long, strong, black hairs and numerous silvery scalelike hairs, longer than those on mesonotum. Postnotum shiny brown, with white pruinosity but no hairs or scales. Pleura light brown, evenly white-pruinose. Stem of halter brown, knob cuplike, tan. Wings, 3.8 mm. long and 1.7 mm. wide; relation of body to wings, 1.1:1; Sc completely pilose; R_1 pilose along apical three-fifths, all but short apical portion of pilose region with spines as well as hairs; R_{2+3} pilose except for small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, 4.3 mm.; coxa, trochanter, and femur yellow; tibia and tarsus black. Leg 2, 3.9 mm.; coxa dark reddish brown; trochanter yellow; femur brown except for dark-brown apical ring; tibia with middle region brown, both extremities dark brown; basal two-thirds of basitarsus yellow, apical third dark brown; basal third of second tarsal segment yellow, remainder dark brown; segments 3-5 dark brown. Leg 3, 4.6 mm.; coxa dark reddish brown;

trochanter light brown; femur and tibia brown; basal two-thirds of basitarsus and basal half of second segment light brown, remainder of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second tarsal segment, 5:1; calcipala well developed, not reaching pedisulcus; pedisulcus well formed, situated one-half distance from base of second segment; heel of claw developed into secondary spur (pl. 35, fig. 238).

ABDOMEN: Tergite of segment 1 brown, pleurites black, the latter clothed with long tan hairs that reach the third segment. Tergite of second segment brown, the pleurites black, with white pruinosity. Segments 3-5 very dark brown to black, 6-9 lighter and shiny; pleurites brown; several long black hairs on last segment. Sternites brown, becoming darker toward the terminal segments.

GENITALIA: Height of cercus (pl. 31, fig. 172) twice its length (width), almost rectangular in shape, clothed with many long, heavy hairs and with numerous fine, spinelike hairs. Anal lobe (pl. 31, fig. 172) somewhat crescentlike, a large, membranous, very hairy structure extending from it ventrally; with similar investiture to that of cercus. Genital rod (pl. 31, fig. 174) without basal dilatation, or, at most, base very slightly expanded; apical expansions of arms of genital fork somewhat triangular in form, the apex blunt, almost squared; apex and outer angle well sclerotized, the inner angle with a hollow, conical spur extending from it; union of both arms wide, the inner border straight. Ovipositor (pl. 31, fig. 173) long, lance-shaped.

Pupa (pl. 37, fig. 294, and pl. 39, fig. 334).—Entire dorsum of thorax with granulosity; 2 bifid and 3 trifid trichomes on each side of midline of thorax. Dorsal surface of abdominal segments: Segment 1 with granulosity on posterior margin; segments 2 and 3 with it on their anterior margin; segment 2 with 6 anteriorly directed simple spines in a transverse row across its middle, the row being separated into two by a median space; segments 3 and 4 with transverse rows, somewhat before the posterior margins, composed of 8 spines, each row also divided by median space; lateral margins of segments 3-7 each with a single, anteriorly directed spine. Ventral surface of abdominal segments: Fifth segment with 4 anteriorly directed spines in transverse row somewhat before the posterior margin, the spines being divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but the two spines on each side of median space are more separated than on segment 5, so that the distance between them is approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 294) of each side arising on lateral margin of thorax, slightly behind the humeral angles; composed of 16 filaments which branch into groups as follows: 7-2-2-3-1-1. Maximum length of filaments, 1.6 mm., about 0.3 times as long as cocoon; average diameter, 40 μ; filaments ending in points, with microscopic spicules.

Cocoon (pl. 39, fig. 334): Length of base, 3.6 mm.; greatest length, 5.4 mm.; greatest width, 2.1 mm.; greatest height, 2.1 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; lateral margins not extended to form "wings." No festoons or prolongations from rim of anterior aperture. Cocoon covering abdomen only.

Larva (pl. 40, fig. 372, and pl. 42, fig. 409).—Total length, 8.8-9.6 mm. Length of head capsule 1.2 times its width. Thoracic and abdominal segments 1-4 only slightly wider than head; segments 5-7 expanded, the greatest width being reached at segment 7 which is 1.5 times as wide as segments 1-4; there seems to be a progressive widening from the anterior to posterior ends; in profile, the dorsum is straight while on the ventral surface there is a gradual slope downward from the fourth to seventh segment and then an abrupt upward trend toward the posterior sucker. General color yellow, with no dark bands on ventrolateral regions of abdominal segments 6 and 7.

Head: Yellow, the designs on the frons-clypeus and epicranial plates (pl. 40, fig. 372) dark reddish brown; design on frons-clypeus in form of shield; epicranial plates somewhat darkened, with 3 extensive clear areas near posterior border and 3-4 other small ones distributed mainly on the posterior half. Each cephalic fan with 36-40 pectinate branches; the minute hairs on these branches are simple, short, close together, with longer, heavier hairs at regular intervals. Mandible with only 1 rather long, narrow tooth on its inner border near apex. Antenna 400 μ long, yellow to light brown; 4-segmented, surpassing the basal stalk of the cephalic brushes; segment 1 equal in length to segment 3; segment 2, 1.8 times the length of either 1 or 3; segment 2 with 2 clear regions which divide it superficially into 5 color bands. Submentum with 9 triangular-shaped apical teeth which are small and almost of equal size; ventrolateral row composed of 8 hairs in a straight line, all being bifid but the basal two which are simple; lateral margin of submentum with 5 teeth in regular sequence. Occipital cleft shaped somewhat like a dome with its apex pointed (pl. 42, fig. 409).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 45-48 rows of hooks at its apex; postclypeal sclerites small, well sclerotized, and separated, situated near posterior junction of the frons-clypeus and epicranial plates. Posterior sucker with 220-230 rows of hooks. Anal gills composed of 3 main branches, each with 10 broad divisions, rounded at their apices. The X-shaped sclerite is simple, anterior and posterior arms well sclerotized, without pigmented patches except between the two anterior arms at their union to each other. No rectal scales or spines. No ventral papillae or plaques on eighth segment.

Types.—Holotype (♂) and allotype (♀), part on slides, the rest on pins, and paratypes (15 ♂♂ and ♀♀, and pupae) in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected in Temixco, Morelos, Mexico, July 3, 1945.

SIMULIUM (DYARELLA) MATHESONI Vargas *

Simulium mathesoni VARGAS, Rev. Inst. Salubr. Enferm. Trop., vol. 4, No. 4, pp. 360-362, figs. 19-27, 1943 (original description, ♂ and pupa).

Simulium (*Dyarella*) *mathesoni* Vargas, VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 178, 1946 (larva).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 55-57, 1951 (presence in Guatemala).

Male (pl. 24, figs. 55-57).—4.5 mm. long.

HEAD: Holoptic. Eyes reddish brown above, black below. Antenna 690 μ long, 11-segmented, slightly tapering, not blunt; segment $3>1+2$, $3<4+5$, $3>11$; scape and pedicel light yellow, flagellum dark brown. Palpi dark brown to black. Clypeus dark brown, with white pruinosity and several long, tan hairs.

THORAX: Mesonotum velvety black; on either side of midline, with its base on the anterior margin of mesonotum, is a white-pruinose triangle, its apex extending posteriorly in the form of a white stripe which blends with the pruinosity of prescutellar region; few short black hairs distributed on mesonotum and several long ones in prescutellar region; numerous rather long, slender, golden, scalelike hairs on anterior half of mesonotum, along its lateral margins, and in prescutellar region. Humeral angles white-pruinose. Pleura dark brown to black, with white pruinosity. Scutellum black, with white pruinosity and several long black hairs. Postnotum black, with white pruinosity, but without hairs of any kind. Stem of halter brown, knob white. Wings, 3.7 mm. long and 1.3 mm. wide; relation of length of body to wing, 1.2:1; Sc pilose along basal fifth; R_1 pilose on distal half; R_{2+3} pilose except for short basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.7 mm.; coxa and trochanter yellow; femur yellow with black subapical patch; tibia black with longitudinal yellow patch in median area; tarsus black. Leg 2, length, 3.0 mm.; coxa and

* See footnote 6, p. 68.

trochanter yellow; femur yellow with apical fifth black; tibia primarily yellow with basal black patch and distal quarter black; basal two-thirds of basitarsus and basal half of second tarsal segment yellow, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 3.8 mm.; coxa black; trochanter yellow; femur yellow with its apical fifth dark and with very small basal dark ring; tibia yellow, with basal and apical black areas and with its outer edge also black; basal half of basitarsus yellow, apical half black; tarsal segments 2-5 black; relation of basitarsus to second joint, 4.1 : 1; calcipala short but well developed, reaching about halfway to pedisulcus; pedisulcus well developed on basal third of second segment.

Abdomen: Tergite and pleurites of first segment very dark brown to black, with long white hairs and short black ones. Segment 2 black, with anterior region of tergite and all of pleurites white-pruinose. Remaining segments dark brown to black, with pruinosity evenly covering them. Sternites light brown with median, longitudinal, shiny, dark-brown stripe.

Genitalia: Sidepiece (pl. 24, fig. 55) rectangular, wider than long; dorsal opening oval, occupying basal half of sidepiece. Length of clasper (pl. 24, fig. 55) three times its width, its central region expanded owing to bulge along outer margin; apical spine small, narrow, slightly blunt, somewhat removed from the tip of clasper. Body of adminiculum (pl. 24, fig. 56) much wider than long, its width 2.4 times the length of the apical prolongation; apical prolongation short and wide in comparison with those of *rubicundulum* and *acatenangoensis,* with concavity at its tip, and numerous hairs along its margins; ventral surface of body of adminiculum with several short hairs; basal prolongations of the body well sclerotized, but not greatly expanded to form spatulate process. Adminicular arms (pl. 24, fig. 57) with approximately 14 teeth, grouped in domelike fashion; lateral plate almost rectangular, very slightly sclerotized.

Female (pl. 31, figs. 175-177, and pl. 35, fig. 239).—(First published description of female.) 4.3 mm. long.

Head: Dichoptic. Eyes very dark reddish brown to black; height of fronto-ocular triangle 1.6 times the base. Antenna 580 μ long, 11-segmented, well tapered; segment $3 < 1+2$, $4+5$, or 11; scape and pedicel tan, flagellum slightly darker. Palpi with base brown, the apex dark brown. Frons brown, with white pruinosity, irregularly clothed with short yellow hairs and longer black ones. Clypeus light brown, with white pruinosity, irregularly covered with short golden hairs which are somewhat longer on the lateral margins. Occipital region brown, with white pruinosity and short black hairs. Cornuae of buccopharyngeal apparatus well sclerotized, flanged along the borders, with numerous impressions; median space dentate, but not sclerotized or pigmented.

THORAX: Mesonotum reddish brown; on either side of midline, with its base on the anterior margin of mesonotum, is a white-pruinose triangle, its apex extending posteriorly in the form of a white stripe which blends with the pruinosity of the prescutellar region; wide band of white pruinosity along the lateral margins and another thin stripe along the midline; long, narrow, yellow, scalelike hairs on entire mesonotum and in prescutellar depression, not in groups; several long black hairs in prescutellar region. Humeral angles shiny brown. Scutellum shiny brown, with numerous long black hairs. Postnotum velvety brown with white pruinosity. Pleura brown with white pruinosity. Stem of halter light brown, the knob tan to white. Wings, 3.5 mm. long and 1.4 mm. wide; relation of length of body to wings, 1.2 : 1; Sc pilose along its basal fifth; R_1 with hairs and spines along apical three-fifths; R_{2+3} pilose except for basal sixth; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, 3.6 mm.; coxa and trochanter yellow; femur yellow with apical brown band; median part of tibia yellow, the basal and apical regions dark brown to black; tarsus black. Leg 2, 3.3 mm.; coxa black; trochanter yellow; femur yellow with apical dark ring; tibia as for leg 1; basal four-fifths of basitarsus and basal third of second segment yellow, the remainder of these segments, as well as all other tarsal segments, black. Leg 3, 3.8 mm.; coxa, trochanter, and femur as for leg 2; tibia with middle region yellow, apical fourth black; the basal fourth divided into very narrow yellow ring followed by wider black band; tarsal colors as for leg 2; relation of basitarsus to second segment, 4.5 : 1; calcipala well developed, broad, almost reaching pedisulcus; pedisulcus very well developed, deep; claw with basal heel well developed, a sharp secondary spur just beyond the heel (pl. 35, fig. 239).

ABDOMEN: Tergite and pleurites of segment 1 black, covered by white pruinosity, the pleurites with long black hairs. All other segments dark brown to black, with white pruinosity on posterior margin.

GENITALIA: Cercus (pl. 31, fig. 175) higher than long (wide), somewhat rectangular in shape, clothed with many long hairs and with numerous fine, spinelike ones. Anal lobe (pl. 31, fig. 175) narrow at its dorsal end, extending around the cercus, with very wide membranous structure ventrally; investiture similar to that of cercus. Genital rod (pl. 31, fig. 177) with basal dilatation in form of triangle; apical expansions of arms of genital fork triangular in form, the apex blunt, outer basal triangle sharply pointed and well sclerotized, and the inner angle with a hollow, conical well-sclerotized spur. Ovipositor (pl. 31, fig. 176) triangular in shape, the length 1.7 times the base.

Pupa (pl. 37, fig. 295, and pl. 39, fig. 335).—Entire dorsum of thorax with granulosity; 4 simple trichomes on each side of midline of thorax. Dorsal surface of abdominal segments: Segments 1 and 2 with granulosity on at least part of dorsum; segment 2 with 6 anteriorly directed simple spines in a transverse row across its middle, the row being divided in two by a median space; segments 3 and 4 with transverse rows somewhat before the posterior margin, each composed of 8 spines divided by a median space. Ventral surface of abdominal segments: Fifth segment with 4 anteriorly directed spines in transverse row a little before the posterior margin, the spines being divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but the two spines on each side of median space are more separated than on segment 5, so that the distance between them is approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 295) of each side arising slightly behind the anterior margin of thorax in the region of the humeral angles; composed of 8 filaments which branch into groups as follows: 2-2-1-1-1-1; the last (most basal) single filament is somewhat removed from all the others which emerge a distance above it. Maximum length of filaments, 3.1 mm., about 0.46 times the length of the cocoon; average diameter, 44 μ; filaments with poorly marked superficial segmentation, covered with microscopic spicules.

Cocoon (pl. 39, fig. 335): Length of base, 4.5 mm.; greatest length, 6.7 mm.; greatest width, 2.5 mm.; greatest height, 2.6 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; ribbonlike festoons extending from the rim of the dorsal aperture; bases of uppermost two festoons on either side not contiguous to each other; dorsal margin of festoons not forming straight line. Cocoon covering abdomen and three-fourths of thorax.

Larva (pl. 40, fig. 373, and pl. 42, fig. 410).—Total length, 10.4 mm. Length of head capsule equal to width. Thorax 1.6 times width of head. Abdominal segments 1-4 almost equal to width of thorax; segments 5-7, 1.3 times width of segments 1-4; there seems to be a gradual widening of the abdomen from the front to rear; in profile, the larva is straight on its dorsal surface, its ventral surface sloping downward until the seventh segment, where it turns abruptly upward toward the posterior sucker. General color greenish gray, with no dark patches on ventrolateral regions of abdominal segments 6-7.

Head: Yellow; design on frons-clypeus (pl. 40, fig. 373) approaching a triangle in shape, the apex being rounded; from the apex to the base there is a longitudinal dark stripe, and a smaller dark patch on either side of the stripe near its midregion; epicranial plates somewhat darker than base color of frons-clypeus, with about 6 dark-brown patches distributed on their posterior half (pl. 40, fig. 373). Each cephalic fan with 54 pectinate branches; small hairs of each branch are both simple and bifid, not very close together, at regular intervals interspersed with longer, heavier bifid hairs. Mandible with 2 well-defined, pointed teeth on its inner margin, the more distal one twice the length of the other. Antenna 460 μ long, light brown, 4-segmented, the first two segments and one-quarter of third reaching apex of the basal stalk of cephalic fan; segment $1<2>3$; segment 2 with 2 superficial divisions also marked by white patches; segment 1 with longitudinal wrinkles; no segments with transverse striations. Submentum with 9 triangular, sharp, apical teeth, the central one and two outer ones being largest; ventrolateral row composed of 8 hairs, the seven apical ones trifid near their apices, the basal one bifid; lateral margin of submentum with 6 teeth, five in a regular sequence, the most-basal tooth somewhat removed from the others. Occipital cleft dome-shaped, the apex with fingerlike prolongation (pl. 42, fig. 410).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 35-40 rows of hooks on its apex; postclypeal sclerites well sclerotized, separated from each other. Posterior sucker with 260-265 rows of hooks. Anal gills composed of 3 main branches, the central one with 19 fingerlike projections, the two lateral branches each with 20 such projections, giving a total of 59 projections in all. The X-shaped sclerite is simple, well sclerotized, without pigmented patches; no rectal scales or spines but with several extremely small spines on each side between the anterior and posterior arms. No ventral papillae or plaques on eighth segment.

Types.—Holotype (♂), in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected in Temixco, Morelos, Mexico, at 1,400-1,500 meters above sea level, November 21, 1943.

SIMULIUM (DYARELLA) MEXICANUM Bellardi

Simulium mexicanum Bellardi, Saggio di Ditterologia Messicana, vol. 2 (Appendix), p. 6, 1862 (original description, male).—Malloch, U. S. Dept. Agr. Bur. Ent. Techn. Ser., No. 26, pp. 35-36, pl. 2, fig. 6, 1914 (female).—Bequaert, *in* Strong, Sandground, Bequaert, and Ochoa, Contr. No. 6, Dept. Trop. Med. and Inst. Trop. Biol. and Med., Harvard Univ., pp. 216-217, fig. 99, 1934 (♀ and pupa).—Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, pp. 236-237, figs. 4 and 11, 1942 (♂ and ♀).—Vargas, ibid., vol. 4, No. 4, p. 368, figs. 30-32, 1943 (pupa).

Simulium (*Dyarella*) *mexicanum* Bellardi, Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 179, fig. 139, 1946 (larva).

Male (pl. 24, figs. 58-60).—3.5 mm. long.

Head: Holoptic. Eyes very dark reddish brown, shiny, with row of hairs between them. Antenna 570 μ long, 11-segmented, slightly tapering; segment 3 two-thirds length of segments 1 and 2 together; remainder of segments subequal; dark brown. Palpi dark brown. Clypeus brown with white pruinosity.

Thorax: Mesonotum velvety black, evenly covered with gray pruinosity, with 3 longitudinal lines of base color showing, one down midline and one on either side of this central one; numerous long, narrow, yellow, scalelike hairs on all parts of mesonotum, these grouped in packets on anterior half, but single on posterior half; short black hairs over entire mesonotum, longer in prescutellar region. Humeral angles white-pruinose. Pleura evenly white-pruinose. Scutellum light brown, with tufts of long black hairs on its sides. Postnotum velvety brown, with white pruinosity, but without hairs of any kind. Stem of halter brown, the knob bright yellow, cuplike, large. Wings, 3.5 mm. long and 1.5 mm. wide; relation of length of body to wing, 1 : 1; Sc pilose along its basal sixth; R_1 with spines along its distal half, these intermixed with very few hairs; R_{2+3} pilose except for very small basal region; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 4.2 mm.; coxa, trochanter, and femur yellow; tibia brown, very wide; tarsus black. Leg 2, length, 3.1 mm.; coxa and trochanter brown; femur dark brown, with small light-brown area on apex; tibia dark brown to black, very hairy; basal two-thirds of basitarsus and basal fourth of second segment light brown, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 4.2 mm.; coxa dark brown; trochanter light brown; femur and tibia reddish brown, with very small light-brown area at base, very hairy; basitarsus with basal third light brown, the remainder black, greatly expanded on distal half; segments 2-5 black; relation of basitarsus to second tarsal segment, 6 : 1; calcipala well developed, short, broad, straight, not reaching pedisulcus; pedisulcus on basal fourth, very small, hardly visible.

Abdomen: Tergite and pleurites of segment 1 light brown, with long black hairs that reach the fourth segment. Segment 2 black, its anterior half white-pruinose. All other segments black, covered with short brown hairs; pleurites of segments 3-5 white-pruinose, with short, yellow, scalelike hairs. Sternites dark brown with short black hairs.

Genitalia: Sidepiece (pl. 24, fig. 58) almost square, the dorsal opening well formed, quadrangular. Clasper (pl. 24, fig. 58) much longer than wide, about one and one-half times length of sidepiece, with large bulge on outer margin and smaller one on inner margin; longitudinal ridge on dorsal surface which is accentuated by numerous small spines; apex much narrower than rest of clasper, with 2 pointed terminal spines, a heavy one somewhat removed from apical margin, and a very small one closer to the margin. Body of adminiculum (pl. 24, fig. 59) almost twice as wide as long, without apical prolongation or concavity but with very high longitudinal keel on the midline of the ventral surface; keel and entire ventral surface invested with numerous hairs; basal prolongations long, well sclerotized, spatulate. Adminicular arms (pl. 24, fig. 60) with approximately 13 blunt teeth arranged in linear fashion; lateral plate somewhat triangular in form, very slightly sclerotized.

Female (pl. 31, figs. 178-180, and pl. 35, fig. 240).—3.5 mm. long.

Head: Dichoptic. Eyes black; height of fronto-ocular triangle equal to the base. Antenna 560 μ long, 11-segmented, tapering; segment $3=4+5=11$; scape and pedicel light brown, segments 3-8 brown, segments 9-11 very dark brown. Palpi brown. Frons light brown, with white pruinosity and several black hairs arranged in 2 rows along each lateral margin. Clypeus light brown, with white pruinosity and many long black hairs. Occipital region brown, with white pruinosity and clothed with black hairs. Cornuae of buccopharyngeal apparatus narrow, somewhat blunt, with membranous extensions on their inner margin; median space hyaline, without teeth.

Thorax: Mesonotum grayish black, completely white-pruinose, without designs; relatively long, yellow, scalelike hairs evenly covering all of mesonotum, in groups of 2-5; short, black hairs sparsely but evenly covering all of mesonotum, these hairs longer in prescutellar region. Humeral angles white-pruinose, with several short brown hairs. Scutellum tan, with several yellow scalelike hairs and long black hairs. Postnotum velvety brown, white-pruinose, without investiture of hairs of any kind. Pleura white-pruinose. Stem of halter light brown, the knob tan, cup-shaped. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1.1 : 1; Sc pilose along basal four-fifths; R_1 completely pilose, its distal half also with spines; R_{2+3} completely pilose; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.9 mm.; coxa, trochanter, and femur tan; basal third of tibia tan, the remainder dark brown; tarsus brown to black, with very few long black hairs. Leg 2, length, 3.5 mm.; coxa brown; trochanter tan; femur brown, with very small basal light region; basal fifth of tibia tan, the remainder brown; basal three-fourths of basitarsus and basal half of second and third tarsal segments tan, the remainder of these segments, as well as all of segments 4-5, dark brown. Leg 3, length, 4.3 mm.; coxa brown; trochanter tan; femur brown, with small basal region which is tan; basal two-fifths of tibia tan, apical part brown; basal three-fifths of basitarsus and basal half of second tarsal segment tan, the remainder of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second segment, 4.6 : 1; calcipala well developed, reaching pedisulcus; pedisulcus well developed on basal half of second segment; claw with well-developed heel and with secondary subbasal spur (pl. 35, fig. 240).

Abdomen: Tergite of segment 1 tan, the pleurites dark brown, the latter with long yellow hairs that reach the third segment. Segment 2 white-pruinose. Remaining segments with light-brown tergites, the pleura black; few long black hairs on pleura of eighth segment. Sternites gray-pruinose.

Genitalia: Cercus (pl. 31, fig. 178) almost four times as high as long (wide), rectangular in shape, with many long, strong hairs directed posteriorly and with numerous short, spinelike hairs. Anal lobe (pl. 31, fig. 178) narrow at dorsal extremity, widening ventrally where it has a large membranous structure, clothed similarly to cercus. Apical expansions of arms of genital fork (pl. 31, fig. 180) in form of triangle with apical and inner angles blunt, the outer angle sharply pointed; outer margin and angle well sclerotized; both arms of genital fork with large membrane between them at point of union; basal dilatation of genital rod well marked, bulblike. Ovipositor (pl. 31, fig. 179) in form of equilateral triangle.

Pupa (pl. 37, fig. 296, and pl. 39, fig. 336).—Granulosity well marked on entire thorax; 3 simple long trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: No granulosity on dorsal region of any segments; segment 2 with 6 anteriorly directed simple spines in a transverse row a little before posterior margin of segment, the row being divided in two by a median space; segments 3 and 4 with transverse rows composed of 8 spines, situated in about the same position as on segment 2, each row also being separated into two by a median space. Ventral surface of abdominal segments: Fifth segment with 4 anteriorly directed spines in transverse row, a little before the posterior margin, the spines being divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but the two spines on either side of median space are more separated than on segment 5, so that the distance between them is approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 296) of each side arising at the humeral angles; composed of 12 filaments which branch in groups as follows: 5-5-1-1. Maximum length of filaments, 1.8 mm., about 0.36 times the length of the cocoon; average diameter, 24 μ; filaments with undulations along surface and covered with microscopic spicules.

Cocoon (pl. 39, fig. 336): Length of base, 4.5 mm.; maximum length, 5.0 mm.; greatest width, 2.5 mm.; greatest height, 2.1 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; without festoons extending from anterior aperture, but with prolongations that extend anteriorly from the ventral part of the rim around the anterior aperture; entire rim somewhat reinforced. Cocoon covering abdomen only.

Larva (pl. 40, fig. 374, and pl. 42, fig. 411).—Total length, 8.6-9.2 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times head. Abdominal segments 1-4 gradually widening from segment 1, which is about the width of the thorax, to segment 4, which is 1.3 times the width of thorax; segments 5-7 somewhat expanded, seventh segment 1.4 times average width of segments 1-4. In profile, like larvae of *mathesoni, acatenangoensis,* and other species of this subgenus. General color yellow, with gray markings; transverse black marking on thorax just interior to the base of each histoblast.

HEAD: Shield-shaped design occupying posterior half of frons-clypeus, a darker form found within the larger design at its posterior end, somewhat in the form of an inverted funnel; also 6 small dark spots along midline of frons-clypeus, near anterior end of shield-shaped design (pl. 40, fig. 374); epicranial plates light, with approximately 7 dark markings (pl. 40, fig. 374). Each cephalic fan with 44-50 pectinate branches; small hairs of each branch simple, close together, with heavier hairs interspersed at regular intervals. Mandible with only 1 well-formed tooth along its inner margin, another aborted tooth just visible at base of large tooth, and another indication of a possible tooth farther toward the base of the mandible. Antenna 490 μ long, yellow to light brown, 4-segmented, surpassing the basal stalk of cephalic fan; segment 2 with 2 clear areas that divide the segment into 5 color bands; segment 2 also with 2 superficial indentations that give it the appearance of being 3 distinct segments; segment $2>1>3$. Submentum with 9 apical teeth, triangular in form, the central one larger than the others; ventrolateral row composed of 8-11 hairs usually in straight line, all generally bifid except the basal two which are simple; at times, hairs 4-6 are trifid, and the third and fourth hairs, counting from the base, may be out of alignment; lateral margin of submentum with 5 small toothlike indentations in regular sequence. Occipital cleft somewhat dome-shaped, its apex pointed (pl. 42, fig. 411).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 42-45 rows of hooks on its apex; postclypeal sclerites well sclerotized, small, and well separated. Posterior sucker with 248-255 rows of hooks. Anal gills composed of 3 main branches, bulbous and fleshy, each with from 12-14 fingerlike projections. The X-shaped sclerite simple, well sclerotized; anterior arms very short; union of arms of both sides very broad and open; no pigmented patches, rectal scales or spines; numerous simple spines on each side, between the anterior and posterior arm. No ventral papillae or plaques on eighth segment.

Types.—♂, in Bellardi collection (present location unknown); collected in Tuxpango, Veracruz, Mexico.

SIMULIUM (DYARELLA) PULVERULENTUM Knab

Simulium pulverulentum Knab, Insecutor Inscitiae Menstruus, vol. 2, No. 12, pp. 177-178, 1914 (original description, female).—Fairchild, Ann. Ent. Soc. Amer., vol. 33, No. 4, pp. 716-717, figs. 4 and 19, 1940 (♂, ♀, and pupa).—Vargas, Díaz, and Martínez, Rev. Inst. Salubr. Enferm, Trop., vol. 4, No. 3, pp. 287-288, figs. 1-2, 1943 (female).—Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 4, No. 4, figs. 10-18, 1943 (♂, ♀ leg, and pupa).

Simulium (*Dyarella*) *pulverulentum* Knab, Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 179, fig. 142, 1946 (larva).

Male (pl. 24, figs. 61-63).—2.7 mm. long.

Head: Holoptic. Eyes dark reddish brown. Antenna 460 μ long, 11-segmented, slightly tapering; segment $3=1+2$, $11=9+10$; segment 3 stalked; scape, pedicel, and first flagellar segment brown, other segments black. Palpi dark brown. Clypeus white-pruinose.

Thorax: Mesonotum velvety reddish brown, completely white-pruinose except for one longitudinal shiny brown band along midline, and one on either side of it, all ending at prescutellar region; long, narrow, golden-yellow, scalelike hairs densely clothe the entire mesonotum, including prescutellar region; short, brownish hairs along anterior margin of mesonotum and in prescutellar region; no long hairs being found in latter region. Humeral angles shiny brown. Pleura evenly white-pruinose. Scutellum shiny brown, with several long tan hairs. Postnotum velvety brown, white-pruinose, without hairs of any kind. Stem of halter brown, the knob pale yellow, cup-shaped. Wings, 2.1 mm. long and 0.9 mm. wide; relation of length of body to wing, 1.3 : 1; Sc with basal third pilose; R_1 with spines on distal half, very few hairs intermixed; R_{2+3} pilose along apical three-fourths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.1 mm.; coxa and trochanter light brown; femur light brown except for dark patch at each end; tibia light brown in midregion, the basal and apical thirds dark brown; tarsus blue black. Leg 2, length, 1.8 mm.; coxa and trochanter light brown; femur dark on basal third, the apical two-thirds light brown except for small apical dark patch; tibia brown except for basal and median yellow rings; basal two-thirds of basitarsus yellow, apical third black; tarsal segments 2-5 black. Leg 3, length, 2.1 mm.; coxa dark brown; trochanter yellow; femur and tibia with basal fourth yellow and apical three-fourths dark brown; basal third of basitarsus and second tarsal segment yellow, the apical two-thirds of each of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second tarsal segment, 4.7:1; calcipala well developed, but not reaching pedisulcus; pedisulcus very small, situated on basal third of second tarsal segment.

ABDOMEN: Tergite of segment 1 light brown, pleurites dark brown, the latter with very long tan hairs which reach segment 4. Segment 2 light brown. Other segments velvety black, with sparsely distributed, short, tan hairs on last segment. Sternites light brown, with dark brown longitudinal band along midline.

GENITALIA: Sidepiece (pl. 24, fig. 62) wider than long, almost perfect rectangle in shape; dorsal opening occupying more than half of dorsal surface of sidepiece, following its contours. Clasper (pl. 24, fig. 62) twice as long as wide, almost twice the length of sidepiece, its margins sinuous owing to large bulge near base of inner margin and other toward middle of outer margin; apex rounded, hardly narrowed, with two well-developed terminal spines next to each other near apical margin. Adminiculum (pl. 24, fig. 61) somewhat in form of inverted Y, the two basal prolongations well sclerotized, spatulate at their ends, with lateral membranes that are continuous with the apical prolongation; apical prolongation about as long as any one of the basal prolongations, with ventral keel which bears several hairs. Adminicular arms (pl. 24, fig. 63) with about 12 pointed teeth near their ends, arranged in form of a club; lateral plate somewhat triangular in shape, slightly sclerotized.

Female (pl. 31, figs. 181-183, and pl. 35, fig. 241).—2.5 mm. long.

HEAD: Dichoptic. Eyes reddish brown; height of fronto-ocular triangle twice the base; both basal angles with extensions to frons. Antenna 450 μ long, 11-segmented, sharply tapering from the third segment to apex; scape and pedicel tan, flagellum becoming progressively darker from third segment to apex. Palpi evenly brown. Frons dark brown, white-pruinose, with row of black hairs on each of its lateral margins. Clypeus light brown, white-pruinose, evenly covered with short white hairs. Occipital region dark brown, white-pruinose, with few short black hairs. Cornuae of buccopharyngeal apparatus somewhat lyre-shaped, well sclerotized but not heavily pigmented; median space well sclerotized with thick rim along its border, without teeth.

Thorax: Mesonotum rust brown, the entire periphery gray-pruinose, with 3 longitudinal gray-pruinose stripes along the mesonotum, one down the midline and one to either side of it; several appressed, silvery, scalelike hairs on periphery of mesonotum, longer in prescutellar region, not in packets; short black hairs covering entire mesonotum. Humeral angles rust brown, with white pruinosity. Scutellum brown, with some appressed, silvery, scalelike hairs and several long, erect, silvery hairs that are directed anteriorly. Postnotum brown, evenly white-pruinose. Pleura evenly white-pruinose. Stem of halter light brown, the knob white, cup-shaped. Wings, 2.5 mm. long and 1.0 mm. wide; relation of length of body to wing, 1 : 1; Sc pilose along its basal third; R_1 with hairs and spines along its distal two-thirds; R_{2+3} pilose along its distal three-fourths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.5 mm.; coxa and trochanter tan; femur tan, with 3 black patches at intervals along its inner margin; basal and apical thirds of tibia black, middle light brown; tarsus black. Leg 2, length, 2.3 mm.; coxa and trochanter tan; femur tan with apical dark ring; tibia marked from its base in the following order; Light patch, dark patch, light patch, the remainder dark with the extreme apex almost black; basal two-thirds of basitarsus tan, remainder black; segments 2-5 black. Leg 3, length, 2.7 mm.; coxa brown; trochanter tan; femur tan with apical dark ring; tibia marked as on leg 2, with color bands even more pronounced; basal three-fourths of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, dark brown; relation of basitarsus to second segment, 6 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus well developed on basal third of second tarsal segment; claw with well-developed heel and with secondary subbasal spur (pl. 35, fig. 241).

Abdomen: Tergite of segment 1 light brown, with dark-brown transverse stripes; pleura of this segment velvety dark brown, with long tan hairs that reach the third segment. Segment 2 light brown, with white pruinosity. Segments 3-6 dark brown, the remaining segments with almost bluish cast; pleura of all of these segments brownish, with white pruinosity. Sternites brown, with yellowish pruinosity.

GENITALIA: Cercus (pl. 31, fig. 181) oval in shape, slightly higher than long (wide), clothed with posteriorly directed, long, strong hairs, and with many minute spinelike hairs. Height of anal lobe (pl. 31, fig. 181) twice its length (width), with broad projection just beneath the cercus. Genital rod (pl. 31, fig. 183) with bulblike basal dilatation; apical expansions of arms of genital fork triangular in shape, the apical and outer basal angles well sclerotized and sharply pointed, the inner basal angle membranous and blunt; outer margin of triangle also well sclerotized. Ovipositor (pl. 31, fig. 182) long, lance-shaped, well tapered to apical point.

Pupa (pl. 37, fig. 297, and pl. 39, fig. 337).—Entire thorax with granulosity; trichomes absent on dorsum of thorax. Dorsal surface of abdominal segments: Granulosity present on segments 1-4; segment 2 with 6 anteriorly directed spines in transverse row three-fourths of the way back from anterior margin, the row being divided in two by a median space; lateral to the terminal spine at each end of the row are 3 somewhat smaller spines arranged in a triangular pattern; segments 3 and 4 with transverse rows composed of 8 spines, situated a little before the posterior margin, each row also being separated into two by a median space. Ventral surface of abdominal segments: Fifth segment with 4 anteriorly directed spines in transverse row, situated near the posterior margin, the spines being divided into two equal groups by a median space; at times this row of spines is lacking; segments 6 and 7 with similar rows of spines, but the two spines on either side of median space are more separated than on segment 5, so that the distance between them is approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 297) of each side arising somewhat behind the anterior margin of thorax; composed of 10 filaments which branch in groups as follows: 4-4-1-1. Maximum length of filaments, 0.9 mm., about 0.2 times the length of cocoon; average diameter, 36 μ; filaments with superficial annulation and with microscopic spicules.

Cocoon (pl. 39, fig. 337): Length of base, 3.2 mm.; maximum length, 4.2 mm.; maximum width, 1.9 mm.; maximum height, 2.0 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; without festoons or prolongations; rim around anterior aperture not thickened. Cocoon covering abdomen and half of thorax.

Larva (pl. 40, fig. 375, and pl. 42, fig. 412).—Total length, 5.2 mm.

Length of head capsule 1.1 times its width. Width of thorax 1.5 times that of head. First 4 abdominal segments about equal in width to thorax; segments 5-7 about 1.3 times width of segments 1-4; expansion of abdomen is gradual from anterior to posterior end, narrowing rapidly at the eighth segment; in profile, the larva appears the same as others of the subgenus *Dyarella.* General color yellow to orange, with dark patches at ventrolateral regions of abdominal segments 6 and 7.

Head: Patterns on frons-clypeus and epicranial plates shown on plate 40, figure 375. Each cephalic fan with 36 nonpectinate branches. Mandible very long and narrow, with only 1 flat tooth on its inner margin. Antenna 430 μ long, pale yellow, 4-segmented, surpassing the basal stalk of the cephalic fan; segment $2>3>1$; segment 2 with 2 white patches; in the middle of each appears a superficial indentation giving the appearance of 3 distinct segments. Submentum with 9 apical teeth, the middle one larger than the others; ventrolateral row composed of 7 hairs in straight line, all appearing trifid or bifid at their apices except the basal two which are simple; lateral margins of submentum with 3 teeth in regular sequence. Occipital cleft widely rounded (pl. 42, fig. 412).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 40-44 rows of hooks on its apex; postclypeal sclerites well sclerotized and pigmented, each near the posterior junction of the frons-clypeus with an epicranial plate. Posterior sucker with 150-156 rows of hooks. Anal gills with 3 main divisions that are bulbous and fleshy; from each lateral division there are 3 fingerlike projections, and from the middle one, 4, giving a total of 10 branches in all. X-shaped sclerite with anterior and posterior arms well sclerotized, the anterior arms broad and somewhat expanded at their ends, with membrane along the anterior margin; bulbous structure present on each side, between anterior and posterior arm, bearing numerous spines; no rectal spines. No ventral papillae or plaques on eighth segment.

Types.—Series of 35 ♀♀ (U.S.N.M. No. 19111), collection of the United States National Museum; collected in Punta Gorda, British Honduras.

SIMULIUM (DYARELLA) RUBICUNDULUM Knab

Simulium rubicundulum Knab, Insecutor Inscitiae Menstruus, vol. 2, No. 12, pp. 177-179, 1914 (original description, female).

Simulium virgatum rubicundulum (Knab), Bequaert, *in* Strong, Sandground, Bequaert, and Ochoa, Contr. No. 6, Dept. Trop. Med. and Inst. Trop. Biol. and Med., Harvard Univ., pp. 215-216, 1934 (♀ and pupa).—Vargas, Rev.

Inst. Salubr. Enferm. Trop., vol. 3, No. 3, pp. 242-243, figs. 7 and 14, 1942 (♂ and ♀).

Simulium virgatum Coquillett, VARGAS, Rev. Inst. Salubr. Enferm. Trop., vol. 4, No. 4, figs. 33-35, 1943 (pupa).

Simulium (*Dyarella*) *rubicundulum* Knab, VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 179-180, fig. 160, 1946 (larva).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, p. 35, 1951 (compared with *Simulium* (*Dyarella*) *acatenangoensis*, new species, and its validity established).

Male (pl. 24, figs. 64-66).—3.5 mm. long.

HEAD: Holoptic. Eyes light reddish brown. Antenna 640 μ, 11-segmented; segment $3>1+2$, $3<4+5$, $3>11$; segment 4 much narrower than segment 3; scape and pedicel light brown, the flagellum gradually becoming darker from base to apex. Palpi dark brown at base, black at apex. Clypeus brown, white-pruinose, irregularly covered with black hairs.

THORAX: Mesonotum yellowish brown, with rather wide band of white pruinosity around periphery, widest at posterior margin; 2 narrow longitudinal stripes of white pruinosity running from anterior to posterior margin on either side of midline, connected with white pruinosity of prescutellar region to form a lyre-shaped design; a narrow dark-brown stripe along midline; narrow, yellow, scalelike hairs completely covering the mesonotum, never in packets, longer on prescutellar area; short black hairs over entire surface of mesonotum, long black ones on prescutellar region. Humeral angles shiny brown, evenly white-pruinose. Pleura white-pruinose. Scutellum shiny brown, with numerous long tan hairs and a few long black ones on either side. Postnotum shiny brown, completely white-pruinose. Stem of halter brown and hairy, the knob yellow. Wings, 3.6 mm. long and 1.5 mm. wide; relation of length of body to wing, 1 : 1; Sc pilose along its basal fourth; R_1 pilose and spiny along the distal half; R_{2+3} pilose along its distal four-fifths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 4.1 mm.; coxa and trochanter tan; femur light brown except for apical fourth which is dark brown; basal two-thirds of tibia tan, remainder black; tarsus black. Leg 2, length, 3.6 mm.; coxa brown; trochanter light brown; femur tan on basal three-fourths, remainder dark brown; basal three-fourths of tibia tan with dark-brown spot near middle of anterior edge, remainder dark brown; basal two-thirds of basitarsus and basal third of second tarsal segment light brown, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 4.2 mm.; coxa dark brown; trochanter tan; basal two-thirds of femur tan, apical third dark brown; basal third of tibia tan with a dark-brown ring, remainder black; basal half of basitarsus and of second tarsal segment light brown, the remainder of these segments, as well as all of segments 3-5, black; basitarsus parallel-sided; relation of basitarsus to second tarsal segment, 4:1; calcipala small, straight, reaching only halfway to pedisulcus; pedisulcus not deeply incised, on basal third of second tarsal segment.

ABDOMEN: Tergite of segment 1 tan, the pleurites black with very long tan hairs reaching third segment. Anterior two-thirds of segment 2 brown, white-pruinose, the posterior third black. All remaining segments black except the sixth, which is dark brown with white pruinosity; all segments with short black hairs. Sternites brown.

GENITALIA: Sidepiece (pl. 24, fig. 65) quadrangular, somewhat wider than long; dorsal opening also quadrangular in shape, occupying more than half of sidepiece. Length of clasper (pl. 24, fig. 65) three times its width, both margins sinuous, the bulge on the outer margin being more pronounced; apex narrower than remainder of clasper, somewhat truncate, with a single, well-developed terminal spine near the apical margin. Body of adminiculum (pl. 24, fig. 66) rectangular in shape, much wider than long, with a very long, slender, apical prolongation, the latter longer and more slender than that of *acatenangoensis* Dalmat, *mathesoni* Vargas, or *virgatum* Coquillett; prolongation constricted near its midregion, with numerous hairs along its surface; posterior angles of body of adminiculum somewhat exaggerated; basal prolongations broad, well sclerotized, and spatulate; body of adminiculum covered with very fine, short hairs. Adminicular arms (pl. 24, fig. 64) with approximately 4 rather dull teeth, all approximately of the same length, arranged in about 2 longitudinal rows; lateral plate long, rectangular, well sclerotized.

Female (pl. 31, figs. 184-186, and pl. 35, fig. 242).—4.0 mm. long.

HEAD: Dichoptic. Eyes dark brown; height of fronto-ocular triangle equal to the base. Antenna 560 μ, 11-segmented; segment 3 very wide, equal to one-half $1+2$, $3=4+5$; segment 11 longer than any other segment; scape and pedicel tan, segments 3, 4, and 5 brown, the remaining flagellar segments black. Palpi dark brown to black. Frons brown, white-pruinose, with 3 irregular rows of strong black hairs on each of its margins. Clypeus brown, white-pruinose, with 4 irregular rows of strong black hairs on each lateral margin. Occipital region dark brown, white-pruinose, covered with strong black hairs. Cornuae of buccopharyngeal apparatus short, well sclerotized, bifurcated at their apices; median space hyaline, very slightly serrated.

THORAX: Mesonotum shiny, light rust brown, with 2 bands of white pruinosity, wider at their anterior extremities, extending longitudinally from 2 white-pruinose triangles situated on the anterior margin, to the prescutellar depression, the latter also being completely white-pruinose; very narrow stripe of white pruinosity on midline; wide band of white pruinosity around entire periphery; short, yellow, scalelike hairs, not in packets, sparsely distributed on anterior fourth of mesonotum; short black hairs also distributed over mesonotum, longer ones present on prescutellar region. Humeral angles shiny brown, with yellow, scalelike hairs. Scutellum brown, with 3-4 short black hairs on each side. Postnotum brown, white-pruinose, devoid of hairs. Pleura brown, evenly white-pruinose. Stem of halter dull brown, the knob tan, cup-shaped. Wings, 4.1 mm. long and 1.7 mm. wide; relation of length of body to wing, 1 : 1; Sc with basal three-fourths pilose; R_1 with its apical three-fifths both pilose and spiny; R_{2+3} pilose except for very small basal section at the base of which are 2 hairs; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 4.3 mm.; coxa, trochanter, and femur light brown; tibia brown on basal fourth, dark brown on apical fourth, and yellow in midregion; tarsus dark brown. Leg 2, length 3.8 mm.; coxa dark brown, with posterior edge black; trochanter light brown; femur light brown, with wide dark-brown apical ring; tibia divided into the following color bands from its base to apex: light brown, dark brown, yellow, dark brown; basal three-fourths of basitarsus and basal fourth of second tarsal segment light brown, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 4.5 mm.; coxa dark brown; trochanter light brown; femur and tibia as on leg 2; basal half of basitarsus and second tarsal joint light brown, the remainder of these segments, as well as all of segments 3-5, dark brown to black; relation of basitarsus to second segment, 4: 1; calcipala well developed, but not quite reaching the pedisulcus; pedisulcus very well developed on basal third of second segment, almost cutting through entire width of segment; claw with well-developed heel and with strong, long, sharply pointed subbasal spur (pl. 35, fig. 242).

Abdomen: Anterior half of tergite of segment 1 black, the posterior half tan; pleurites black, with long tan hairs reaching the third segment. Segment 2 light brown, its posterior half white-pruinose; pleurites brown. All other segments with tergites black and pleurites brown, the latter with short tan hairs. Sternites tan, with dark band in central region.

Genitalia: Cercus (pl. 31, fig. 184) somewhat trapezoidal in shape, dorsal margin sinuous, higher than long (wide), clothed with long, strong hairs and numerous fine spicules. Anal lobe (pl. 31, fig. 184) narrow where it curves around the cercus, with extensive expanded region ventral to the latter; with similar investiture to that of cercus. Genital rod (pl. 31, fig. 185) with triangular-shaped basal dilatation that is poorly sclerotized; apical expansions of arms of genital fork triangular in shape, all the angles being well sclerotized; inner basal angle with hollow, cone-shaped structure extending from it; membrane along outer margin near apex. Ovipositor (pl. 31, fig. 186) almost triangular in shape, longer than wide, the apex blunt.

Pupa (pl. 37, fig. 298, and pl. 39, fig. 338).—Granulosity on entire thorax; 3 simple trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Segment 1 with granulosity along posterior margin and segment 2 having it along the anterior margin; segment 2 with 6 anteriorly directed spines in transverse row somewhat before posterior margin, the row being divided in two by a median space; segments 3 and 4 with transverse rows of 8 spines, situated as on segment 2, each row also being separated in two by a median space. Ventral surface of abdominal segments: Without granulosity; segment 5 with 4 anteriorly directed simple spines in transverse row, situated a little before the posterior margin, the spines being divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but the two spines on either side of the median space are more separated than on segment 5, so that the distance between them is approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 298) of each side arising just posterior to anterior margin of thorax; composed of 8 filaments which branch into two main trunks from a rather long, narrow basal stalk, each trunk subdividing into four filaments which emerge at different levels; the formula of branching is: 4-4. Maximum length of filaments, 2.7 mm., about 0.4 times the length of the cocoon; average diameter, 52 μ; filaments with undulations along their surface and with microscopic spicules.

Cocoon (pl. 39, fig. 338): Length of base, 4.5 mm.; maximum length, 6.7 mm.; maximum width, 2.6 mm.; height with festoons, 2.6 mm.; height of case without festoons, 2.1 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; ribbonlike festoons extending from rim of dorsal aperture, usually 6 on either side, the posterior five being connected dorsally by transverse band; dorsal margin of festoons forming straight line, parallel to base of cocoon; rim around anterior aperture not thickened. Cocoon covering abdomen and half of thorax.

Larva (pl. 41, fig. 376, and pl. 42, fig. 413).—Total length, 9.6-9.9 mm. Length of head capsule 1.2 times the width. Thorax and first 4 abdominal segments about equal in width, 1.4 times the width of head; abdominal segments 5-7 somewhat expanded, 1.3 times width of segments 1-4; in profile, the larva appears like others in subgenus *Dyarella,* with the posterior end narrowing rapidly. General color yellow to tan, without dark patches on ventrolateral areas of segments 6 and 7.

HEAD: Patterns on frons-clypeus and epicranial plates best demonstrated on plate 41, figure 376. Each cephalic fan with approximately 56 pectinate branches; hairs on these very short and close together, with longer, stouter hairs, simple or bifid, at regular intervals. Mandible with 2 teeth on its inner margin, appearing to arise from a single base, the most distal better developed. Antenna 440 μ long, yellow, 4-segmented, easily surpassing the basal stalk of the cephalic fan; segment $2>1>3$; segment 2 with 2 clear regions in which there are superficial indentations making the segment appear like three individual segments; segment 1 with longitudinal striations. Submentum with 9 apical teeth, the central one and two outer ones longer than the others; all teeth triangular in shape, pointed; ventrolateral row composed of 9-10 hairs in straight line, the apical five trifid, next three bifid, and basal hair simple; lateral margin of submentum with 6 toothlike indentations near apex. Occipital cleft pointed (pl. 42, fig. 413).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 56-58 rows of hooks on its apex; postclypeal sclerites small, but well sclerotized and separated, one at each posterior junction of the frons-clypeus and epicranial plate. Posterior sucker with 220-230 rows of hooks. Anal gills with 3 fleshy, bulbous branches, each with 12 short fingerlike projections that are close together. The X-shaped sclerite is simple, both anterior and posterior arms well sclerotized; posterior arms rather long, reaching a distance down on either side of the larva; no pigmented patches, rectal scales or spines. No ventral papillae or plaques on eighth segment.

Types.—Two ♀♀ (U.S.N.M. No. 19112), collection of the United States National Museum; one collected in Córdoba, Mexico, December 17, 1907, the other in Las Vegas Hot Springs, N. Mex., U. S. A., August 7.

SIMULIUM (DYARELLA) SMARTI Vargas

Simulium (*Eusimulium*) *smarti* VARGAS, Puerto Rico Journ. Publ. Health Trop. Med., vol. 21, pp. 327-331 (English) or 332-335 (Spanish), figs. 1-5, 1946 (original description, ♂, ♀, and pupa).

Simulium (*Dyarella*) *smarti* Vargas, VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 180, figs. 140 and 159, 1946 (larva).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 55-57, 1951 (presence in Guatemala).

Male (pl. 25, figs. 67-69).—4.6 mm. long.

HEAD: Holoptic. Eyes dark reddish black. Antenna 700 μ, 11-segmented; segment $3>1+2$, $3=4+5$, $3>11$; segment 3 is widest, the remainder of flagellum tapering slightly; scape and pedicel brown, the flagellum black. Palpi black. Clypeus brown, white-pruinose, with long, strong, black hairs.

THORAX: Mesonotum dark burgundy to black, covered with white pruinosity throughout and with 3 longitudinal black lines running from anterior margin to prescutellar region; narrow, long, bronze-colored, scalelike hairs completely covering the mesonotum, in packets on anterior half, longer in prescutellar region; short black hairs over entire mesonotum, long black ones in prescutellar region. Humeral angles shiny brown with golden scalelike hairs and short black hairs. Pleura with anterior half dark brown and posterior half light brown, all evenly white-pruinose. Scutellum brown, with long, strong, black hairs and yellow scalelike hairs. Postnotum brown, the anterior half white-pruinose. Stem of halter with light-brown base and dark-brown apex, knob tan. Wings, 4.2 mm. long and 1.8 mm. wide; relation of length of body to wing, 1.1 : 1; Sc pilose along its basal fourth; R_1 with spines along its apical half with only 2 or 3 hairs scattered among them; R_{2+3} pilose along the distal two-thirds, the hairs very sparse; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 4.4 mm.; coxa, trochanter, and femur brown; tibia and tarsus black. Leg 2, length, 3.9 mm.; coxa, trochanter, femur, and tibia brown; basal two-thirds of basitarsus and basal half of second tarsal segment light brown, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 4.6 mm.; coxa dark brown; trochanter light brown; femur with basal fourth brown, the apical three-fourths black; tibia with anterior fourth tan, the remainder black; basitarsus spindle-shaped, with basal half tan, remainder black; tarsal segments 2-5 black; relation of basitarsus to second tarsal segment, 4.5 : 1; calcipala broad, somewhat curved, well developed, reaching pedisulcus; pedisulcus well formed on basal third of second segment.

ABDOMEN: Tergite 1 with anterior half brown and posterior half black; pleurites black, white-pruinose, with long black hairs almost reaching segment 4. Segment 2 with anterior half brown and posterior half black, all white-pruinose. All other segments black with the anterior half of the pleurites white-pruinose; segments 3 and 4 with short tan hairs and last segment with black hairs. Sternites black with white pruinosity.

GENITALIA: Sidepiece (pl. 25, fig. 67) almost square, very slightly wider than long; dorsal opening occupying basal half of sidepiece. Length of clasper (pl. 25, fig. 67) about four times its width, its margins being sinuous, with only very slight convexities; clasper about of equal width throughout; a sclerotized dorsal ridge extends from the dorsal opening on the clasper to the apical spine; apex blunt, with a single, well-formed spine near margin. Body of adminiculum (pl. 25, fig. 68) rectangular in shape, about twice as long as wide; along the body on the ventral surface is a pronounced keel which is clothed with numerous hairs; basal prolongations broad, their apices greatly expanded, somewhat spatulate, and well sclerotized. Arms of adminiculum (pl. 25, fig. 69) with approximately 30 teeth arranged in linear fashion; lateral plate almost triangular in shape, not heavily sclerotized.

Female (pl. 32, figs. 187-189, and pl. 35, fig. 243).—4.1 mm. long.

HEAD: Dichoptic. Eyes black; height of fronto-ocular triangle three times the base. Antenna 820 μ long, 11-segmented, tapering; segment $3>1+2$, $11=1+2$, $11>3$; segment 11 rather blunt; scape and pedicel light brown, the flagellum dark brown to black. Palpi dark brown. Frons black, white-pruinose, with 3 rows of black hairs around periphery. Clypeus and occipital region black, white-pruinose, covered with long black hairs. Cornuae of buccopharyngeal apparatus with apical half sclerotized, bifurcated; median space hyaline, with 7 irregular rows of very small scalelike teeth.

THORAX: Mesonotum blue black, completely white-pruinose with no longitudinal stripes or bands; long, narrow, yellow, scalelike hairs, in packets of 2-5, over entire mesonotum; short black hairs all over mesonotum, longer on prescutellar region. Humeral angles velvety brown to black, with white pruinosity. Scutellum black, with numerous yellowish scalelike hairs as on mesonotum, and with several long black hairs. Postnotum velvety brown to black, with white pruinosity. Pleura evenly brown to black, with white pruinosity. Wings, 4.4 mm. long and 1.9 mm. wide; relation of length of body to wing, 1 : 1.1; Sc pilose except for very short apical portion; R_1 completely pilose, the apical half with spines also, at times with short interruption in hairs near base; R_{2+3} completely pilose; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 4.9 mm.; coxa, trochanter, and femur light brown; tibia black, with very narrow light-brown basal ring; tarsus black. Leg 2, length, 4.2 mm.; coxa dark brown; trochanter brown, the inner surface black; femur brown; tibia varying from brown to dark brown at apex, with light-brown basal ring; basal three-fourths of basitarsus and basal half of second and third tarsal segments light brown, the remainder of these segments, as well as all of segments 4-5, black. Leg 3, length, 5.2 mm.; coxa black; trochanter brown; femur and tibia black with basal brown rings; basal half of basitarsus tan, the remainder black; tarsal segments 2-5 black; relation of basitarsus to second tarsal segment, 5:1; calcipala very long, surpassing the pedisulcus; pedisulcus well formed on basal third of second segment; claw well formed with secondary subbasal spur (pl. 35, fig. 243).

Abdomen: Tergite of segment 1 brown, the pleurites black with long tan hairs reaching the fourth segment. Second segment with anterior half light brown and posterior half dark brown, all white-pruinose. Other segments black, the pleura with short black hairs. Sternites tan.

Genitalia: Cercus (pl. 32, fig. 187) higher than long (wide), with posterior angles rounded, covered with long strong hairs and fine spicules. Anal lobe (pl. 32, fig. 187) with ventral portion extending beneath cercus well expanded, somewhat membranous; with similar investiture to that of cercus. Genital rod (pl. 32, fig. 189) blunt, slightly bulbous, well sclerotized; apical expansions of arms of genital fork triangular in shape, the inner basal angle almost 90 degrees; apical angle blunt, outer basal angle sharply pointed and very heavily sclerotized. Ovipositor (pl. 32, fig. 188) somewhat dome-shaped, height very slightly greater than the base, apex rounded.

Pupa (pl. 37, fig. 299, and pl. 39, fig. 339).—Granulosity on entire thorax, more marked on anterior three-fourths; 6 simple trichomes, not very long, on either side of midline of thorax. Dorsal surface of abdominal segments: Segment 1 with granulosity on posterior half, and segment 2 having it on the anterior half; segment 2 with 6 anteriorly directed spines in transverse row somewhat anterior to posterior margin, the row being divided in two by a median space; segments 3 and 4 with transverse rows of 8 spines, situated as on segment 2, each row also being separated in two by a median space. Ventral surface of abdominal segments: Without granulosity; segment 5 with 4 anteriorly directed simple spines in transverse row, a little before posterior margin, the spines being divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but with the two spines on either side of the median space more separated than on segment 5, so that the distance between them is approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 299) of each side arising behind the humeral angles of the thorax, each composed of 18 filaments which branch as follows: 6-2-8-2; filaments with superficial annulation and with microscopic spicules; filaments extended so that they appear to form an open fan. Maximum length of filaments, 2.6 mm., about 0.4 times the length of the cocoon; average diameter, 28 μ.

Cocoon (pl. 39, fig. 339): Length of base, 4.9 mm.; maximum length, 6.6 mm.; maximum width, 3.2 mm.; maximum height, 3.0 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; no festoons or prolongations; rim around anterior aperture thickened. Cocoon covering abdomen and half of thorax.

Larva (pl. 41, fig. 377, and pl. 42, fig. 414).—Total length, 11.6-12.7 mm. Length of head 1.1 times its width. Width of thorax 1.6 times width of head. Abdominal segments 1-4 about equal in width to thorax; segments 5-7 about 1.3 times width of segments 1-4; expansion of abdomen is gradual from anterior to posterior ends, segment 8 narrowing rapidly; in profile, larva appears like others of subgenus *Dyarella.* General color yellow to gray, with no dark patches on ventrolateral regions of segments 6-7.

Head: Frons-clypeus usually all dark, although at times a more distinct pattern is visible; designs on frons-clypeus and epicranial plates shown on plate 41, figure 377. Each cephalic fan with 51-52 pectinate branches, the short hairs on these branches simple, close together, interspersed with stouter, slightly longer hairs at regular intervals. Mandible with only 1 well-developed tooth on its inner margin, an indication of a second minute tooth visible somewhat closer to the base. Antenna 430 μ long, light yellow in part, dark brown on remainder, 4-segmented, just passing the basal stalk of the cephalic fan; segment $2>1>3$; segment 1 with small white patch at its base, the rest dark brown; segment 2 almost transparent except for 2 dark-brown patches beyond the middle, and 1 longitudinal patch extending from the base to first of 2 patches near midregion; segments 3 and 4 dark brown, appearing almost black; segment 1 with longitudinal striations. Submentum with 11 apical teeth, the middle seven of approximately the same length, like one end of a hexagon in shape; two outer teeth on either side are light yellowish in color, smaller than the others; ventrolateral row composed of 11 hairs in straight line, at least the apical six hairs bifid; lateral margin of submentum with 9 very small toothlike indentations near the apex. Occipital cleft pointed, deep, and broad (pl. 42, fig. 414).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 65-70 rows of hooks on its apex; postclypeal sclerites small, well sclerotized, very dark, one at each posterior junction of the frons-clypeus with an epicranial plate. Posterior sucker with 450-460 rows of hooks. Anal gills with 3 main branches, these being fleshy but not very large; from each base extend 19 fingerlike prolongations which are short but not stubby. The X-shaped sclerite well sclerotized, its anterior arms with winglike structures at the ends; with 6 to 7 rows of rectal scales which are either single, bifid, or trifid, the patch extending to lateral margins of the larva. No ventral papillae or plaques on eighth segment.

Types.—Holotype (♀), allotype (♂), and paratypes (1 ♂ and 3 ♀♀) in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected from the stream El Rubí, Finca El Vergel, Chiapas, Mexico, 1,000 meters above sea level, January 1945.

SIMULIUM (DYARELLA) YEPOCAPENSE Dalmat

Simulium (*Dyarella*) *yepocapense* Dalmat, Ann. Ent. Soc. Amer., vol. 42, No. 4, pp. 548-553, figs. 23-28, 1949 (original description, ♂, ♀, and pupa).

Male (pl. 25, figs. 70-72).—3.3 mm. long.

Head: Holoptic. Eyes reddish brown. Antenna 570 μ, 11-segmented; segment $3>1+2$, $3<4+5$, $3<11$; appears widest at segments 8 and 9; scape and pedicel light brown, flagellum dark brown. Palpi dark reddish brown. Clypeus grayish brown, white-pruinose, with short tan hairs.

Thorax: Mesonotum coppery brown, with 2 very wide longitudinal bands of white pruinosity, one on either side of midline; each band is approximately one-fourth the width of the dorsum; a very narrow black line running down the midline; periphery of mesonotum white-pruinose except for break at center of anterior margin; broad, yellow, scalelike hairs over entire mesonotum, never in packets, longer in prescutellar region; short black hairs entirely covering the mesonotum longer in prescutellar region. Humeral angles white-pruinose, with very pale-yellow scalelike hairs. Scutellum grayish brown, white-pruinose, with yellow scalelike hairs and longer black ones. Postnotum velvety brown, with white pruinosity; devoid of all hairs. Pleura white-pruinose. Stem of halter brown, knob tan. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1; Sc pilose along its apical third; R_1 pilose and spiny along distal three-fifths, beginning at point where R_{2+3} emerges; R_{2+3} pilose along distal two-thirds; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.6 mm.; coxa brown; trochanter light brown;

basal and apical fourths of femur black, middle region light brown; tibia and tarsus black. Leg 2, length, 3.0 mm.; coxa brown; trochanter tan; femur with basal two-thirds tan, apical third black; tibia black except for basal tan ring; basal half of basitarsus tan, remainder black; tarsal segments 2-5 black. Leg 3, length, 3.8 mm.; coxa black; trochanter tan; femur with basal fourth tan, the remainder black; tibia black, with small basal tan ring; basal half of basitarsus tan, the apical half, as well as all of tarsal segments 2-5, black; basitarsus parallel-sided, with only slight expansion; relation of basitarsus to second tarsal segment, 4.1 : 1; calcipala well formed, small, broad, reaching only halfway to pedisulcus; pedisulcus hardly discernible, formed on basal third of second segment.

Abdomen: Tergite of segment 1 very dark brown, covered with short hairs; pleurites black, with numerous long tan hairs reaching fifth segment. Segment 2 black, with white pruinosity. All other segments black, the pleura somewhat white-pruinose. Sternites brown.

Genitalia: Sidepiece (pl. 25, fig. 70) quadrangular, wider than long; dorsal opening occupying almost two-thirds of dorsal surface of sidepiece. Length of clasper (pl. 25, fig. 70) three times its width, its margins sinuous, a large bulge on the outer margin; apex narrowed, rounded, but blunt; a single apical spine almost terminal in position. Body of adminiculum (pl. 25, fig. 71) wider than long, somewhat rectangular in shape, the posterior angles well rounded; apex with indentation from which extends a small crown of short hairs; no apical prolongation; sides of body appear to be in form of winglike expansions; basal processes short, more heavily sclerotized than the rest of adminiculum, somewhat pointed. Arms of adminiculum (pl. 25, fig. 72) with approximately 35 teeth arranged in linear fashion, the longer teeth toward the end, forming a clublike apex; lateral plate broadly triangular, lightly sclerotized.

Female (pl. 32, figs. 190-192, and pl. 35, fig. 244).—3.1 mm. long.

Head: Dichoptic. Eyes reddish black; height of fronto-ocular triangle 1.8 times the base. Antenna 580 μ long, 11-segmented, slightly tapering; third segment widest, segment 11 pointed; segment $3<1+2$, $3=4+5=11$; scape, pedicel, and first segment of flagellum light brown, the remaining segments dark reddish brown. Palpi dark brown, the apex darkest. Frons brown, white-pruinose, with black hairs around periphery. Clypeus brown, white-pruinose, covered with black hairs. Occipital region grayish black, white-pruinose, with black hairs. Cornuae of buccopharyngeal apparatus well sclerotized, the ends bifurcated; median space somewhat sclerotized, thickened, with a single irregular row of scalelike teeth.

Thorax: Mesonotum light reddish brown, with 3 poorly defined white-pruinose longitudinal stripes extending from anterior margin to prescutellar region, one on the midline and one on either side of the midline; long, yellow, scalelike hairs, never in packets, covering all of mesonotum, longer in prescutellar region; short black hairs over entire mesonotum, longer in prescutellar region. Humeral angles white-pruinose, anterior part with black hairs. Scutellum brown, with yellow scalelike hairs and long black hairs. Postnotum brown, white-pruinose, devoid of hairs. Pleura evenly white-pruinose. Stem of halter brown, the knob almost white, cup-shaped. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1:1.1; Sc pilose along basal half, usually with a single apical hair; R_1 pilose and with spines on apical three-fourths; R_{2+3} pilose except for very short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.6 mm.; coxa, trochanter, and femur tan; tibia with basal fourth light brown, middle half yellow, and apical fourth dark brown; tarsus black. Leg 2, length, 3.0 mm.; coxa brown; trochanter yellow; femur light brown with apical dark ring; tibia with color bands from its base to apex that are tan, dark brown, tan, and dark brown; basal two-thirds of basitarsus and basal fourth of second tarsal segment light brown, the remainder of these segments, as well as all of segments 3-5, dark brown. Leg 3, length, 3.7 mm.; coxa brown; trochanter yellow; femur and tibia yellow with dark apical ring; basal two-thirds of basitarsus and basal third of second segment yellow, the remainder of these segments, as well as all of tarsal segments 3-5, dark brown; relation of basitarsus to second tarsal segment, 4:1; calcipala well developed reaching pedisulcus; pedisulcus well developed on basal third of second segment, cutting through about two-thirds the segment; claw strong, with well-developed secondary subbasal spur (pl. 35, fig. 244).

Abdomen: Tergite of segment 1 light brown with transverse dark band; pleurites black, with long tan hairs reaching third segment. Segment 2 light brown, with dark brown posterior margin; pleurites the same. Segments 3, 4, and 5 blue black; other segments reddish brown; pleura of all segments dark brown. Sternites yellow, that of the last segment darker with white pruinosity and some long tan hairs.

Genitalia: Height of cercus (pl. 32, fig. 190) twice its length (width), the posterior angles rounded, its anterior ventral angle rather well pointed; clothed with stout long spines and with numerous spicules. Anal lobe (pl. 32, fig. 190) extending well beneath the cercus, with a posteriorly directed prolongation just beneath the cercus; investiture similar to that of cercus. Genital rod (pl. 32, fig. 192) with only small, bulblike dilatation; apical expansions of arms of genital fork triangular in shape, the apical angle very sharply pointed and heavily sclerotized; the outer basal angles somewhat rounded and pigmented; the inner angle with a very long conical projection extending from it. Ovipositor (pl. 32, fig. 191) long, lance-shaped.

Pupa (pl. 37, fig. 300, and pl. 39, fig. 340).—Thorax with granulosity only on its posterior fourth; 1 bifid, 3 trifid, and 2 arborescent trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: Segments 1 and 2 with granulosity on their posterior margins; segment 2 with 6 anteriorly directed simple spines in transverse row somewhat anterior to posterior margin, the row being divided into two by a median space; segments 3 and 4 with transverse rows of 8 spines, situated as on segment 2, each row also being separated into two by a median space. Ventral surface of abdominal segments: Without granulosity; segment 5 with 4 anteriorly directed simple spines in transverse row a little before posterior margin, the spines being divided into two equal groups by a median space; segments 6 and 7 with similar rows of spines, but with the two spines on either side of the median space more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 37, fig. 300) of each side arising behind anterior margin of thorax, each composed of 8 filaments which branch as follows: 2-1-2-2-1; filaments with superficial annulations and covered with microscopic spicules. Maximum length of filaments, 1.3 mm., about 0.25 times the length of the cocoon; average diameter, 44 μ.

Cocoon (pl. 39, fig. 340): Length of base, 4.0 mm.; maximum length, 5.2 mm.; maximum width, 2.1 mm.; maximum height, 1.8 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; no festoons or prolongations from margin of anterior aperture; in profile, the margin of the anterior aperture is sinuous, with a very slightly hardened rim. Cocoon covering abdomen and half of thorax.

Larva (pl. 41, fig. 378, and pl. 42, fig. 415).—(First description of larva.) Total length, 6.8-7.9 mm. Length of head capsule 1.1 times its width. Width of thorax 1.5 times width of head. Abdominal segments 1-4 about equal in width to thorax; segments 5-7 about 1.2 times width of segments 1-4; general expansion of abdomen from anterior to posterior ends, the posterior end narrowing rapidly; in profile, the larva appears the same as others of the subgenus *Dyarella.*

General color somewhat orange, with no dark patches on ventrolateral parts of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 378. Each cephalic fan with 46 pectinate branches, the hairs on these branches being exceptionally short, shorter than those of any other representatives of this subgenus, interspersed at intervals with somewhat longer and stouter hairs; all hairs simple. Mandible with a single, well-formed, sharp tooth on its inner margin, a sign of another more basal minute tooth also visible. Antenna 480 μ long, light yellow, 4-segmented, far surpassing the basal stalk of the cephalic fan; segment $2>1>3$; segment 2 with 3 clear patches, each with a superficial indentation causing the segment to appear divided into 7 parts; segment 4 with white band in middle; segment 1 with longitudinal striations. Submentum with 9 triangular-shaped apical teeth, the central one longer than the others; ventrolateral row composed of 9 hairs in a straight line, all appearing bifid or trifid except the most basal, which is simple; lateral margin of submentum with 3-4 toothlike indentations near apex. Occipital cleft with apex dome-shaped, rounded (pl. 42, fig. 415).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 48 rows of hooks at its apex; postclypeal sclerites small, well sclerotized, one at each posterior junction of the frons-clypeus with an epicranial plate. Posterior sucker with 220-222 rows of hooks. Anal gills with 3 main branches, each with a somewhat bulbous base, less so than in *rubicundulum;* each branch with 11 fingerlike projections that are long and slender. The X-shaped sclerite well sclerotized, the posterior arms reaching the sides of the larva; apices of anterior arms somewhat expanded; no rectal scales or spines, or pigmented patches; no ventral papillae or plaques on eighth segment.

Types.—Holotype (♀), on 7 slides; allotype (♂), on 5 slides; and 2 paratypes (1 ♂, 1 ♀), mounted on pins, in the collection of the United States National Museum. Holotype collected from the Río Sacayá, Finca Niágara, San Pedro Yepocapa, Department of Chimaltenango, Guatemala, October 4, 1948, and allotype collected from the Río Kikiyá, Finca El Naranjo, Acatenango, Chimaltenango, August 12, 1948. Other paratypes (9 ♀♀, 3 ♂♂) in the collection of Herbert T. Dalmat.

SIMULIUM (SIMULIUM) JACUMBAE Dyar and Shannon

Simulium jacumbae DYAR AND SHANNON, Proc. U. S. Nat. Mus., vol. 69, art. 10, pp. 25, 44-45, figs. 113-114, 1927 (original description, ♂ genitalia).

Simulium (*Simulium*) *jacumbae* Dyar and Shannon, VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 146-147 and 174, figs. 83-86 and 150, 1946 (♀, ♂ genitalia [photograph] pupa, and larva).—VARGAS AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 9, No. 4, pp. 333-334, 1948 (synonymized the Guatemalan species, *Simulium guatemalensis* De León, with this species).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 54-57, 1951 (distribution in Guatemala).

Male (pl. 25, figs. 73-75).—(First complete description of male.) 2.5 mm. long.

HEAD: Holoptic. Eyes rusty brown. Antenna 530 μ long, 11-segmented, tapering; segment 3 long and narrow, $3=1+2$, $3>4+5$, $3>11$; scape and pedicel brown, the flagellum black. Palpi black. Clypeus black, white-pruinose, 1 row of black hairs around periphery.

THORAX: Mesonotum velvety black, with continuous band of white pruinosity along the posterior and lateral margins; near the humeral angles on each side, the band bends posteriorly at a 45-degree angle, continuing toward the center of the scutum rather than following the anterior margin; the ends of the band on each side terminate about halfway between the lateral margin and the midline; long, narrow, yellow, scalelike hairs distributed over mesonotum, numerous on anterior third of scutum, in prescutellar region, and in narrow bands along the lateral margins, few in central region; those on prescutellar area are somewhat longer; short black hairs distributed over entire mesonotum, long black ones in prescutellar region. Humeral angles brownish black, with white pruinosity. Scutellum black, with many short, yellow, scalelike hairs and a few long black ones. Postnotum velvety brown to black, white-pruinose, devoid of hairs. Pleura dark brown, with white pruinosity. Stem of halter brown to black, the knob yellow to orange. Wings, 2.7 mm. long and 1.2 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along basal sixth; R_1 pilose and spiny along distal half; R_{2+3} pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.7 mm.; coxa and trochanter black; femur and tibia black with numerous yellow scalelike hairs; tarsus black. Leg 2, length, 2.3 mm.; leg colors and investiture like on leg 1 with the exception of the basitarsus, which has a very small light-brown basal ring. Leg 3, length, 2.9 mm.; leg colors and investiture like on legs 1 and 2 with the exception of the basitarsus, which has its basal half brown; relation of basitarsus to second segment, 4.8 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed one-third the distance from the base of segment 2.

ABDOMEN: Tergite and pleurites of segment 1 black, the pleurites with long brown hairs that reach segment 5. Segment 2 black, with white pruinosity. Other segments black, the pleurites of segments 5-7 white-pruinose. All segments with short black hairs. Sternites dark brown.

Genitalia: Sidepiece (pl. 25, fig. 73) somewhat wider than long; dorsal opening occupying almost entire dorsal surface of sidepiece. Clasper (pl. 25, fig. 73) long and slender, about 1.5 times length of sidepiece, the apex rounded, wtih a single terminal spine; with basal process that is long and slender, its length about four times its width, the apex serrate, clothed with hairs. Adminiculum (pl. 25, fig. 74) in form of elongated bonnet, with very small longitudinal keel-like structure near the apex that is clothed with numerous hairs; several groups of minute spines on ventral surface; basal processes long, broad, well sclerotized, divergent, pointed at the ends, appearing to be part of a continuous band that crosses the body of the adminiculum at its base. Adminicular arms (pl. 25, fig. 75) with about 15 teeth, about four of them long, the others much shorter; lateral plate long and slender, wrinkled, partly sclerotized.

Female (pl. 32, figs. 193-195, and pl. 35, fig. 245).—2.6 mm. long.

Head: Dichoptic. Eyes black; fronto-ocular triangle very small, its height equal to the base. Antenna 480 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3=11$; scape and pedicel brown, the flagellum black. Palpi black. Frons black, with some white pruinosity. Clypeus black, white-pruinose, with some short tan hairs. Occipital region black, covered with many short tan hairs. Cornuae of buccopharyngeal apparatus sclerotized, very broad, ending bluntly; median space hyaline, with serrations and 1 large tooth in center.

Thorax: Mesonotum black; on each side of the midline and contiguous with the anterior margin, there is a large white-pruinose triangular patch; from the posterior apex of the triangle there extends posteriorly a stripe of white pruinosity that blends with the pruinosity on the prescutellar region; narrow white-pruinose stripe along posterior part of midline; long, narrow, yellow, scalelike hairs scattered over entire mesonotum, dense on anterior fourth and on prescutellar region; few long black hairs in prescutellar region. Humeral angles black, with short brown hairs. Scutellum black, with some short yellow, scalelike hairs and some long black ones. Postnotum dark brown with white pruinosity, devoid of hairs. Pleura brown, white-pruinose. Stem of halter brown on its base and tan apically, the knob white to tan. Wings, 2.7 mm. long and 1.2 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal fifth; R_1 pilose and spiny along distal half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.5 mm.; coxa and trochanter black; basal three-fourths of femur brown, the apical fourth black; basal and apical fourths of tibia black, the median part brown; tarsus black. Leg 2, length, 2.3 mm.; color patterns like on leg 1 with the exception of the basitarsus which is brown on the basal half and black apically. Leg 3, length, 2.8 mm.; color patterns on coxa, trochanter, femur, and tibia as on legs 1 and 2; basal two-thirds of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5.4:1; calcipala well developed but small; pedisulcus very poorly marked, hardly noticeable; claw with minute subbasal tooth (pl. 35, fig. 245).

Abdomen: Tergite and pleurites of segment 1 very dark brown, the pleurites with long brown hairs that reach segment 4. Segment 2 with anterior half brown, the posterior half black. Segments 3 and 4 black, the others dark brown. All segments with short dark-brown hairs. Sternites tan.

Genitalia: Cercus (pl. 32, fig. 193) dome-shaped, its height more than twice its length (width). Anal lobe (pl. 32, fig. 193) with the anterior margin rounded, the posterior margin convex, its dorsal extremity tapered and its ventral portion, which extends well below the cercus, quite expanded. Genital rod (pl. 32, fig. 195) with short, somewhat triangular-shaped dilatation; apical expansions of arms of genital fork narrow and elongate, the apex truncate and angular; 2 triangular-shaped expansions near the base, one from the inner margin and the other from the outer one. outer expansion somewhat sclerotized on the margins. Ovipositor (pl. 32, fig. 194) small, somewhat triangular in shape, the base greater than the length.

Pupa (pl. 37, fig. 301, and pl. 39, fig. 341).—Granulosity on entire thorax, concentrated in central region; numerous (about 80) fine, simple trichomes grouped together near the center of thorax in an almost triangular patch. Dorsal surface of abdominal segments: Dorsum of segment 1 with very light granulosity throughout; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with 8 simple, hairlike spines in a transverse row three-fourths the distance from the anterior margin, the row divided by a median space; anterior to the outermost spine on both extremities of the row are 2 similar spines; segments 3 and 4 each with a transverse row of 8 simple spines crossing at or near the posterior margin, the row divided by a median space; segment 7 with 20 simple and bifid spines in uninterrupted row somewhat behind the anterior margin and with numerous comblike groups of spines distributed over entire surface; segment 8 with 7-9 simple spines in an uninterrupted row one-fourth the way from the anterior margin, and with combs over entire surface of segment; segment 9 with about 30 comblike groups of spines arranged along the anterior half of the segment. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with a single simple spine on each side of the midline about one-fourth the distance from the anterior margin, the spine of each side separated from that of the other by a median space; segment 5 with 4 trifid spines in transverse row along the posterior margin, separated by median space; segments 6 and 7 each with a single bifid spine on either side of the midline, separated from each other by a median space, the spines situated three-fourths the distance from the anterior margin. Terminal spines very small, the tips well sclerotized.

Respiratory apparatus (pl. 37, fig. 301) of each side arising slightly behind the anterior margin of thorax; composed of 26 filaments which branch as follows: 10-6-6-4; filaments are not superficially annulated; with microscopic spicules over entire surface. Maximum length, 2.6 mm., about 0.73 times length of cocoon; average diameter, 28 μ.

Cocoon (pl. 39, fig. 341): Length of base, 3.7 mm.; maximum width, 2.1 mm.; maximum height, 1.2 mm. Cocoon of wall-pocket type, without collar; base prolonged anteriorly on both sides, but without winglike expansions; rim around anterior aperture not thickened but with anteriorly directed dorsal prolongation, hornlike in appearance, 1.9 mm. long; texture of case spongelike, threads appear loosely arranged. Cocoon covers abdomen only, the dorsal prolongation also covering a central longitudinal section of the thorax; attached along three-fourths of its base.

Larva (pl. 41, fig. 379, and pl. 43, fig. 416).—Total length, 5.5-5.7 mm. Length of head capsule 1.3 times its width. Width of thorax 1.4 times that of head. Abdominal segments 1-4 no wider than head; segments 5-7 expanded, greatest at segment 6 which is 1.7 times width of segments 1-4; cross section and profile like that of *metallicum*. General color tan to brown; dorsum of abdomen with a dark patch on either side of the first 4 abdominal segments and with similar patches on the ventrolateral margins of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 379. Each cephalic fan with 56-66 nonpectinate branches. Mandible with 2 well-separated teeth on its inner margin, both sharp-pointed, the distal one longer. Antenna 528 μ long, 4-segmented, light brown, far surpassing basal stalk of cephalic fan; segment 2 short, about half the length of first or third segment; segment 1 with longitudinal striations and segment 2 with transverse striations. Submentum with 9 apical teeth, triangular in shape, the central tooth and the outermost tooth on either side longer than the others; ventrolateral row composed of 4 to 5 hairs, usually simple; when there are five hairs in the row, the two basal hairs are usually not in line with the other three; lateral margin of submentum with 7 tooth-like structures, the two most-distal teeth well sclerotized, situated just lateral to the outermost of the apical teeth, the others more basal. Occipital cleft narrow, small, the margin irregular (pl. 43, fig. 416).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 34-38 rows of spines at its apex; postclypeal sclerites so small that they usually are not visible. Posterior sucker with 68-76 rows of hooks. Anal gills composed of 3 main divisions, each of which usually is simple; at times, each division has two further branches. Anterior and posterior arms of X-shaped sclerite heavily sclerotized, without expansions or patches; posterior arms are at right angles to the long axis of the larva, completely encircling the posterior sucker; less heavily sclerotized on ventral surface; no rectal scales. Two pronounced ventral papillae on eighth segment, conical, well pigmented; no sclerotized plaques.

Types.—♂ (U.S.N.M. No. 28348), collection of the United States National Museum; collected at Jacumba Springs, Calif., U. S. A.

SIMULIUM (SIMULIUM) JOBBINSI Vargas, Martínez, and Díaz

Simulium (*Simulium*) *jobbinsi* VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 147-149, figs. 87-90, 1946 (original description, ♂, ♀, and pupa).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 54-57, 1951 (presence and distribution in Guatemala).

Male (pl. 25, figs. 76-78).—3.0 mm. long.

HEAD: Holoptic. Eyes reddish brown. Antenna 560 μ long, 11-segmented, slightly tapering; segment $3=1+2$, $3<4+5$, $3>11$; black. Palpi black. Clypeus black, partially white-pruinose, with single row of long black hairs along lateral and distal margins.

THORAX: Mesonotum dark reddish brown, velvety; band of white pruinosity around entire periphery, broader along posterior margin; band interrupted at middle of anterior margin where there is either a diffusion of the color or where 2 medially directed arms are formed, the arms directed somewhat toward the center of the scutum; long, narrow, brown, appressed hairs on anterior fourth of mesonotum, long black ones in prescutellar region and a few on anterior margin. Humeral angles brown to black, with white pruinosity. Scutellum shiny dark brown, with long, strong, black hairs. Postnotum velvety dark brown, white-pruinose, devoid of hairs. Pleura dark brown, with white pruinosity. Stem of halter dark brown, the knob yellow. Wings, 2.9 mm. long and 1.3 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along its basal fifth; R_1 spiny along distal half (no hairs); R_{2+3} pilose except for the basal eighth; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.8 mm.; coxa and trochanter brown; femur brown with very small basal and apical dark-brown rings; basal and apical fourths of tibia black, median half dark brown; tarsus black. Leg 2, length, 2.5 mm.; coxa, trochanter, femur, and tibia dark brown; basal two-thirds of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 3.1 mm.; coxa, trochanter, and femur shiny dark brown; tibia black except for a very small tan basal patch; basal half of basitarsus and second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus not very deep, formed at middle of second segment.

Abdomen: Tergite and pleurites of segment 1 black, the pleurites with long black hairs that reach the fifth segment. Segment 2 dark brown, its anterior half white-pruinose. Other segments very dark brown, pleurites with gray pruinosity. All segments clothed with numerous black hairs. Sternites tan.

Genitalia: Sidepiece (pl. 25, fig. 76) wider than long, with concavity at middle of apical margin, the two apical angles somewhat prolonged; dorsal opening occupying more than half the dorsal surface of sidepiece. Length of clasper (pl. 25, fig. 76) about four times its average width, narrower toward the middle than at either end; apex rather blunt, without apical spine but with a very long slender hair that is quite removed from apex; with basal triangular prolongation which is clothed with hairs. Body of adminiculum (pl. 25, fig. 77) in shape of bonnet, the apex strongly convex; with semicircular band of hairs that surrounds a circular bare region at apex; heavily sclerotized band at base of adminicular body that approximates the contours of the latter in shape, its ends appearing to enter the basal processes; basal processes short, divergent, well sclerotized, somewhat pointed, with backward-directed spurlike structures. Arm of adminiculum (pl. 25, fig. 78) with several (20-30) teeth along its length, both short and long ones intermixed; lateral plate triangular, with wrinkles.

Female (pl. 32, figs. 196-198, and pl. 35, fig. 249).—2.9 mm. long.

Head: Dichoptic. Eyes black; fronto-ocular triangle very small, its base equal to its height. Antenna 580 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3<11$; scape and pedicel light brown, flagellum black. Palpi dark brown. Frons dark brown, shiny, with single row of black hairs on proximal and lateral margins. Clypeus dark brown, white-pruinose, with a few tan hairs on lateral margins. Occipital region black, covered with short tan hairs. Cornuae of buccopharyngeal apparatus sclerotized, wide, the ends shovel-like; median space hyaline, smooth.

THORAX: Mesonotum velvety black; band of silvery pruinosity around entire scutum, the posterior third to fourth of scutum completely pruinose; 3 longitudinal bands of white pruinosity extending from the white pruinosity along the anterior margin to that at the posterior margin, the central band located along the midline, the others being on either side of it; short black hairs over entire mesonotum, long ones in prescutellar region. Humeral angles black, with white pruinosity. Scutellum brown to black, with some long black hairs. Postnotum brown to black, the anterior half white-pruinose. Pleura dark brown, with white pruinosity. Stem of halter dark brown, the knob yellow. Wings, 2.9 mm. long and 1.3 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal fifth; R_1 pilose and spiny along distal half, very few hairs among the spines; R_{2+3} pilose except for very minute basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.8 mm.; coxa and trochanter light brown; femur light brown with apical dark ring; tibia with its basal and apical fourths black, the median part light brown; tarsus black. Leg 2, length, 2.5 mm.; coxa and trochanter brown; femur brown on basal three-fourths, black on apical fourth; tibia with its basal and apical thirds black, the median third brown; basal three-fourths of basitarsus, basal two-thirds of second segment, and basal half of third segment tan, the apical parts of these segments, as well as all of segments 4 and 5, black. Leg 3, length, 3.2 mm.; coxa dark brown; trochanter brown; femur and tibia with basal three-fourths brown, the apical fourths black; basal two-thirds of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5.4 : 1; calcipala well developed, surpassing the pedisulcus; pedisulcus well formed one-third the distance from the base of second segment; claw with well-developed heel and with strong subbasal tooth (pl. 35, fig. 249).

ABDOMEN: Tergite of segment 1 black; pleurites black with rather long dark-brown hairs that reach only to segment 2. Segment 2 brown, pleura white-pruinose. Other segments shiny black, covered with short black hairs. Sternites tan.

GENITALIA: Cercus (pl. 32, fig. 196) higher than long (wide), the posterior angles well rounded, rather small. Anal lobe (pl. 32, fig.

196) shaped very much like the cercus in reverse, except that its dorsal extremity is somewhat tapered; not quite twice as high as cercus. Genital rod (pl. 32, fig. 198) with basal dilatation confined to small region only; apical arms of genital fork not expanded, branch like the arms of a Y, each appearing like a twisted ribbon. Ovipositor (pl. 32, fig. 197) somewhat triangular in shape, the apex well rounded, small, the base equal to twice the height.

Pupa (pl. 37, fig. 302, and pl. 39, fig. 342).—Granulosity well marked on midregion of thorax; 3 to 4 trifid trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with transverse row of 8 simple spines, situated three-fourths the distance from the anterior margin, with median separation; anterior to the outermost spine on each extremity are 2 similar spines; segments 3 and 4 each with 8 simple spines in transverse row three-fourths the distance from the anterior margin, the row divided in two by a median space; segment 7 with 8-10 simple spines in transverse row just beyond the anterior margin, the row not interrupted by a median space, and with comblike groups of minute spines lateral to both ends of the row; segment 8 with 12-14 simple spines in uninterrupted row just beyond the anterior margin, also with combs lateral to both ends; segment 9 with 8 simple spines in an uninterrupted row across anterior margin, without combs. Ventral surface of abdominal segments: No granulosity; segment 4 with a single spine on either side of midline, about three-fourths the distance from the anterior margin, with median separation; segment 5 with 4 spines in transverse row before the posterior margin, with median space, the outer two spines bifid, the inner spines trifid; segments 6 and 7 each with 4 spines in transverse row before the posterior margin, the outer spines simple, the inner ones bifid; the two spines on either side of midline of segments 6 and 7 farther apart than those on segment 5, the distance between them about equal to that of median space. Terminal spines very small, blunt, with apical indentation.

Respiratory apparatus (pl. 37, fig. 302) of each side arising slightly behind the anterior margin of the thorax; composed of 6 filaments which branch as follows: 2-2-2: two groups of two filaments branch at the same level, the third slightly lower; filaments without superficial annulation but with microscopic spicules. Maximum length, 5.0 mm., about 1.4 times the length of the cocoon; average diameter, 32 μ.

Cocoon (pl. 39, fig. 342): Length of base, 3.5 mm.; maximum width, 1.4 mm.; maximum height, 1.9 mm. Cocoon of wall-pocket type, without collar; texture of case parchmentlike, the threads very close together; rim around anterior aperture not thickened. Cocoon covers the abdomen and thorax; attached along posterior half of its base.

Larva (pl. 41, fig. 380, and pl. 43, fig. 417).—Total length, 5.9-6.1 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times that of head. First 4 abdominal segments 1.2 times width of head; abdominal segments 5-7 expanded, greatest at segment 6 which is 1.6 times abdominal segments 1-4; cross section and profile like that of *metallicum*. General color tan to gray, with dark-brown patches on ventrolateral areas of segments 6 and 7; light-gray collar across the anterior margin of thorax, extending ventrally to the thoracic proleg.

Head: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 380. Each cephalic fan with 28 pectinate branches, the hairs on these branches rather heavy, short, simple, and well separated, not interspersed with other types of hairs. Mandible with 2 teeth along its inner margin, the distal tooth well developed and somewhat pointed, the other appearing like a protuberance from the base of the distal tooth. Antenna 550 μ long, 4-segmented, brown, the first two segments alone surpassing the basal stalk of cephalic fan; segments 1 and 2 equal in length, each longer than segment 3; segments 1 and 2 with transverse striations. Submentum with 9 apical spines, each appearing like a half of a hexagon, the central tooth and the outermost tooth on either side larger than the others; ventrolateral row composed of 4-6 hairs, at least the distal two bifid; lateral margin of submentum with 7 toothlike structures, the apical three heavily sclerotized. Occipital cleft small, triangular in shape (pl. 43, fig. 417).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 20-32 rows of hooks on its apex; postclypeal sclerites small but well sclerotized. Posterior sucker with 82-84 rows of hooks. Anal gills with 3 main divisions, each with 5 fingerlike projections that arise close to one another, their ends somewhat pointed, all of almost equal length. Anterior arms of X-shaped sclerite completely covered by wedge-shaped patches; posterior arms short, barely reaching the lateral margins of the larva; dark patch visible between the two anterior arms; 3 rows of rectal scales, each scale with 3 to 4 teeth at its apex; on either side of dark central patch, and lateral to the anterior arms, is a protuberance which is directed somewhat toward the midline, clothed with long scales each of which has several teeth at its apex. Two distinct ventral papillae on eighth segment, not very long, each somewhat double-lobed; about 18-20 heavily sclerotized plaques in transverse row between the papillae and posterior sucker, the more-lateral plaques being somewhat larger.

Types.—Holotype (♂) and allotype (♀), mounted, in part, on slides, the rest on pins, and paratypes (40 ♂♂ and ♀♀), in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected in the Aldea El Naranjo, Soconusco, Chiapas, Mexico, 1,400 meters above sea level, December 1944.

SIMULIUM (SIMULIUM) KOMPI Dalmat

Simulium (*Simulium*) *kompi* Dalmat, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 38-42, figs. 8-15, 1951 (original description, ♂, and ♀ genitalia, pupa).

Only the 2 pupae used to prepare the original description of this species have been collected to date. The following descriptions of the male and female genitalia were made from the formed imagines that were dissected from the pupal cases.

Male (pl. 25, figs. 79-81).

Genitalia: Sidepiece (pl. 25, fig. 79) 0.14 mm. long, 0.17 mm. wide, with no outstanding projections or prominences; dorsal opening occupying more than half the dorsal surface of sidepiece. Clasper (pl. 25, fig. 79) 0.18 mm. long, about three and one-half times as long as it is wide, the middle being slightly constricted and the base with a slight swelling; distal end broadly rounded, with a single blunt, bifid terminal spine; on the ventral face, about one-fourth the distance from the apex, there is one very strong, heavily sclerotized spine. Body of adminiculum (pl. 25, fig. 80) longer than wide, with a distinctive pentagonal shape; apex in form of blunt angle, both arms forming the angle completely clothed with numerous rather long, wavy hairs; similar hairs present in central patch on body of adminiculum; basal processes well sclerotized, terminating in broad, spatulate expansions; on outer margin of each process is a hyaline, winglike expansion. Arms of adminiculum (pl. 25, fig. 81) with approximately 14 well-separated teeth along the distal three-fourths, some of the teeth extremely long; lateral plate irregularly triangular in shape.

Female (pl. 32, figs. 199-201).

Genitalia: Cercus (pl. 32, fig. 199) higher than long (wide), somewhat narrower ventrally, with posterior angles well rounded. Anal lobe (pl. 32, fig. 199) with posterior margin almost straight and anterior margin rounded; strongly tapered dorsally and with a small posteriorly directed protuberance from the ventral margin. Genital rod (pl. 32, fig. 201) with rather extensive ovate basal dilatation; arms of genital fork branch broadly, each arm bearing 2 irregular, triangular-shaped expansions near its middle, one on the inner margin, the other on the outer margin; apex of arm heavily sclerotized and pointed; wavelike expansion extending on outer margin of each arm from apex to median expansions. Ovipositor (pl. 32, fig. 200) short and broad, triangular in shape.

Pupa (pl. 37, fig. 303, and pl. 39, fig. 343).

Respiratory apparatus (pl. 37, fig. 303) of each side arising slightly behind anterior margin of thorax; composed of 3 inflated, tubelike branches, arranged one above the other, the longest one dorsal; with annulations. The branches, from the dorsal to the ventral one, measure 2.1 mm., 1.8 mm., and 1.3 mm.

Cocoon (pl. 39, fig. 343): Wall-pocket type, without collar; roof subparallel to substratum; ventral surface with its midregion fixed to substratum, its anterior fourth slightly raised and its posterior third markedly raised to meet the roof; ventral surface woven along approximately the posterior three-fourths of its extent; anterior aperture very slightly thickened.

Larva (pl. 41, fig. 381, and pl. 43, fig. 418).—(First description of larva.) Total length, 6.2 mm. Length of head capsule 1.1 times its width. Width of thorax 1.5 times that of head. Abdominal segments 1-4 equal to 1.2 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.6 times width of segments 1-4. General color gray, with dark patches on ventrolateral areas of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 381. Each cephalic fan with 28 pectinate branches, the hairs on these branches small, simple, well separated, interspersed at regular intervals with stronger bifid hairs. Mandible with 2 teeth along its inner margin, one well-formed, pointed tooth and one extremely small tooth that appears to emerge from near the base of the other. Antenna 390 μ long, 4-segmented, dark brown, about as long as basal stalk of cephalic fan; segments 2 and 3 subequal, 2 somewhat longer than 1; segments 1 and 2 with transverse striations. Submentum with 9 apical teeth, each like half a hexagon in shape, the central tooth and the outermost tooth on either side longer than the others; ventrolateral row composed of 7 hairs in a straight line, the basal lateral margin of submentum with 6 toothlike processes, the four more-basal ones appearing more like serrations of the margin, the two apical ones like heavily sclerotized teeth; the latter appear to arise from the side of the outermost of the apical teeth. Occipital cleft small, with liplike projection from its rounded apex (pl. 43, fig. 418).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 38-40 rows of hooks at its apex; postclypeal sclerites very small, thin, well separated. Posterior sucker with 78-82 rows of hooks. Anterior and posterior arms of X-shaped sclerite well sclerotized, the anterior arms completely covered by a large patch which extends from the region between the anterior and posterior arm of either side completely over to the same region of the other side, with a slight concavity between the two anterior arms; numerous rather long, simple spines on either side in the region between the anterior and posterior arm; posterior arms long, reaching lateral margins; no rectal scales.

Simulium (*S.*) *kompi* appears closest to *S.* (*S.*) *tricornis* De León but can easily be distinguished from the latter species by the form of the adminiculum, the bifid condition of the apical spine of the clasper, presence of isolated heavy spine on ventral surface of clasper; shape of cercus, longer dorsal necklike extension of anal lobe, presence of basal dilatation of genital rod, difference in form of median extensions of arms of genital fork; form and arrangement of pupal filaments, shape of cocoon; number of rows of hooks on posterior sucker of larva and form of X-shaped sclerite.

Types.—Holotype (♂ dissected from pupal skin), on 3 slides, and allotype (♀ dissected from pupal skin), on 3 slides, in the collection of the United States National Museum; collected from the Río Ciprés, Aldea Los Pajales, Acatenango, Department of Chimaltenango, Guatemala, June 15, 1949.

SIMULIUM (SIMULIUM) METALLICUM Bellardi

Simulium metallicum Bellardi, Saggio di Ditterologia Messicana, vol. 1, p. 14, 1859 (original description, male).—Dyar and Shannon, Proc. U. S. Nat. Mus., vol. 69, art. 10, p. 41, figs. 72-73, 1927 (female).—Fairchild, Ann. Ent. Soc. Amer., vol. 33, No. 4, pp. 712-713, figs. 13, 17, 26, and 38, 1940 (♀, ♂, and pupa).—Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, pp. 234-236, figs. 3 and 10, 1942, (♂ and ♀ genitalia).

Simulium avidum Hoffmann, An. Inst. Biol., Univ. Mexico, vol. 2, pp. 207-218, figs. 2a, 10, 13, and 17, 1931(b) (larva, pupa, and genital rod of ♀).

Simulium (*Simulium*) *metallicum* Bellardi, Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, p. 175, fig. 143, 1946 (larva).

Male (pl. 25, figs. 82-84).—2.7 mm. long.

Head: Holoptic. Eyes reddish brown. Antenna 490 μ long, 11-segmented, tapering from basal segment onward; segment $3<1+2$, $3=4+5$, $3>11$; scape and pedicel light brown, flagellum very dark brown. Palpi dark brown. Clypeus very dark brown, irregularly covered with long black hairs.

Thorax: Mesonotum black; narrow band of white pruinosity along entire periphery except at anterior margin where the band is divided in the middle to form two posteromedially directed arms; infrequently these arms are contiguous; numerous short reddish-brown to black hairs over entire mesonotum, long black hairs in prescutellar region. Humeral angles black, with white pruinosity. Scutellum reddish brown with long black hairs. Postnotum dark reddish brown, white-pruinose. Pleura dark brown, with white pruinosity. Stem of halter dark brown, the knob yellow. Wings, 2.2 mm. long and 1.1 mm. wide; relation of body length to wing, 1.2 : 1; Sc pilose along basal eighth; R_1 spiny along distal half (no hairs); R_{2+3} pilose except for very short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.3 mm.; coxa and trochanter light brown; femur light brown with dark-brown apical ring; tibia with apical and basal fourths dark brown, the median half light brown; tarsus black. Leg 2, length, 2.0 mm.; coxa, trochanter, femur, and tibia dark brown; basal three-fourths of basitarsus and basal two-thirds of second tarsal segment light brown, the remainder of these segments, as well as all of segments 3-5, dark brown to black. Leg 3, length, 2.5 mm.; coxa black; trochanter, femur, and tibia dark brown; basal half of basitarsus and of second segment light brown, the apical halves of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5.1 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed at middle of second segment.

Abdomen: Tergite of segment 1 dark brown with short black hairs; pleurites black with long black hairs that reach segment 5. Segment 2 dark brown, the anterior half of the tergum and all of pleurites white-pruinose, with short black hairs. All other segments dark brown, the anterior half of pleural regions of segments 5-7 white-pruinose; all segments with short black hairs, segment 3 with a concentration of them. Sternites white-pruinose.

Genitalia: Sidepiece (pl. 25, fig. 82) somewhat wider than long; apical margin narrower than base, with inner apical angle somewhat prolonged on ventral surface; dorsal opening occupying about three-fourths of dorsal surface of sidepiece. Clasper (pl. 25, fig. 82) about three and one-half times longer than it is wide, tapering slightly from base to apex; with basal extension on dorsal surface, directed laterally, wedge-shaped, slightly longer than its base; 1 terminal spine. Body of adminiculum (pl. 25, fig. 84) in form of narrow cone-shaped structure, the apex quite acute; with longitudinal wrinkles; basal processes very long, broad, well sclerotized, their apices spatulate; darkly pigmented ribbonlike structure passing along the basal region of the body of adminiculum and appearing to enter each of the basal processes; triangular-shaped, membranous, winglike expansion on either side, extending from basal third of body to near the end of basal processes. Arms of adminiculum (pl. 25, fig. 83) with about 10 teeth, two apical ones which are long, the others short and blunt; lateral plate triangular in shape, wrinkled.

Female (pl. 32, figs. 202-204, and pl. 35, fig. 246).—2.3 mm. long.

HEAD: Dichoptic. Eyes black; fronto-ocular triangle very small, its base about equal to its height. Antenna 680 μ long, 11-segmented; segment $3<1+2$, $3<4+5$, $3=11$; scape and pedicel brown, flagellum black. Palpi brown. Frons black, slightly white-pruinose, with 1 row of black hairs on lateral margins. Clypeus black, white-pruinose, irregularly covered with short black hairs. Occipital region black, with short black hairs. Cornuae of buccopharyngeal apparatus heavily sclerotized, ending in sharp points; median space hyaline, smooth.

THORAX: Mesonotum velvety black, with 3 longitudinal bands extending down the scutum; one band is along the midline; each of the other two are lateral to the middle band, starting anteriorly as an extension of a large triangular-shaped patch of white pruinosity which is contiguous with the anterior margin; the two lateral bands are divergent near their midregion; all three bands terminate where they blend with the white pruinosity of the prescutellar region; lateral margins also white-pruinose; short black hairs scattered over dorsum, denser on anterior half and in prescutellar region. Humeral angles dark brown, with some pruinosity. Scutellum shiny black, with long black hairs and some short ones. Postnotum dark brown, the anterior half white-pruinose, devoid of hairs. Pleura dark brown, with white pruinosity. Stem of halter brown on the base and tan toward the apex, knob yellow. Wings, 2.4 mm. long and 1.0 mm. wide; relation of body length to wing, 1:1; Sc pilose along basal seventh; R_1 spiny along distal half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.6 mm.; coxa brown; trochanter light brown; femur light brown with dark-brown apical ring; tibia with basal and apical fourths black, the median half light brown; tarsus black. Leg 2, length, 2.5 mm.; coxa and trochanter brown; femur brown on basal three-fourths, black on apical fourth; tibia black on basal and apical thirds, light brown in midregion; basitarsus and second tarsal segment tan except for small brown apical ring; tarsal segments 3-5 tan to black. Leg 3, length, 2.7 mm.; coxa and trochanter dark brown; femur brown on basal two-thirds, the apical third dark brown; tibia dark brown on basal and apical fourths, brown in midregion; basal two-thirds of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5.8:1; calcipala well developed, overreaching the pedisulcus; pedisulcus well developed one-third the distance from the base of second segment; claw with well-developed heel and subbasal tooth (pl. 35, fig. 246).

Abdomen: Tergite of segment 1 dark brown, with short black hairs; pleurites dark brown with long black hairs that reach segment 3. Segment 2 with its anterior half brown, the posterior half black, the posterior half and sides white-pruinose. All other segments velvety dark brown, the posterior halves appearing almost black; lateral regions of these segments white-pruinose; short black hairs on all segments, longer ones on segments 7 and 8. Sternites tan.

Genitalia: Height of cercus (pl. 32, fig. 202) about three and one-half times its length (width), the posterior angles well rounded. Anal lobe (pl. 32, fig. 202) triangular in shape, narrow at its dorsal extremity, very wide (long) ventrally where the posterior angle extends under the cercus. Genital rod (pl. 32, fig. 204) usually without basal dilatation, at most with very slight broadening; arms of genital fork ribbonlike, twisted, with 1 or 2 somewhat sclerotized triangular extensions near the midregion. Ovipositor (pl. 32, fig. 203) small, triangular in shape, the height equal to the base.

Pupa (pl. 37, fig. 304, and pl. 39, fig. 344).—Granulosity over entire thorax, more pronounced in central region; 3 trifid and 1 simple trichome on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in transverse row three-fourths the distance from the anterior margin, the row divided by median space; anterior to the outermost spine on each extremity are 2 similar spines; segments 3 and 4 each with 8 simple spines in transverse row three-fourths the distance from the anterior margin, the row divided by median space; segment 6 with 5-12 (usually 8-10) simple spines in irregular transverse row behind the anterior margin, without median separation, and with comblike groups of spines lateral to both ends of the row; segment 7 with 10-12 simple spines in transverse row across the anterior margin, the row divided in two by median separation, and with combs lateral to each end; segment 8 with 11-13 simple spines in transverse row across anterior margin, without median separation, and with combs lateral to both ends; segment 9 with 8 spines in transverse row across anterior margin, divided by median space, without combs. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with 4 simple spines in transverse row across posterior margin, the row divided in two by median separation; segment 5 with 4 bifid teeth in transverse row somewhat before the posterior margin, with median separation; segments 6 and 7 with 4 spines in transverse row somewhat before the posterior margin, the outer teeth simple, the inner one bifid; the two spines on either side of midline of segments 6 and 7 are farther apart than those on segment 5, the distance between them about equal to that of median space. Terminal spines small, the tips rounded.

Respiratory apparatus (pl. 37, fig. 304) arising somewhat behind the anterior margin of thorax; composed of 6 very long filaments which branch close to the base, and at the same level, as follows: 2-2-2; filaments with microscopic spicules and with poorly marked superficial annulations. Maximum length, 4.8 mm.; about 1.3 times the length of cocoon; average diameter, 32 μ.

Cocoon (pl. 39, fig. 344): Length of base, 3.8 mm.; width, including winglike expansions, 4.0 mm.; maximum height, 1.0 mm. Cocoon of wall-pocket type, without collar; lateral margins with winglike expansions that give the cocoon a circular appearance when viewed from above; these expansions vary with the substratum and may be completely absent when the pupation occurs on restricting surfaces; the expansions are always present on cocoons formed on leaf surfaces, the usual substratum used by this species; texture of case spongy, soft, the threads loose and easily visible; rim around anterior aperture not thickened. Cocoon covers the abdomen and thorax; attached along the posterior three-fourths of its base.

Larva (pl. 41, fig. 382, and pl. 43, fig. 419).—Total length, 5.3-5.5 mm. Length of head capsule 1.1 times its width. Width of thorax almost twice that of head. First 4 abdominal segments equal to width of head; segments 5-7 greatly expanded, greatest at segment 6 which is twice the width of segment 1; greatly reduced after segment 7; in dorsal view the larva has the appearance of a dumbbell; abdomen almost round in cross section. General color milky gray, with pinkish hue on posterior abdominal segments; with large, black, granular patches on ventrolateral regions of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 382. Each cephalic fan with 34-40 pectinate branches, the hairs on these branches long, slender, simple, not very close together, without intermixture of other kinds of hairs. Mandible with 2 sharp-pointed teeth on its inner margin, the more-distal one longer and broader, the more-basal one appearing to emerge from the same base. Antenna 450 μ long, 4-segmented, first segment dark brown, the others light brown, segments 1 and 2 alone surpassing the basal stalk of cephalic fan; segment 1 with longitudinal wrinkles; segment 2 with transverse striations. Submentum with 9 triangular-shaped teeth, the central tooth and outermost tooth on either side larger than the others; ventrolateral row composed of 4 to 5 hairs in straight line, usually simple; lateral margin of submentum with 4 to 6 toothlike processes, some of them very small. Occipital cleft dome-shaped, its sides almost parallel, its apex slightly pointed (pl. 43, fig. 419).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 15-21 rows of hooks on its apex; postclypeal sclerites minute, hardly visible. Posterior sucker with 64-72 rows of hooks. Anal gills with 3 main divisions, each with from 3-5 fingerlike projections. Anterior arms of X-shaped sclerite each with a wedge-shaped, well-pigmented patch along its outer margin which appears to reach the base of the posterior arms; patches completely cover anterior arms; just in front of the anterior arms and between them and the anal aperture is a raised, reticulated patch with purplish pigmentation; on either side of this, and lateral to the anterior arms, is a bulblike protuberance the apex of which is directed toward the midline; these are clothed by simple spines; 4 to 5 rows of rectal scales. Eighth segment with two well-formed, conical ventral papillae; between them and the posterior sucker is a transverse row composed of about 20 heavily sclerotized plaques, the more lateral ones larger and somewhat raised.

Types.—♂; according to the original description, it is in the Museo Zoologico di Parigi; type locality given as "Mexico (Sallé)."

SIMULIUM (SIMULIUM) OCHRACEUM Walker

Simulium ochraceum Walker, Trans. Ent. Soc. London, n. s., vol. 5, p. 332, 1861 (original description, female).—Fairchild, Ann. Ent. Soc. Amer., vol. 33, No. 4, pp. 706 and 708, figs. 6, 11, 23, and 35, 1940 (♀, ♂, and pupa).—Vargas, Rev. Inst. Salubr. Enferm. Trop., vol. 3, No. 3, pp. 238-239, figs. 5 and 12, 1942 (♂ and ♀ genitalia).

Eusimulium ochraceum (Walker), Hoffmann, An. Inst. Biol. Univ. México, vol. 2, pp. 207-218, figs. 3, 4, 8, 12, 14, and 15, 1931(b) (pupa and larva).

Male (pl. 26, figs. 85-87).—2.3 mm. long.

Head: Holoptic. Eyes brown. Antenna 430 μ long, 11-segmented, slightly tapering; segment $3>1+2$, $3>4+5$, $3>11$; scape, pedicel, and half of first flagellar segment brown, the remainder of the flagellum black. Palpi black. Clypeus black, white-pruinose, irregularly covered by long black hairs.

Thorax: Mesonotum yellow to orange; a rather narrow band of pale-yellow pruinosity around the periphery except in middle of anterior margin where it is interrupted; few short black hairs concentrated principally on the anterior and posterior fourths of the mesonotum. Humeral angles pale yellow, with sparse black hairs. Scutellum yellow with pale pruinosity and with long black hairs. Postnotum velvety brown, white-pruinose, devoid of hairs. Pleura brown, partially white-pruinose. Stem of halter brown, the knob light brown to yellow. Wings, 2.1 mm. long and 0.9 mm. wide; relation of body length to wing, 1.1 : 1; Sc pilose along basal eighth; R_1 completely pilose, and with spines also along distal half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.1 mm.; coxa black; trochanter brown on basal half, black on apical half; femur with basal three-fourths brown, the apical fourth black; tibia and tarsus black. Leg 2, length, 1.8 mm.; coxa and trochanter black; femur brown on basal three-fourths, black on apical fourth; tibia black on basal and apical fourths, brown on median half; tarsus black. Leg 3, length, 2.2 mm.; coxa and trochanter black; femur brown on basal three-fourths, black on apical fourth; tibia black on basal and apical thirds, median third brown; tarsus black; relation of basitarsus to second segment, 5.1 : 1; calcipala very well developed, reaching pedisulcus; pedisulcus well developed at middle of second segment.

Abdomen: Segment 1 yellow, the tergite with short black hairs, and the pleura with long black hairs that reach the fifth segment. Segments 2, 3, and 4 yellow, with short black hairs. Segments 5, 6, 7, and 8 black, their pleural region partially white-pruinose; clothed with short black hairs. Sternites yellow.

Genitalia: Sidepiece (pl. 26, fig. 85) very slightly wider than long, irregularly quadrangular in shape, with dorsal depression near its apex; dorsal opening occupying about half of dorsal surface of sidepiece. Clasper (pl. 26, fig. 85) shorter than the sidepiece, its length slightly more than twice its width, apex tapering with single subterminal spine. Body of adminiculum (pl. 26, fig. 86) semicircular in shape, the apex rounded, clothed with numerous minute spinelike hairs and longer fine hairs; short longitudinal structure on midline with numerous hairs; with basal, heavily pigmented ribbonlike structure, the ends of which seem to enter the basal processes; basal processes short, well sclerotized, tapered but blunt. Arms of adminiculum (pl. 26, fig. 87) with approximately 6 large pointed teeth and with several short teeth, all intermixed and arranged in linear fashion; lateral plate somewhat triangular in shape, wrinkled.

Female (pl. 32, figs. 205-207, and pl. 35, fig. 250).—2.3 mm. long.

Head: Dichoptic. Eyes black; fronto-ocular triangle very small, the base equal to the height. Antenna 400 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3>11$; scape and pedicel light brown, the flagellum black. Palpi black. Frons black, white-pruinose, with very few short black hairs. Clypeus black, white-pruinose, with tan to brown hairs. Occipital region black, with short black hairs. Cornuae of buccopharyngeal apparatus heavily sclerotized, bifurcate, the branches sharply pointed; median space somewhat sclerotized, with well-formed concavity, and with a single row of large, sclerotized teeth that are like small equilateral triangles in shape.

THORAX: Mesonotum yellow to orange; 2 longitudinal bands of pale-yellow pruinosity extending from anterior margin to prescutellar region which is also yellow-pruinose; yellow pruinosity around entire periphery except between the origins of the two longitudinal bands on the anterior margin; short black hairs on anterior half of mesonotum and in prescutellar region. Humeral angles pale yellow. Scutellum yellow with some short black hairs along margin, longer in lateral regions. Postnotum brown, the anterior half white-pruinose. Pleura dark brown, somewhat lighter dorsally, with yellow pruinosity. Stem of halter light brown, the knob yellow. Wings, 2.1 mm. long and 1.0 mm. wide; relation of body length to wing, 1.1 : 1; Sc pilose along basal two-thirds; R_1 completely pilose, with spines also along distal two-thirds; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.1 mm.; coxa, trochanter, and femur dark brown; tibia and tarsus black. Leg 2, length, 1.9 mm.; coxa, trochanter, and femur dark brown; basal and apical fourths of tibia black, the median half dark brown; tarsus black. Leg 3, length, 2.5 mm.; coxa and trochanter black; femur dark brown along basal three-fourths and black on apical fourth; tibia black on basal and apical fourths, dark brown on median half; tarsus black; relation of basitarsus to second tarsal segment, 5.7 : 1; calcipala well developed, overreaching the pedisulcus; pedisulcus well formed one-third the distance from the base of second segment; claw with heel well formed, although not greatly expanded, with subbasal tooth (pl. 35, fig. 250).

ABDOMEN: Tergite and pleurites of segment 1 yellow, with short yellow hairs, the pleurites also with longer ones that reach the third segment. Segments 2-4 yellow; other segments black; segments 4-8 with short black hairs. Sternites tan, brown toward the rear.

GENITALIA: Cercus (pl. 32, fig. 205) dome-shaped, somewhat higher than long (wide). Anal lobe (pl. 32, fig. 205) about five times higher than it is long (wide), the ventral extremity somewhat pointed; with projection from its posterior margin that extends somewhat under the cercus. Genital rod (pl. 32, fig. 207) with pronounced basal dilatation; apical expansions of arms of genital fork irregularly quadrangular in shape, the margins appearing like small lobelike undulations; outer basal angle well sclerotized, pronounced, rounded. Ovipositor (pl. 32, fig. 206) small, narrow, its length twice the width, the apex somewhat expanded.

Pupa (pl. 37, fig. 305, and pl. 39, fig. 345).—Thorax smooth, without granulosity; usually 4 arborescent trichomes on either side of midline on anterior fourth of thorax. Dorsal surface of abdominal segments: Without granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with 12 simple spines in transverse row three-fourths the distance from the anterior margin, with median separation; segments 3 and 4 with 8 simple spines in transverse row three-fourths the distance from the anterior margin, the spines larger and heavier than on any other segment, with median separation; segments 7 and 8 each with transverse row of 16 simple spines across the anterior margin, the row on segment 7 with median separation, that on segment 8 without interruption; segment 7 with comblike groups of minute spines lateral to the ends of the row, in the median space, and intermixed with the spines forming the row; segment 8 with combs only lateral to both extremities of the row; segment 9 with band composed of comblike groups of spines across the anterior margin, in more-or-less three irregular rows, the band divided by median space. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with transverse row somewhat before the posterior margin, composed of either 2 or 4 simple spines, divided by median space; transverse rows on segments 5-7 situated along the posterior margins; segment 5 with row composed of 4 bifid spines, with median separation; segment 6 with 4 spines in row, the outer spines simple, the inner ones trifid; segment 7 with 4 spines in row, the outer ones simple, the inner ones bifid; the two spines on either side of midline of segments 6 and 7 are farther apart than those on segment 5, the distance between them about equal to that of median space. Terminal spines very small, like flattened cones.

Respiratory apparatus (pl. 37, fig. 305) of each side arising slightly behind the anterior margin of thorax; composed of 8 filaments that branch as follows: 3-3-2; all branching rather close to base; all filaments with undulations along the surface and with microscopic spicules. Maximum length, 2.3 mm., about 0.8 times the length of cocoon; average diameter, 28 μ.

Cocoon (pl. 39, fig. 345): Length of base, 2.9 mm.; maximum width, 1.4 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, without collar; rim around anterior aperture thickened; texture of case parchmentlike, the threads very close together. Cocoon covering abdomen and all but very small anterior band of thorax; attached along posterior half of base.

Larva (pl. 41, fig. 383, and pl. 43, fig. 420).—Total length, 4.4-5.0 mm. Length of head capsule 1.2 times its width. Width of thorax 1.6 times that of head. First 4 abdominal segments 1.2 times width of head; segments 5-7 expanded, with greatest width (segment 6) 1.7 times width of segment 1-4; body with same general shape as that of *metallicum*. General color greenish yellow; a wide dark-green to gray band almost completely encircling the thorax along its anterior margin; large gray patch just posterior to pseudopod; dorsum of segments 5-8 darker than remainder of abdomen; segments 6 and 7 with dark patches on the ventrolateral regions.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 383. Each cephalic fan with 28-34 pectinate branches, the hairs on these branches all appearing to be of one type, rather heavy, long, and close together. Mandible with 2 teeth on its inner margin, the teeth appearing to have a common base, the division between them rather deep; both teeth sharp-pointed, the distal one about twice the length of the other. Antenna 310 μ long, 4-segmented, pale yellow, surpassing the basal stalk of the cephalic fan; segments 1 and 2 subequal, each slightly shorter than segment 3; segment 1 with marginal indentation near the middle; segment 2 appears to be superficially divided into 2 segments one-third the distance from its base; no transverse striations. Submentum with 9 apical teeth, rather slender and blunt, somewhat separated, none of the teeth much longer than the others; ventrolateral row with 4-5 hairs in straight line, all simple; lateral margin of submentum with about 5 toothlike indentations. Occipital cleft extremely deep, reaching the base of the submentum, strongly convergent toward the middle of the lateral margins (pl. 43, fig. 420).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 34 rows of hooks on its apex; postclypeal sclerites usually not present, at times just visible. Posterior sucker with 74-76 rows of hooks. Anal gills with 3 main divisions each with 8 fingerlike extensions of approximately equal length. Anterior and posterior arms of X-shaped sclerite well sclerotized; triangular-shaped patch over each anterior arm, the apex of patch at anterior extremity, gradually widening posteriorly, the patches of both arms fusing at the midline; bases of patches contiguous with posterior arms; posterior arms extending to lateral margins of larva; no rectal scales. Eighth segment with 2 ventral papillae which are small and transparent, the apices rather pointed; no sclerotized plaques.

Types.—♀, lost; type locality given as "Mexico." There are Mexican specimens of this species in the British Museum.

SIMULIUM (SIMULIUM) PARRAI Vargas, Martínez, and Díaz

Simulium (*Simulium*) *parrai* VARGAS, MARTÍNEZ, AND DÍAZ, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 151-153, 175-176, figs. 98-105 and 150, 1946 (original description, ♀, ♂ genitalia, pupa, and larva).—VARGAS AND DÍAZ, ibid., vol. 9, No. 4, pp. 336-337, 1948 (external characters of ♂).—DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 55 and 57, 1951 (presence and distribution in Guatemala).

Male (pl. 26, figs. 88-90).—2.8 mm. long.

HEAD: Holoptic. Eyes yellowish brown. Antenna 510 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3>11$; scape and pedicel light brown, the flagellum black. Palpi black. Clypeus black, white-pruinose, irregularly covered with long black hairs.

THORAX: Mesonotum velvety black; with wide band of white pruinosity around the periphery, interrupted only at the middle of the anterior margin where 2 arms are formed that are directed toward the center of the scutum; long, narrow, yellow, scalelike hairs covering entire mesonotum, not in packets; short black hairs over entire mesonotum, long black ones in prescutellar region. Humeral angles black, white-pruinose, with golden scalelike hairs. Scutellum black, with yellow scalelike hairs and with long black ones. Postnotum velvety black, white-pruinose, devoid of hairs. Pleura dark brown to black, with white pruinosity. Stem of halter dark brown, the knob tan. Wings, 2.6 mm. long and 1.2 mm. wide; relation of body length to wing, 1.1 : 1; Sc pilose along basal seventh; R_1 pilose and spiny along distal half; R_{2+3} pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.7 mm.; coxa and trochanter light brown; femur and tibia dark brown; tarsus black. Leg 2, length, 2.4 mm.; coxa dark brown; trochanter light brown; femur dark brown; tibia dark brown with very small tan basal ring; basal half of basitarsus tan, the apical half black; tarsal segments 2-5 black. Leg 3, length, 2.9 mm.; coxa black; trochanter and femur dark brown; tibia dark brown with very small basal tan ring; basal half of basitarsus and of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5.1 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed one-third the distance from the base of second segment.

ABDOMEN: Tergite of segment 1 black with short black hairs; pleurites black with long black hairs that reach the fifth segment. Segment 2 black, the anterior half white-pruinose, with short black hairs. Other segments black, pleura partially white-pruinose, with short black hairs. Sternites black, white-pruinose.

GENITALIA: Sidepiece (pl. 26, fig. 88) rectangular in shape, the width about 1.5 times the length; dorsal opening occupying about half of dorsal surface of sidepiece. Clasper (pl. 26, fig. 88) much longer than wide, about 1.7 times the length of sidepiece; broader at base than at apex, the middle region somewhat constricted; apex rounded with a single subterminal spine that is situated within a longitudinal groove; with very long, troughlike basal process that extends at least to the edge of the dorsal opening of the sidepiece, its terminal margin serrated. Body of adminiculum (pl. 26, fig. 90) subquadrangular, somewhat bonnet-shaped, longer than wide, the apical angles well rounded; basal processes broad, strongly divergent, with heavy pigmentation that extends longitudinally across the body of adminiculum on either side of midline; numerous rather long hairs emerging from circular region near apex of adminiculum. Adminicular arms (pl. 26, fig. 89) with about 15 strong teeth, all of about equal length, emerging in all directions from the axis of the arm; lateral plate large and triangular in shape, with numerous wrinkles.

Female (pl. 33, figs. 208-210, and pl. 35, fig. 248).—3.1 mm. long.

HEAD: Dichoptic. Eyes black; fronto-ocular triangle very small, its base equal to the height. Antenna 600 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3>11$; scape and pedicel brown, the flagellum black. Palpi black. Frons black, white-pruinose, with 1 irregular row of long black hairs along the margins. Clypeus black, white-pruinose, margins irregularly covered with black hairs. Occipital region black, white-pruinose, with long black hairs. Cornuae of buccopharyngeal apparatus sclerotized, with blunt, somewhat serrated apex; median space hyaline, with 4 rows of wide, blunt teeth.

THORAX: Mesonotum velvety black; on anterior margin there is a rectangular patch of white pruinosity on either side of midline; from the inner posterior angle of each patch there extends a longitudinal white-pruinose band that continues posteriorly to the white pruinosity of the prescutellar region, the bands convergent near the middle to form a lyre-shaped design; midline with narrow stripe of white pruinosity; lateral margins with band of white pruinosity the anterior limit of which continues around the anterior margin of the scutum, almost reaching the rectangular patches; long, narrow, yellow, scalelike hairs on mesonotum, more numerous around periphery; fine black hairs over entire mesonotum, long black ones in prescutellar region. Humeral angles black, with white pruinosity. Scutellum black, with yellow scalelike hairs and long black hairs. Postnotum velvety black, white-pruinose, devoid of hairs. Pleura black, with white pruinosity. Stem of halter brown, the knob tan. Wings, 3.1 mm. long and 1.4 mm.

wide; relation of length of body to wing, 1 : 1; Sc pilose along basal seventh; R_1 pilose along apical half, with some spines intermixed; R_{2+3} pilose except for small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.3 mm.; coxa light brown; trochanter brown; femur and tibia dark brown; tarsus black. Leg 2, length, 2.9 mm.; coxa, trochanter, and femur brown; tibia brown with small basal tan ring; basal half of basitarsus tan, the apical half black; tarsal segments 2-5 black. Leg 3, length, 3.7 mm.; coxa, trochanter, and femur dark brown; tibia dark brown with small basal tan ring; basal three-fifths of basitarsus and basal half of second segment tan, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 5.1 : 1; calcipala well developed, reaching the pedisulcus; pedisulcus well formed one-third the distance from the base of second segment; claw long, the heel expanded, and with a long, somewhat curved, submedian tooth (pl. 35, fig. 248).

Abdomen: Tergite of segment 1 dark brown, with short yellow and black hairs; pleurites dark brown, with long tan hairs that reach the third segment. Segment 2 black, the anterior half white-pruinose. Other segments completely black, segments 6-8 shiny. Segments 2-8 with short black hairs. Sternites tan.

Genitalia: Cercus (pl. 33, fig. 208) dome-shaped, higher than long (wide), the posterior angles well rounded. Anal lobe (pl. 33, fig. 208) triangular in shape, the ventral area expanded, similar to that of *tricornis*. Genital fork (pl. 33, fig. 210) very dark, with slight basal dilatation; each apical expansion of genital fork like a wide twisted ribbon, with a single toothlike extension near the midregion. Ovipositor (pl. 33, fig. 209) small, like an equilateral triangle in shape, the inner margin somewhat more heavily pigmented.

Pupa (pl. 37, fig. 306, and pl. 39, fig. 346).—Very sparse granulosity, only in center of thorax; approximately 6 very short simple trichomes on either side of midline. Dorsal surface of abdominal segment: Without granulosity; spines on segments 2-4 are anteriorly directed, those on segments 7-9 are posteriorly directed; segment 2 with 8 simple spines in transverse row across the middle, divided in two by median space; anterior to the outermost spine on either extremity of the row are 2 similar spines; segments 3 and 4 with 8 simple spines in transverse row somewhat before the posterior margin, with median separation; segment 7 with 12 simple spines in transverse row across the anterior margin, with median separation, and with comblike groups of spines lateral to both extremities of the row; segment 8 with 14 simple spines in uninterrupted row across the anterior margin, and with combs lateral to both extremities of the row; segment 9 with 3 transverse rows of very small spines, without median separation, crossing on the anterior part of the segment. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 4 with transverse row of 6 simple spines across the posterior margin, with median separation; segment 5 with 4 bifid spines in transverse row, with median separation; segments 6 and 7 each with a single bifid spine on either side of midline, the two spines on each segment well separated; all spines on segments 5-7 situated somewhat before the posterior margin of the respective segment. Terminal spines very small.

Respiratory apparatus (pl. 37, fig. 306) of each side arising slightly behind the anterior border of thorax; from a narrow base 2 very wide, inflated tubes divide off, each of these with at least another subdivision closer to its apex; more-dorsal element with numerous rather long hairs, present from where it branches from ventral element almost to its apex; elements with transverse wrinkles, but without superficial segmentation or minute spicules. Maximum length (dorsal element), 2.0 mm.; maximum width, 700 μ.

Cocoon (pl. 39, fig. 346): Length of base, 4.9 mm.; maximum width, 3.5 mm.; maximum height, 1.4 mm. Cocoon of wall-pocket type, with definite collar; texture of case parchmentlike, the threads rather loose and easily visible; lateral margins expanded to form winglike structures that give the cocoon an oval appearance when viewed from above; wings extend and join each other anteriorly in the form of a broad ribbon, which gives the cocoon the appearance of having a slight collar. Cocoon covers the abdomen only; attached along the posterior half of its base.

Larva (pl. 41, fig. 384, and pl. 43, fig. 421).—Total length, 6.0-6.3 mm. Length of head capsule 1.1 times its width. Width of thorax 1.3 times width of head. First 4 abdominal segments 1.1 times width of head; segments 5-7 expanded, widest at segment 6 which is 1.7 times width of segments 1-4; body with same general shape as that of *metallicum*. General color dark gray; abdominal segments at times with tannish cast; segments 4-8 milky gray on ventral surface.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 384. Each cephalic fan with 44-50 pectinate branches, the hairs on these branches simple, short, well separated, like minute spines, not interspersed with hairs of other types. Mandible with 2 teeth on its inner margin, both sharp-pointed, appearing to emerge from the same base; the apical tooth somewhat more than twice the length of the basal one, neither very long. Antenna 380 μ long, 4-

segmented, surpassing the basal stalk of the cephalic fan; segment 1 dark brown, the others lighter; segment 2 about one and one-third times the length of segment 1 which is about one and one-third times the length of segment 3; segments 1 and 2 with transverse striations. Submentum with 9 apical teeth, triangular in shape, the central one and the two outermost teeth larger than the others; ventrolateral row composed of 7 very thick hairs that appear to be 3- or 4-branched near the apex; lateral margin of submentum with 6 toothlike serrations, the most apical one more heavily pigmented than the others and appearing to emerge from the lateral margin of the outermost of the apical teeth. Occipital cleft deep, like half of a hexagon in shape, the apex pointed (pl. 43, fig. 421).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 34 rows of hooks on its apex; postclypeal sclerites minute and poorly sclerotized. Posterior sucker with 81-88 rows of hooks. Anal gills with 3 main divisions, each with from 4-6 fingerlike projections; usually the middle division has 6 and the two outer divisions 4 each. Anterior and posterior arms of X-shaped sclerite well sclerotized; broad, almost rectangular, pigmented patch on each of the anterior arms, the two patches meeting on the midline between the arms; outer margin of patches almost reaching posterior arms; no rectal scales. Eighth segment with very small, transparent, hardly visible, ventral papillae; no sclerotized plaques.

Types.—Holotype (♀) mounted, in part, on slides, the rest on a pin; allotype (♂) mounted on slides; paratypes (2 ♀♀) on pins. These types, as well as 20 pupae preserved in alcohol, are in the collection of the Instituto de Salubridad y Enfermedades Tropicales, Mexico City; collected from Cascada de Teocelo, Veracruz, Mexico, May 1946.

SIMULIUM (SIMULIUM) TRICORNIS De León

Simulium tricornis De León, Bol. Sanit. Guatemala, vol. 52, p. 68, fig. 4, 1944 (original description, pupal respiratory apparatus).

Simulium (*Simulium*) *tricornis* De León, Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 155-157 and 176, figs. 110-116, 122, and 151, 1946 (♂, ♀, pupa, and larva).

Male (pl. 26, figs. 91-93).—3.4 mm. long.

Head: Holoptic. Eyes reddish brown with yellowish cast. Antenna 630 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3=4+5$, $3=11$; black except for the apex of the pedicel and base of first flagellar segment which are brown. Palpi black. Clypeus black, white-pruinose, with 2 rows of long black hairs along the margins.

Thorax: Mesonotum velvety black; with continuous band of white pruinosity around the periphery, the anterior arm indented toward the center of scutum along its midregion; quite long, narrow, yellow, scalelike hairs on entire mesonotum, more numerous around periphery and on anterior fourth and in the prescutellar region, never in packets; entire scutum clothed with short black hairs, the hairs being longer and heavier in the prescutellar region. Humeral angles black, with white pruinosity and yellow scalelike hairs. Scutellum black, with yellow scalelike hairs and long black hairs. Postnotum velvety black, completely white-pruinose, devoid of hairs. Pleura black, with white pruinosity; pre-alar cluster yellow. Stem of halter black, the knob yellow. Wings, 3.4 mm. long and 1.6 mm. wide; relation of body length to wing, 1 : 1; Sc pilose along basal fifth; R_1 pilose and spiny along distal half; R_{2+3} pilose except for basal seventh; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.4 mm.; coxa, trochanter, and femur black; tibia black, the median half of its anterior face tan; tarsus black. Leg 2, length, 3.1 mm.; coxa, trochanter, and femur black; tibia black with tan basal ring; basal third of basitarsus tan, apical two-thirds black; segments 2-5 black. Leg 3, length, 4.0 mm.; coxa, trochanter, and femur black; tibia black with tan basal ring; basal two-fifths of basitarsus and basal third of second segment tan, the remainder of these segments, as well as all of tarsal segments 3-5, black; relation of basitarsus to second segment, 5 : 1; calcipala well developed, reaching pedisulcus; pedisulcus well formed one-third the distance from the base of second segment.

Abdomen: Tergite of segment 1 black with short black hairs; pleurites black with long black hairs that reach segment 4. Segment 2 black, the anterior half white-pruinose, with short black hairs. Other segments black, part of pleural regions white-pruinose, with lateral tufts of long black hairs as well as short black ones over entire segment. Sternites dark brown, with some white pruinosity.

Genitalia: Sidepiece (pl. 26, fig. 91) wider than long, almost oval in shape, with dorsal depression near middle of apical margin; dorsal opening occupying more than half of dorsal surface of sidepiece, its margins also somewhat rounded. Clasper (pl. 26, fig. 91) longer than sidepiece, not very wide, of about equal width throughout, the apex not narrowed but truncate, with single terminal spine; very short, broad basal process. Adminiculum (pl. 26, fig. 92) with characteristic X-shaped appearance, the body trapezoidal and the basal processes long and divergent; lateral margins more hyaline; apical angles somewhat prolonged; with well-sclerotized ribbonlike structure along base of body, the ends of which extend into the basal processes; longitudinal keel-like structure, with numerous hairs, along ventral surface; entire ventral surface with numerous hairs; club-shaped extension from the middle of basal margin of adminicular body, the terminal expanded portion very hairy; basal processes curved ventrally toward their ends, somewhat spatulate, with posteriorly directed spurlike structures. Arms of adminiculum (pl. 26, fig. 93) with about 20 teeth arranged in linear fashion, fine long ones at regular intervals and the remaining short ones intermixed; lateral plate large, triangular, with few wrinkles.

Female (pl. 33, figs. 211-213, and pl. 35, fig. 247).—3.2 mm. long.

HEAD: Dichoptic. Eyes very dark reddish brown; the base of fronto-ocular triangle about equal to its height. Antenna 610 μ long, 11-segmented, flagellum tapering; segment $3=1+2$, $3=4+5$, $3<11$; scape and pedicel brown, flagellum black. Palpi black. Frons and clypeus black, white-pruinose, irregularly covered with black hairs. Occipital region black, irregularly covered with rather long black hairs. Cornuae of buccopharyngeal apparatus heavily sclerotized, almost triangular in shape, the angles pointed; median space hyaline, smooth.

THORAX: Mesonotum velvety black; 2 small quadrangular white-pruinose patches on anterior margin, one on either side of midline; from inner posterior angle of each patch extends a very narrow, longitudinal stripe of white pruinosity that widens just before fusing with the white pruinosity of the prescutellar region; lateral margins also white-pruinose; midline with very narrow stripe of white pruinosity; long, narrow, yellow, scalelike hairs on mesonotum, more numerous on anterior fourth and along lateral margins; short black hairs over entire scutum, long, heavy black hairs in prescutellar region. Humeral angles brown. Scutellum shiny black, with some long, heavy black hairs and with narrow, yellow, scalelike hairs. Postnotum black, completely white-pruinose, devoid of hairs. Pleura black, with white pruinosity. Stem of halter with black base and brown apex, the knob tan. Wings, 3.4 mm. long and 1.7 mm. wide; relation of body length to wing, 1.1 : 1; Sc pilose along basal sixth; R_1 pilose and spiny along distal half; R_{2+3} pilose except for very small basal region; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.4 mm.; coxa and trochanter dark brown; basal three-fourths of femur dark brown, the apical fourth black; basal and apical thirds of tibia black, the median third dark brown; tarsus black. Leg 2, length, 3.1 mm.; coxa, trochanter, and femur black; tibia light brown on basal three-fourths, black on apical fourth;

basal half of basitarsus light brown, apical half black; tarsal segments 2-5 black. Leg 3, length, 4.0 mm.; coxa and trochanter dark brown; femur black; tibia tan on basal half, black on apical half; basal half of basitarsus and basal fourth of second tarsal segment tan, the remainder of these segments, as well as all of tarsal segments 3-5, black; relation of basitarsus to second segment, 5.5 : 1; calcipala well developed, overreaching the pedisulcus; pedisulcus well formed one-third the distance from the base of second segment; claw with well-developed heel and with strong subbasal tooth (pl. 35, fig. 247).

Abdomen: Tergite of segment 1 dark brown, with short black hairs; pleurites black, with long black hairs that reach the fourth segment. Segment 2 brown on anterior half and black on posterior half, with white prunosity on lateral regions. All other segments black, segments 6-8 shiny, the others almost velvety; all segments with short black hairs. Sternites yellow to tan.

Genitalia: Cercus (pl. 33, fig. 211) almost rectangular in shape, its height almost twice the length (width), posterior angles rounded. Anal lobe (pl. 33, fig. 211) somewhat triangular in shape, expanded ventrally, the posterior ventral corner extending slightly under the cercus. Genital rod (pl. 33, fig. 213) long, without basal dilatation; apical expansions of arms of genital fork ribbonlike, somewhat triangular in shape, the apical angle strongly tapered and pointed, the outer basal angle heavily sclerotized and acute, the inner basal angle hyaline, created only by median folding over of expansion. Ovipositor (pl. 33, fig. 212) small, triangular in shape, the base slightly greater than the length.

Pupa (pl. 37, fig. 307, and pl. 39, fig. 347).—Granulosity on entire thorax; about 30 short, simple, spinelike trichomes on either side of midline. Dorsal surface of abdominal segments: Dorsum of segments 1 and 2 completely granulose, dorsum of segments 3 and 4 sparsely granulose; spines on segments 2-4 are anteriorly directed, those on segments 5-9 are posteriorly directed; segment 2 with 8 simple spines in transverse row about three-fourths the distance from the anterior margin, the row divided in two by median space; anterior to the outermost spine on either extremity of the row are 2 similar spines; segments 3 and 4 each with 8 simple spines in transverse row three-fourths the distance from the anterior margin, with median separation; segments 5 and 6 with comblike groups of spines covering the entire dorsum; segment 7 with 12 simple spines in uninterrupted row along the anterior margin and with combs over entire dorsum; segment 8 with 12-14 simple spines in transverse row along anterior margin, with median separation, and with combs over entire dorsum; segment

9 with a single simple spine on either side of midline at anterior margin, with separation between them, and with combs over entire dorsum. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed and all transverse rows are situated somewhat before the posterior margin of the particular segment; segment 4 with 6 simple spines in transverse row with median separation; segment 5 with 4 bifid spines in transverse row with median separation; segments 6 and 7 each with 2 bifid spines, one on either side of midline, with space between them. Terminal spines very small.

Respiratory apparatus (pl. 37, fig. 307) of each side arising slightly behind the anterior margin of thorax; composed of 3 broad, curved, cylindrical processes, each tapering to a point at its apex; processes with wrinkles and some minute spicules, but without superficial segmentation. Maximum length of apparatus (anterior and posterior processes combined), 4.8-5.2 mm.; maximum diameter, 600 μ.

Cocoon (pl. 39, fig. 347): Length of base, 4.5 mm.; maximum width, 2.3 mm.; maximum height, 1.9 mm. Cocoon of wall-pocket type, without collar; texture of case parchmentlike, the threads visible; in profile, the rim of the anterior aperture slopes posteriorly at strong angle; rim somewhat thickened; longitudinal keel-like structure passing down middle of dorsum from anterior aperture to posterior end. Cocoon covering abdomen and posterior half of thorax; attached along posterior three-fourths of its base.

Larva (pl. 41, fig. 385, and pl. 43, fig. 422).—Total length, 7.2-7.5 mm. Length of head capsule 1.1 times its width. Width of thorax 1.6 times that of head. First 4 abdominal segments 1.2 times width of head; segments 5-7 expanded, greatest at segment 6 which is 1.6 times width of segments 1-4; body with same general shape and profile as *metallicum*. General color tan to gray, the dorsum of thorax more grayish white, the ventral surface of abdominal segments 5-7 more tan; large black granular patches on ventrolateral regions of segments 6 and 7.

Head: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 385. Each cephalic fan with 22-31 pectinate branches, the hairs on these branches simple, rather long, heavy, and well separated, not interspersed with hairs of other types. Mandible with 2 teeth on its inner margin, the basal tooth appearing to arise from the distal one which is much larger; both teeth sharply pointed. Antenna 330 μ long, 4-segmented, just passing the basal stalk of cephalic fan; segment 1 dark brown, the others yellow-brown; segments 1-3 subequal in length, without pseudoarticulations; segments 1 and 2 with transverse striations. Submentum with 9 triangular-shaped apical teeth, the central tooth and the outermost tooth on either side larger than the others; ventrolateral row composed of 6-10 hairs usually in a straight row, the two basal ones at times out of line; hairs bifid or trifid; lateral margin of submentum with 6 toothlike serrations, the apical two appearing to arise from the lateral margin of the outermost of the apical teeth. Occipital cleft dome-shaped (pl. 43, fig. 422).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 34-40 rows of hooks on its apex; postclypeal sclerites small but well sclerotized. Posterior sucker with 86-97 rows of hooks. Anal gills with 3 main divisions, the middle one with 9 fingerlike projections and the lateral ones each with 11-12 projections; some of the projections are longer than others, each of the main divisions with at least one projection that is twice the size of any other. Posterior arms of X-shaped sclerite very heavily pigmented and well sclerotized, reaching across the entire dorsum of segment; anterior arms not visible without clearing, owing to the presence of a very heavily pigmented quadrangular patch over each of these arms; no rectal scales but with groups of simple spines lateral to the region between the anterior and posterior arms. Eighth segment without ventral papillae or sclerotized plaques.

Types.—Pupa, in the collection of J. Romeo de León; collected from a stream in the high region called María Tecún, between Sololá and Totonicapán, Guatemala, 1940.

SIMULIUM (HEARLEA) BURCHI Dalmat

Simulium (*Hearlea*) *burchi* Dalmat, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 42-47, figs. 16-23, 1951 (original description, ♂, ♀, and pupa).

Male (pl. 26, figs. 94-96).—3.0 mm. long.

Head: Holoptic. Eyes reddish brown. Antenna 580 μ long, 11-segmented, tapering; segment $3<1+2$, $3>4+5$, $3>11$; scape and pedicel dark reddish brown, flagellum black. Palpi black. Clypeus black, white-pruinose, with very long, strong black hairs.

Thorax: Mesonotum velvety black, with band of white pruinosity around the periphery, narrow along anterior margin, indented toward center of mesonotum along midregion of anterior component; long, narrow, yellow, scalelike hairs sparsely distributed on mesonotum in same regions as pruinosity, never in packets, these hairs being larger in region of humeral angles; fine black hairs all over mesonotum, longer in prescutellar region. Humeral angles black, with white pruinosity. Scutellum velvety black, with short, yellow, scalelike hairs and long black hairs. Postnotum velvety black, with white pruinosity, devoid of hairs. Pleura black, with white pruinosity. Stem of halter dark brown to black, the knob yellow, cup-shaped. Wings, 3.1 mm.

long and 1.2 mm. wide; relation of length of body to wing, 1:1; Sc pilose along basal sixth; R_1 pilose and spiny along distal half; R_{2+3} pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.1 mm.; coxa, trochanter, and femur black; inner face of femur with yellow pruinosity and with appressed, golden-yellow, scalelike hairs; both extremities of tibia black, the middle region tan, with band of silver pruinosity on outer margin, the latter clothed with several silvery scalelike hairs; tarsus completely black. Leg 2, length, 2.7 mm.; completely black except for basal third of tibia which is tan. Leg 3, length, 3.3 mm.; coxa and trochanter black; femur dark brown, its apical third black; tibia black, with basal tan ring; basal third of basitarsus and of second tarsal segment tan, the remainder of these segments, as well as all of segments 3-5, black; tibia and basitarsus very broad and spindle-shaped; relation of basitarsus to second tarsal segment, 4:1; calcipala well developed, reaching pedisulcus; pedisulcus very well formed on basal fourth of second tarsal segment.

Abdomen: Tergite and pleurites black; short black hairs on tergite; long tan hairs, reaching the fourth segment, on pleurites. Segment 2 black, anterior half of tergite and the pleurites white-pruinose. Other segments black; pleura of segments 5-8 partially white-pruinose; pleura of segments 2-4 with tuft of long black hairs. Sternites tan.

Genitalia: Sidepiece (pl. 26, fig. 94) rectangular, with protuberance from outer posterior angle; dorsal opening small, occupying less than half of dorsal surface of sidepiece. Clasper (pl. 26, fig. 94) long and slender, with dorsal expansion on outer margin near base; apex of clasper somewhat broader than its midregion, truncate, with a single, strong terminal spine; a few very long, stout hairs on distal third of clasper more pronounced than the others. Body of adminiculum (pl. 26, fig. 95) wider than long, quadrangular; basal processes long, well sclerotized, ending in points; extending longitudinally along the midline of the ventral surface of the body of the adminiculum is a raised, keel-like structure which is clothed with fine hairs; on the dorsal surface the apical half of the adminiculum is doubled over to form a pocketlike flap which is clothed with short hairs. Arms of adminiculum (pl. 26, fig. 96) with numerous teeth, concentrated at apex; a single, almost triangular tooth near apex and 1 very long tooth located halfway along its length; lateral plate subquadrangular, wrinkled.

Female (pl. 33, figs. 214-216, and pl. 35, fig. 251).—2.8 mm. long.

Head: Dichoptic. Eyes black; base of fronto-ocular triangle twice its height; triangle very small. Antenna 510 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3<11$; scape and pedicel brown, flagellum black. Palpi black. Frons and clypeus black, white-pruinose, irregularly covered with black hairs. Occipital region black, with white pruinosity and long black hairs. Cornuae of buccopharyngeal apparatus greatly expanded, somewhat bifurcate, not heavily sclerotized; median space with marked median concavity, hyaline, very slightly serrated.

Thorax: Mesonotum velvety black; 2 subquadrangular, white-pruinose patches contiguous with the anterior margin, one on either side of the midline, from each of which extends a white-pruinose longitudinal band that unites with the white-pruinose patch in the prescutellar region; wide band of white pruinosity on lateral margins; broad band of appressed, short, narrow, golden-yellow, scalelike hairs along entire periphery of mesonotum; short black hairs over entire mesonotum, longer in prescutellar region. Humeral angles brown, with white pruinosity. Scutellum black, white-pruinose, with short, golden-yellow, scalelike hairs and several long black hairs. Postnotum black, with 2 triangular gray-pruinose patches contiguous with the anterior margin and meeting at the midline; devoid of hairs or scales. Pleura black, with white pruinosity. Stem of halter brown to black, the knob yellow. Wings, 3.1 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1.1; Sc pilose along its basal three-fifths; R_1 pilose and spiny along distal half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.6 mm.; coxa, trochanter, and femur light brown; tibia tan on basal three-fourths, apical fourth black; tarsus black. Leg 2, length, 2.7 mm.; coxa dark brown to black; trochanter light brown; femur and tibia light brown with apical dark ring; basal third of basitarsus and of second tarsal segment tan, the remainder of these segments, as well as all of segments 3-5, black. Leg 3, length, 3.3 mm.; coxa black; trochanter light brown; femur and tibia light brown on basal four-fifths, black on apical fifth; basal half of basitarsus and of second tarsal segment tan, the remainder of these segments, as well as all of tarsal segments 3-5, black; relation of basitarsus to second tarsal segment, 4.6 : 1; calcipala well developed, but not reaching pedisulcus; pedisulcus well developed at middle of second tarsal segment; claw with rather blunt, small, submedian tooth (pl. 35, fig. 251).

Abdomen: Tergite of segment 1 black, its midregion tan, with short black hairs; pleurites black, with long tan hairs reaching the fourth segment. Segment 2 black, white-pruinose. Segments 3-5 dull black, 6-8 shiny and clothed with semierect black hairs. Sternites tan, evenly pruinose.

Genitalia: Cercus (pl. 33, fig. 214) more than twice as high as it is long (wide), subquadrangular in shape, entire surface clothed with many strong hairs and numerous spicules. Anal lobe (pl. 33, fig. 214) also higher than long (wide); posterior margin evenly curved, anterior margin irregularly curved; posterior half and median region of anterior half rather heavily sclerotized, the posterior half with numerous strong hairs; dorsal and ventral angles of anterior half hyaline, the former with minute spicules similar to those on cercus, the latter with hairs similar to those on posterior half of anal lobe but finer. Genital rod (pl. 33, fig. 216) with well-developed basal dilatation, oval in shape; genital fork (pl. 33, fig. 216) with branches narrowly divergent; apical expansions of arms triangular, rather hyaline, with all angles rounded. Ovipositor (pl. 33, fig. 215) more than twice as long as is its base, somewhat triangular in shape.

Pupa (pl. 38, fig. 308, and pl. 39, fig. 348).—Thorax with abundant granulosity, principally in the midregion; 5 short, simple, stout, spine-like trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity on dorsal surface; segment 2 with 8 anteriorly directed simple spines in a transverse row three-quarters the distance back from the anterior margin, the row being divided into two by a median space; anterior to the outer spine at either extremity of the row are 2 smaller spines, giving a total of 12 spines for the segment; segments 3 and 4 with transverse rows of 8 spines, situated somewhat before the posterior margin, each row also being separated into two by a median space; along anterior margin of segments 5 and 6 there is an uninterrupted band composed of comblike groups of spines, posteriorly directed, with from 2-7 spines in each group; segment 7 with transverse row of 20 posteriorly directed spines, simple, bifid, or trifid, situated along the anterior margin, the row separated by a median space; comblike groups of spines, 2-6 spines per group, lateral to transverse row as well as between the spines that compose the row; segment 8 with uninterrupted transverse row of 30 posteriorly directed spines, simple or bifid, and with combs like on segment 7; segment 9 with transverse band of combs along anterior margin, 2-5 spines per comb, posteriorly directed, without interruption. Ventral surface of abdominal segments: Without granulosity; segment 5 with 4 anteriorly directed, simple spines in transverse row somewhat before the posterior margin, the row being divided into two by a median space; segments 6 and 7 with similar rows of spines, but with the two spines on either side of the midline more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 308) of each side arising somewhat behind the anterior margin of thorax; each composed of 2 main divisions, which are inflated, having a posterior "tail" where the two elements diverge; apparatus hornlike, the dorsal element long, club-shaped, with its upper surface somewhat tuberculated near the apex; the ventral element passes around the anterior aperture of the cocoon, with which it is in close apposition; all elements of respiratory apparatus with superficial annulation, more pronounced on dorsal element; with many longitudinal and transverse folds. Maximum length, 1.5 mm.; maximum width, 0.6 mm.

Cocoon (pl. 39, fig. 348): Length of base, 2.4 mm.; maximum length, 4.2 mm.; maximum width, 1.6 mm.; maximum height, 1.6 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; no festoons or prolongations from margin of anterior aperture; in profile, anterior aperture is at 45 degree angle to base, its rim slightly thickened. Cocoon attached along half of its base; covers the abdomen and half of the thorax.

Larva (pl. 41, fig. 386, and pl. 43, fig. 423).—Total length, 7.3 mm. Length of head capsule equal to the width. Width of thorax 1.5 times width of head. Abdominal segments 1-4 approximately 1.3 times width of head; segments 5-7 somewhat expanded, greatest at segment 7 which is 1.4 times the average width of segments 1-4; in profile, the larval form appears similar to that of members of subgenus *Dyarella*. General color gray to tan, with irregular dark patches on ventrolateral areas of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 386. Each cephalic fan with 46-50 pectinate branches, the hairs on these branches being short, simple, and close together, interspersed with longer bifid ones at regular intervals. Mandible with 2 to 3 teeth on its inner margin, the most basal one longer than the other two, the apical one blunt; all three teeth contiguous. Antenna 380 μ long, 5-segmented, yellow, just passing the end of the basal stalk of cephalic fan; segment $1>2>3=4>5$; segment 2 with superficial division at its middle and with white patches at the midregion and apical end; also with a longitudinal dark-brown patch on each yellow area; segment 1 with white patch at base and with longitudinal striations. Submentum with 9 apical teeth, the central one and two outer teeth longer than the others; teeth triangular in shape, large; ventrolateral row with 14-15 hairs in an irregular line, almost all bifid except the basal ones; lateral margin of submentum with 4 toothlike indentations. Occipital cleft very small, dome-shaped, with angular apex (pl. 43, fig. 423).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 47-50 rows of hooks on its apex; postclypeal sclerites long, poorly sclerotized, wider at lateral ends, almost joining near midline. Posterior sucker with 172-178 rows of hooks. Anal gills with 3 principal branches, each of the lateral branches with 28 narrow, filamentous extensions, the central branch with 22 extensions, giving a total of 78. X-shaped sclerite with anterior and posterior arms well sclerotized, the anterior arms short with a winglike, somewhat pigmented patch on their posterior margin; no rectal scales or spines. No ventral papillae or sclerotized plaques on eighth segment.

Types.—Holotype (♀), pinned, and allotype (♂), on 3 slides, in the collection of the United States National Museum; collected from the Río Micovez, Nebáj, Department of El Quiché, Guatemala, November 15, 1949. Paratypes (4 ♀♀, 3 ♂♂, and 6 pupae) in the collection of Herbert T. Dalmat.

SIMULIUM (HEARLEA) CAPRICORNIS De León

Simulium capricornis De León, Bol. Sanit. Guatemala, vol. 52, pp. 71-72, figs. 8-9, 1944 (original description, pupal respiratory apparatus).

Male (pl. 26, figs. 97-99).—(First description of male.) 3.0 mm. long.

Head: Holoptic. Eyes reddish brown. Antenna 600 μ long, 11-segmented, slightly tapering; segment $3=1+2$, $3>4+5$; completely black. Palpi black. Clypeus black, white-pruinose, with long black hairs.

Thorax: Velvety black, with narrow band of white pruinosity around entire periphery, somewhat wider at middle of anterior margin; very long, narrow, golden-yellow, scalelike hairs in wide band around entire periphery, so numerous in prescutellar region that the area appears golden; few on central region; few long black hairs in prescutellar region. Humeral angles white-pruinose with yellow scalelike hairs. Scutellum brown to black, with both yellow scalelike hairs and erect long black hairs. Postnotum brown to black, with white pruinosity. Pleura white-pruinose. Stem of halter dark brown, the knob tan. Wings, 3.1 mm. long and 1.4 mm. wide; relation of length of body to wing, 1:1; Sc pilose along its basal sixth; R_1 pilose and spiny along distal half; R_{2+3} pilose except for very short basal portion; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.3 mm.; coxa, trochanter, and femur tan; outer surface of tibia with its ends black, the midregion tan; inner surface dark brown; tarsus black. Leg 2, length, 2.8 mm.; coxa brown; trochanter tan; femur tan with apical black ring; tibia tan on basal two-thirds, apical third black; tarsus black. Leg 3, length, 3.5 mm.; coxa brown; trochanter tan; femur with basal three-fourths tan, the apical fourth black; tibia tan on basal third, apical two-thirds black; basal half of basitarsus and basal fourth of second tarsal segment brown, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second tarsal segment, 3.8:1; calcipala well developed, reaching the pedisulcus; pedisulcus present, but not deeply incised.

ABDOMEN: Tergite of segment 1 black on anterior half and brown on posterior half, clothed with short black hairs; pleurites black, with long tan hairs reaching segment 5. Segment 2 dark brown, white-pruinose, with short black hairs. Other segments black, the pleura partially white-pruinose; tufts of black hairs on pleura of segments 3-5. Sternites tan.

GENITALIA: Sidepiece (pl. 26, fig. 97) subquadrangular in shape, somewhat wider than long, with protuberance from outer posterior angle; dorsal opening occupying about half of the surface of sidepiece. Clasper (pl. 26, fig. 97) about five times as long as it is wide, narrowed toward the middle; longitudinal projection on outer margin of dorsal surface extending from the base about halfway to the apex; apex truncate, with a single, strong, terminal spine near its end. Body of adminiculum (pl. 26, fig. 98) quadrangular, wider than long, its basal processes long, broad, well sclerotized, and pointed; on its ventral surface, the body of the adminiculum has a longitudinal keel which is clothed with numerous hairs; there is a small apical concavity which also bears several hairs. Arms of adminiculum (pl. 26, fig. 99) with 15-20 teeth, mainly concentrated at the apex to form a crown; 3 very long teeth closer to the lateral plate, 1 broadly triangular tooth near apex; lateral plate subquadrangular in shape, wrinkled, slightly sclerotized.

Female (pl. 33, figs. 217-219, and pl. 35, fig. 252).—(First description of female.) 3.0 mm. long.

HEAD: Dichoptic. Eyes black; fronto-ocular triangle very small, its height equal to the base. Antenna 510 μ long, 11-segmented, tapering; segment $3<1+2$, $3>4+5$, $3=11$; scape and pedicel brown, flagellum black. Palpi black. Frons black, white-pruinose, with 3 irregular rows of black hairs along lateral margins. Clypeus dark reddish brown, white-pruinose, irregularly covered with black hairs. Occipital region black, covered with short tan hairs. Cornuae of buccopharyngeal apparatus well sclerotized, somewhat expanded;

median space hyaline, without teeth, but with well-marked median concavity.

THORAX: Mesonotum velvety blue-black; a triangular white-pruinose patch at anterior margin on either side of midline from which extends a longitudinal white-pruinose band that unites with the pruinosity of the prescutellar region; short, broad, yellow, scalelike hairs on anterior fourth of mesonotum, on the lateral margins, and on prescutellar region; few long black hairs and several short tan hairs on prescutellar region. Humeral angles brown, white-pruinose, with yellow scalelike hairs. Scutellum black, with long black hairs and short tan ones. Postnotum black, white-pruinose, devoid of hairs. Pleura evenly white-pruinose. Stem of halter reddish brown, the knob tan. Wings, 2.8 mm. long and 1.3 mm. wide; relation of body length to wings, 1.1 : 1; Sc pilose on basal four-fifths; R_1 with hairs and spines along apical three-fifths; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.2 mm.; coxa and trochanter tan; femur tan with apical dark-brown ring; tibia with basal four-fifths tan, remainder black; tarsus black. Leg 2, length, 2.9 mm.; coxa reddish brown; trochanter tan; femur light brown with dark-brown apical ring; tibia with basal four-fifths light brown, the remainder dark brown; basal half of basitarsus light brown, apical half dark; tarsal segments 2-5 dark brown. Leg 3, length, 3.6 mm.; coxa dark brown; trochanter light brown; femur and tibia light brown, with apical dark ring; basal two-thirds of basitarsus and basal half of second tarsal segment tan, the remainder of these segments, as well as all of tarsal segments 3-5, black; relation of basitarsus to second tarsal segment, 6: 1; calcipala very long, passing beyond pedisulcus; pedisulcus well developed at basal third of second tarsal segment, deeply incised; claw with well-developed subbasal secondary spur (pl. 35, fig. 252).

ABDOMEN: Tergite of segment 1 brown; pleurites black with long tan hairs reaching third segment. Segment 2 with tergite brown, the pleurites black with white pruinosity. Tergites of other segments black; pleurites of segments 3-6 light brown; few long black hairs on last segment. Sternites light brown.

GENITALIA: Cercus (pl. 33, fig. 217) twice as high as it is long (wide), subquadrangular, with a few long, strong hairs and numerous minute spicules. Anal lobe (pl. 33, fig. 217) also much higher than long (wide), curving somewhat under cercus; investiture similar to that of cercus. Genital rod (pl. 33, fig. 219) with very much enlarged basal dilatation; apical expansions of arms of genital fork triangular in shape, the outer angle and inner basal angle hyaline and rounded, the outer basal angle well sclerotized, deeply pigmented, and sharply pointed. Ovipositor (pl. 33, fig. 218) somewhat dome-shaped, the base slightly greater than the height, more heavily sclerotized region near apex.

Pupa (pl. 38, fig. 309, and pl. 39, fig. 349).—(Respiratory apparatus alone previously described.) Granulosity on entire thorax; 5 short, simple, stout spinelike trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in a transverse row across middle of segment, the row being divided in two by a median space; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 with 8 simple spines in transverse rows, situated somewhat before the posterior margin, each row also being separated into two by a median space; segment 6 with a band across the anterior margin composed of comblike groups, each group with 3-7 spines, the band divided by a median space; segment 7 with 10-16 simple spines in transverse row at anterior margin, the row being interrupted by median space; also with combs (2-7 spines each) lateral to row of spines and intermixed with it; segment 8 with 19 simple spines in uninterrupted transverse row along anterior margin, and with combs lateral to row; segment 9 with wide uninterrupted band of combs (1-4 spines each) across anterior margin. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 bifid spines in transverse row three-fourths the distance from anterior margin, the row being divided by median space; segments 6 and 7 with similar rows of simple spines, but with the 2 spines on either side of midline more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 309) with dorsal and ventral elements, and with short "tail" formed where the two elements diverge; both elements curve so that their pointed apices approach one another; with superficial annulation and covered by microscopic spicules. Maximum length, 1.9 mm.; maximum width, 0.5 mm.

Cocoon (pl. 39, fig. 349): Length of base, 4.3 mm.; maximum width, 3.5 mm.; maximum height, 1.4 mm. Wall-pocket type, with only minute rise at anterior end to form an almost imperceptible collar; cocoon with lateral winglike expansions; rim of anterior aperture thickened; parchmentlike texture, threads not visible. Cocoon covers abdomen and half of thorax, attached along about 0.3 of its base.

Larva (pl. 41, fig. 387, and pl. 43, fig. 424).—(First description of larva.) Total length, 6.6 mm. Head capsule 1.1 times longer than it is wide. Width of thorax 1.4 times width of head. Abdominal segments 1-4 approximately 1.2 times width of head; segments 5-7 somewhat expanded, widest at segment 6 which is 1.4 times average width of segments 1-4; cross section of larva oval; in profile, appearing similar to those of subgenus *Dyarella*. General color gray to tan, without dark patches on ventrolateral regions of segments 6 and 7.

Head: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 387. Each cephalic fan with 44-45 pectinate branches, the hairs on these branches simple, close together, rather long, interspersed with slightly longer, heavier hairs at regular intervals. Mandible with 2 sharp-pointed teeth on its inner margin, both appearing to emerge from the same base, the apical one longer. Antenna 370 μ long, 5-segmented, yellow, just passing the basal stalk of the cephalic fan; segment $1 > 2 = 3 < 4$; segment 2 with superficial division at its midregion; segment 1 with longitudinal striations. Submentum with 9 apical teeth, the median one longer than the others, in shape like one end of a hexagon; ventrolateral row with 6-10 hairs in a straight line, either trifid or with four branches; lateral margin of submentum with 5 toothlike indentations. Occipital cleft triangular in shape (pl. 43, fig. 424).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 39-44 rows of hooks at its apex; postclypeal sclerites long, poorly sclerotized, appearing to emerge from the posterior junction of the frons-clypeus and the epicranial plates. Posterior sucker with 115-125 rows of hooks. Anal gills with 3 principal branches, each with 1 large fingerlike projection and three shorter, more slender ones, giving a total of 12 branches in all. Anterior and posterior arms of X-shaped sclerite long; anterior arms well sclerotized only on basal half; posterior arms well sclerotized reaching the lateral margin of the larva; well-sclerotized patch between the anterior and posterior arm of each side; large group of scales on either side between the anterior and posterior arms, lateral to the patches; rectal scales present, bifid to 4-branched, in irregular group. No ventral papillae or plaques on eighth segment.

Types.—Pupae, in the collection of J. Romeo de León; collected in streams above Totonicapán, and in the Río Samalá, Totonicapán, Department of Totonicapán, Guatemala. Among the ♂♂ and ♀♀ used for the above descriptions, the following two have been designated as plesiotypes: Male (Accession Acat. 112-9); reared from pupa collected in Río Laguneta, Finca Tehuyá, Acatenango, Department of Chimaltenango, Guatemala, on April 2, 1948; collectors, José H. Rosales and Daniel Luch; mounted on 4 slides, containing the wings, legs, genitalia, and head. Female (Acat. 139-1); reared from pupa collected in the same stream as the male on March 12, 1948; collectors, José H. Rosales and Daniel Luch. Both plesiotypes are in the collection of the author.

SIMULIUM (HEARLEA) CAROLINAE De León

Simulium carolinae De León, Bol. Sanit. Guatemala, vol. 52, pp. 73-75, figs. 12-13, 1944 (original description, pupal respiratory apparatus, and terminal plate of larva).

Simulium (*Hearlea*) *carolinae* De León, Vargas, Martínez, and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 7, No. 3, pp. 122-124 and 182, figs. 29-34 and 137, 1946 (♂, ♀, pupa, and larva).

Male (pl. 26, figs. 100-102).—3.2 mm. long.

Head: Eyes dark reddish brown. Antenna 540 μ long, 11-segmented, slightly tapering; segment $3>1+2$, $3=4+5$, $3>11$; black. Palpi black. Clypeus black, white-pruinose, irregularly covered with long, strong, black hairs.

Thorax: Mesonotum velvety black, with band of white pruinosity around the periphery, the band interrupted only at the middle of the anterior margin where the ends of both arms broaden; long, narrow, yellow scalelike hairs over entire mesonotum, more numerous along the periphery, never in packets; longer in prescutellar region; long black hairs on prescutellar region. Humeral angles white-pruinose, covered with yellow scalelike hairs. Scutellum black, white-pruinose, with numerous yellow scalelike hairs and some long black hairs. Postnotum velvety black, white-pruinose, devoid of hairs. Pleura brown, with white pruinosity. Stem of halter black on its base and dark brown near apex, the knob yellow and cup-shaped. Wings, 3.2 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1; Sc pilose along its basal fifth; R_1 pilose and spiny along the distal half; R_{2+3} pilose except for short basal region; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.4 mm.; coxa and trochanter dark brown; femur black; tibia black, its central region dark brown; tarsus black. Leg 2, length, 3.0 mm.; coxa, trochanter, and femur black; tibia black except for its basal fourth which is brown; basal half of basitarsus brown, apical half black; tarsal segments 2-5 black. Leg 3, length, 3.5 mm.; coxa, trochanter, and femur black; tibia black with small basal brown ring; basal third of basitarsus and of second segment brown, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second tarsal segment, 4.0 : 1; calcipala not very well developed, not reaching pedisulcus; pedisulcus well developed at basal fourth of second segment.

Abdomen: Tergite of segment 1 black, its midregion yellow, with short black hairs; pleurites of this segment black, with long dark hairs reaching segment 5. Segment 2 black, the anterior half of tergite white-pruinose, all with short black hairs. Other segments black with short black hairs; pleura of segments 6 and 7 white-pruinose. Sternites tan.

Genitalia: Sidepiece (pl. 26, fig. 100) quadrangular in shape, width almost twice the length; dorsal opening occupying about half of dorsal surface of sidepiece. Clasper (pl. 26, fig. 100) long and narrow, its length about five times its width, about 1.6 times the length of the sidepiece; swelling on outer dorsal margin near base; apex rounded, somewhat truncate, with a single terminal spine. Body of adminiculum (pl. 26, fig. 101) wider than long, somewhat rectangular in shape, its apex extended; along its ventral surface there is a longitudinal keel-like structure which is clothed with numerous hairs; basal processes well sclerotized, somewhat pointed. Adminicular arms (pl. 26, fig. 102) with approximately 10 teeth, two to three near base, the remainder forming a crownlike process at the apex; lateral plate oval, wrinkled.

Female (pl. 33, figs. 220-222, and pl. 35, fig. 253).—3.1 mm. long.

Head: Dichoptic. Eyes black; base of fronto-ocular triangle 1.5 times the height. Antenna 580 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3=4+5$, $3>11$; scape and pedicel brown, flagellum black. Palpi black. Frons black, white-pruinose, with 3 irregular rows of black hairs along each margin. Clypeus black, white-pruinose, with some short tan hairs. Occipital region black, white-pruinose, with many long black hairs. Cornuae of buccopharyngeal apparatus completely sclerotized, broad at bases, tapering to apical points; median space small, hyaline, without teeth.

Thorax: Mesonotum velvety black; a white-pruinose triangle on either side of midline, contiguous with anterior margin; a single white-pruinose longitudinal band extending from somewhat behind each triangle to the prescutellar region which is also white-pruinose; short, narrow, pale-yellow, scalelike hairs completely clothing the mesonotum, more dense on anterior half; few short black hairs along anterior margin of mesonotum, several long black ones in prescutellar region. Humeral angles black, evenly white-pruinose. Scutellum black, white-pruinose, with long black hairs and yellow scalelike hairs. Postnotum velvety black, evenly white-pruinose, devoid of hairs. Pleura black, evenly white-pruinose. Stem of halter light brown, the knob yellow, elongate. Wings, 3.9 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1.3; Sc pilose along basal two-thirds; R_1 pilose and spiny along distal half; R_{2+3} pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.2 mm.; coxa and trochanter light brown; femur dark brown, its basal third somewhat lighter than the apical two-thirds; basal three-fourths of tibia yellow, apical fourth black; tarsus black. Leg 2, length, 2.9 mm.; coxa and trochanter brown; femur brown with apical black ring; tibia yellow on the basal three-fourths, black on apical fourth; basal half of basitarsus yellow, apical half black; tarsal segments 2-5 black. Leg 3, length, 3.7 mm.; coxa dark brown, trochanter light brown; femur brown with apical black ring; tibia with basal half yellow, middle fourth brown, and apical fourth black; basal halves of basitarsus and second segment yellow, the apical halves of these segments, as well as all of segments 3-5, black; relation of basitarsus to second tarsal segment, 5.1 : 1; calcipala well developed, reaching only halfway to pedisulcus; pedisulcus well developed at middle of second segment; claw with basal heel well developed and with submedian tooth (pl. 35, fig. 253).

ABDOMEN: Tergite of segment 1 black; pleurites black with long dark hairs reaching third segment. Segment 2 black, the tergite white-pruinose. Other segments black, the pleurites somewhat white-pruinose; few long black hairs on last segment. Sternites tan.

GENITALIA: Cercus (pl. 33, fig. 220) rectangular, its height 1.5 times its length (width), clothed with some long, strong hairs and with numerous minute spinelike hairs. Anal lobe (pl. 33, fig. 220) somewhat crescent-shaped, curving around the ventral margin of the cercus. Genital rod (pl. 34, fig. 222) with slight basal dilatation; apical expansions of arms of genital fork triangular in shape, hyaline; the outer basal angle somewhat pointed, the others blunt. Ovipositor (pl. 33, fig. 221) somewhat triangular in shape, the apex rounded, its height equal to the base.

Pupa (pl. 38, fig. 310, and pl. 39, fig. 350).—Granulosity on entire thorax; 6 short, simple, stout, spinelike trichomes on either side of midline. Dorsal surface of abdominal segments: Segment 1 with granulosity along middle of posterior margin; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in a transverse row crossing the segment three-fourths the distance from the anterior margin, the row being divided into two by a median space; outermost spine on either side more distant from the neighboring spine than the distance between any other two; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 with 8 simple spines in a transverse row across the posterior margin, the row being divided into two by a median space; anterior margin of segments 5-9 with band composed of groups of comblike spines; each group on segment 5 with 2 to 5 spines; on segment 6 with 2-6 spines; and on segments 7-9 with 2-7 spines. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 simple spines in transverse row about three-fourths the distance from the anterior margin, the row being divided by a median space; segments 6 and 7 with similar rows of simple spines, but with the two spines on either side of midline more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 310) of either side arising slightly behind the anterior margin of thorax; antlerlike structure with somewhat variable number of tubular elements, the longer ones tapering strongly; apices of all elements with single point; with longitudinal and transverse wrinkles over entire surface. Maximum length, 2.3 mm. (dorsal element); maximum diameter, 0.2 mm.

Cocoon (pl. 39, fig. 350): Length of base, 3.0 mm.; greatest width, 1.5 mm.; greatest height, 1.3 mm. Cocoon of wall-pocket type, without collar; parchmentlike texture, threads not visible; rim around anterior aperture not thickened. Cocoon covering abdomen and half of thorax; attached along posterior fourth.

Larva (pl. 41, fig. 388, and pl. 43, fig. 425).—Total length, 7.8 mm. Width of head 1.1 times its length. Width of thorax 1.6 times width of head. Average width of abdominal segments 1-4 approximately 1.4 times width of head; segments 5-7 expanded, segment 7 the widest, 1.2 times average width of segments 1-4; cross section and profile as for *capricornis*. General color gray to tan, with irregular dark patches on ventrolateral regions of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 388. Each cephalic fan with 44-45 pectinate branches, the hairs on these branches short, close together, simple, interspersed at regular intervals by longer, stouter, bifid hairs. Mandible short and broad, with 2 teeth (or 1 bifid tooth) on its inner margin, these apparently emerging from the same base, the more distal tooth somewhat longer than the other. Antenna 360 μ long, yellow, 5-segmented, just passing the basal stalk of the cephalic fan; segment $1>2>3<4$; segment 2 superficially divided into two segments, with a white patch at the median division; segment 3 with white patch at its distal end; segment 1 with white patch at its base and with longitudinal striations.

Submentum with 9 apical teeth, triangular in shape, the central one and the outermost on either side longer than the others; ventrolateral row composed of 8-11 hairs in a straight line, the apical five bifid or trifid, the others simple; at times some of the hairs are deeply bifurcated, one of the branches subdividing; lateral margin of submentum with a single, poorly defined toothlike serration. Occipital cleft dome-shaped, the apex somewhat pointed (pl. 43, fig. 425).

THORAX AND ABDOMEN: Pseudopod (thoracic proleg) with 45-46 rows of hooks at its apex; postclypeal sclerites long, narrow, poorly sclerotized, appearing to extend from the posterior junction of the frons-clypeus with the epicranial plates. Posterior sucker with 196-204 rows of hooks. Anal gills with 3 main divisions that are short and fleshy; each of the two outer divisions usually has 1 broad projection and 8 more slender projections; the median division usually has 1 broad and 11 slender projections; besides this more common arrangement, giving a total of 30 branches, there are at times only 25 branches, eight from each lateral division and nine from the median one; all projections are fingerlike in appearance. Anterior arms of X-shaped sclerite well sclerotized and somewhat broad; posterior arms completely encircling the posterior sucker, well sclerotized, slender; lateral to the union with the anterior arms, the posterior arms bear large, heavily sclerotized, pigmented plates that are triangular in form and erect, with the apex pointing dorsally; at times, a few specimens are found in which a larger ventrally directed plate may also be present; no spines between the pigmented plates and the anterior arms; rectal scales absent. No dark wide bands transversely crossing the dorsal surface just anterior to the branchiae as there are in *larvispinosum*. No ventral papillae or plaques on eighth segment.

Types.—Pupa and larvae, in the collection of J. Romeo de León; collected from the "Salto de Zunil," a waterfall near the town of Zunil, Department of Quezaltenango, 1,900 meters above sea level. Numerous specimens, collected in Guatemala by the present author, were used for the above description.

SIMULIUM (HEARLEA) DELATORREI Dalmat

Simulium (*Dyarella*) *delatorrei* DALMAT, Ann. Ent. Soc. Amer., vol. 43, No. 1, pp. 137-143, figs. 1-7, 1950(b) (original description, ♂, ♀, and pupa).

Simulium (*Hearlea*) *delatorrei* DALMAT, Ann. Ent. Soc. Amer., vol. 44, No. 1, p. 53, 1951.

Male (pl. 26, figs. 103-105).—3.1 mm. long.

HEAD: Holoptic. Eyes dark reddish brown, shiny. Antenna 510 μ long, 11-segmented, very slightly tapering; segment $3=4+5=11=$

9+10; scape and pedicel light brown, flagellum dark brown with white pruinosity. Palpi dark reddish brown; clypeus somewhat extended, white-pruinose with long black hairs.

Thorax: Mesonotum velvety black with band of white pruinosity completely encircling it along the periphery, much wider on anterior margin; long, silvery to pale-yellow, scalelike hairs on entire mesonotum, denser on anterior fourth and along the periphery, longer in prescutellar region, never in packets; some long black hairs on prescutellar region. Humeral angles shiny, with white pruinosity. Scutellum reddish brown, gray-pruinose, with silvery to pale-yellow scalelike hairs and long black hairs. Postnotum black, with gray pruinosity, devoid of hairs. Pleura evenly white-pruinose. Stem of halter short, broad, brown in color, the knob pale yellow, cup-shaped. Wings, 3.0 mm. long and 1.4 mm. wide; relation of length of body to wing, 1:1; Sc pilose on basal fourth; R_1 pilose and spiny on distal half; R_{2+3} pilose except for basal fifth; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 2.7 mm.; coxa, trochanter, and femur reddish brown; tibia light brown with apical fourth dark; tarsus dark reddish brown. Leg 2, length, 2.6 mm.; coxa dark brown to black; trochanter dark brown to black with basal light patch; femur reddish brown, with black apical ring and light preapical area; tibia and basitarsus light brown on basal half, black on apical half; tarsal segments 2-5 black. Leg 3, length, 3.3 mm.; coxa dark brown; trochanter light brown; femur reddish brown; tibia reddish brown with light basal ring; anterior half of basitarsus light brown, the remainder black; tarsal segments 2-5 black; relation of basitarsus to second segment, 4.2:1; calcipala well developed, reaching only halfway to pedisulcus; pedisulcus not deeply incised but easily visible.

Abdomen: Tergite and pleurites of segment 1 black, the pleurites with long black hairs that reach segment 4. Segment 2 black, the pleurites white-pruinose. Other segments black, the pleurites white-pruinose on anterior half. All segments clothed with short black hairs. Sternites white-pruinose.

Genitalia: Sidepiece (pl. 26, fig. 103) only slightly wider than long; dorsal opening occupying more than half of surface of sidepiece. Outer posterior angle protruding, somewhat dome-shaped. Clasper (pl. 26, fig. 103) long and narrow, about one and one-fourth times the length of the sidepiece; basal third wider than the apical portion, definite bulge on outer dorsal area extending along basal third of clasper; apex somewhat truncate, with a single strong, blunt terminal spine that appears to emerge from a transverse furrow. Body of adminiculum (pl. 26, fig. 105) rectangular, wider than long, with short but pronounced apical expansion; along ventral surface there is a longitudinal keel-like structure, extending from the apex to about the center of the adminicular body, clothed with numerous hairs; basal processes well sclerotized, the ends blunt, almost spatulate, with small winglike expansion lateral to each. Adminicular arms (pl. 26, fig. 104) with about 11 teeth arranged in linear fashion, half of them being small, the others very large; lateral plate irregularly quadrangular, wrinkled, somewhat sclerotized.

Female (pl. 33, figs. 223-225, and pl. 35, fig. 258).—3.1 mm. long.

HEAD: Dichoptic. Eyes small, black; fronto-ocular triangle very small, relation of base to height, 2:1. Antenna 500 μ long, 11-segmented, strongly tapering; segment $3=4+5$, $3>1$ or 2; scape and pedicel light brown, the flagellum black. Frons white-pruinose with 2 rows of black hairs along each margin. Clypeus and occipital region white-pruinose with black hairs. Cornuae of buccopharyngeal apparatus sclerotized, wide, somewhat shovel-like; median space semicircular, hyaline, without teeth.

THORAX: Mesonotum black, with 2 longitudinal stripes of white pruinosity, each beginning at the anterior end as an extension of a white-pruinose triangle that is contiguous with the anterior margin of the mesonotum, and ending posteriorly where it blends with the white pruinosity of the prescutellar region; light-yellow scalelike hairs rather evenly distributed over entire mesonotum; few long black hairs in prescutellar region. Humeral angles pronounced, white-pruinose. Scutellum black, with yellow scalelike hairs and with long black ones. Postnotum velvety black with white pruinosity, devoid of hairs. Pleura white-pruinose. Stem of halter brown at base and tan apically; the knob pale yellow, cup-shaped. Wings, 3.1 mm. long and 1.4 mm. wide; relation of length of body to wing, 1:1; Sc pilose along basal four-fifths; R_1 spiny and pilose along distal half; R_{2+3} pilose except for very small basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 2.8 mm.; coxa and trochanter light brown; femur light brown with apical dark ring; basal two-thirds of tibia tan, apical third black; tarsus black. Leg 2, length, 3.0 mm.; coxa and trochanter light brown; femur, tibia, and tarsus as on leg 2. Leg 3, length, 3.5 mm.; coxa dark brown; trochanter yellow; femur light brown with small apical black region; tibia with basal two-thirds tan, the apical third black; basitarsus tan on basal half, black on apical half; tarsal segments 2-5 black; relation of basitarsus to second segment, 4.3:1; calcipala small, not reaching pedisulcus; pedisulcus well developed at middle of second segment; claw with well-developed basal heel and with submedian tooth (pl. 35, fig. 258).

Abdomen: Tergite of segment 1 brown with short yellowish-white hairs; pleurites dark brown, the posterior half white-pruinose, with long yellowish-white hairs that reach segment 3. Segment 2 with brown tergite and white-pruinose pleurites. Other segments shiny black, the pleurites with somewhat yellowish pruinosity; last segment with long black hairs. Sternites with yellowish pruinosity.

Genitalia: Height of cercus (pl. 33, fig. 223) more than three times its length (width), rectangular in shape, clothed with some long, strong hairs and numerous minute spinelike hairs. Anal lobe (pl. 33, fig. 223) about six times higher than it is long (wide), with irregular shape. Genital rod (pl. 33, fig. 225) with well-marked basal dilatation, spatulate; apical expansions of arms of genital fork triangular in shape, all the angles blunt; outer basal angle slightly pigmented, the other hyaline, clear. Ovipositor (pl. 33, fig. 224) somewhat triangular in shape, the apex truncate and pigmented, the base greater than the height.

Pupa (pl. 38, fig. 311, and pl. 39, fig. 351).—Granulosity on entire thorax; 7 simple hairlike trichomes on either side of midline. Dorsal surface of abdominal segments: Posterior three-fourths of segment 1 with granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in a transverse row across the middle of the segment, the row divided into two by a median space; the outermost spine on either side more distant from its neighboring spine than the distance between any other two; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 with 8 simple spines in a transverse row across the segment three-fourths the distance from the anterior margin, the row being divided into two by a median space; segment 6 with band composed of comblike groups of spines (2-7 spines per comb) across the anterior margin, with median separation; segment 7 with transverse row of 4 simple spines along anterior margin, the row being divided in two by a median space; also with band of comblike groups of spines, with separation; segment 8 with transverse row of 14 simple spines along anterior margin, the row divided in half by a median space; also with band of comblike groups of spines (2-7 spines per comb) crossing the segment in the same region, with median separation. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 bifid spines in transverse row about three-fourths the distance from the anterior margin, the row being divided by a median space; segments 6 and 7 each with a row of 4 spines, the outermost simple, the inner ones bifid, situated about three-fourths the distance from the anterior margin, the two spines on either side of midline separated more than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 311) of each side arising a little behind the anterior margin of the thorax; composed of 2 main elements which are inflated, and a "tail" extending posteriorly from the point of divergence of the two elements; there is a very massive, hornlike dorsal element, a smaller ventral element, and a short, well-formed, tail-like posterior extension of the dorsal element which is directed mesad; dorsal element with concavity on its upper surface; with superficial annulation, each ring with longitudinal folds. Maximum length (dorsal element), 2.3 mm.; maximum diameter, 0.4 mm.

Cocoon (pl. 39, fig. 351): Length of base, 3.5 mm.; greatest length, 4.2 mm.; greatest width, 1.9 mm.; greatest height, 1.9 mm. Cocoon slipper-shaped, with definite collar; fine parchmentlike texture, threads not visible; rim around anterior aperture somewhat thickened. Cocoon covering abdomen and three-fourths of thorax; attached along posterior half of its base.

Larva (pl. 41, fig. 389, and pl. 43, fig. 426).—(First description of larva.) Total length, 7.0 mm. Width of head capsule equal to its length. Width of thorax 1.6 times that of head. Width of abdominal segments 1-3 somewhat less than width of thorax, all three subequal; segment 4 equal in width to thorax; segments 5-8 expanded, greatest on segments 6 and 7 which are 1.5 times width of segments 1-4; cross section and profile are the same as for *capricornis*. General color gray, with dark irregular patches on ventrolateral regions of segments 7 and 8.

Head: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 389. Each cephalic fan with 39-40 pectinate branches, the hairs on the branches simple, short, close together, interspersed at regular intervals with longer, stouter, bifid hairs. Mandible with 2 teeth on its inner margin, these emerging from a common base, the more distal tooth somewhat larger. Antenna 400 μ long, 5-segmented, light yellow, surpassing the basal stalk of cephalic fan; segment $1>2=3<4$; segment 2 superficially divided in two near its middle, the division being in the middle of a white patch; no other white patches on antenna; segment 1 with longitudinal striations. Submentum with 9 apical teeth, in shape like one-half of a hexagon, the central tooth, and the outermost tooth on either side larger than the others; ventrolateral row composed of approximately 21 hairs arranged irregularly in groups of one, two, or three, all hairs appearing bifid; lateral margin of submentum with 7 toothlike indentations.

Occipital cleft dome-shaped, the apex with short, tubelike extension (pl. 43, fig. 426).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 40-42 rows of hooks at its apex; postclypeal sclerites distinct, but poorly sclerotized, long and broad, almost meeting at the midline. Posterior sucker with 184 rows of spines. Anal gills with 3 principal divisions with a fleshy base; each division with 24-25 slender fingerlike projections, giving a total of usually 74 projections. Anterior and posterior arms of X-shaped sclerite well sclerotized, the anterior arms with winglike expansions that are more extensive on their outer margin; minute spines, or their bases, between the anterior and posterior arm of each side and a group of about 20 short black spines between the anterior arms; 3 rows of simple rectal spines. No ventral papillae or plaques on eighth segment.

Types.—Holotype (♀), on 5 slides, and allotype (♂), mounted on pins, one wing on slide; collected from the Río Samalá, Totonicapán, Department of Totonicapán, Guatemala, on February 24, 1949. Paratypes (8 ♀♀, 4 ♂♂, and 24 pupae). Holotype and one ♂ paratype (pinned) in the collection of the United States National Museum; the allotype and all other paratypes in the collection of Herbert T. Dalmat.

SIMULIUM (HEARLEA) ETHELAE Dalmat

Simulium (*Hearlea*) *ethelae* Dalmat, Ann. Ent. Soc. Amer., vol. 43, No. 1, pp. 143-148, figs. 8-14, 1950(b) (original description, ♂ genitalia and legs, ♀, and pupa).—Dalmat, ibid., vol. 44, No. 1, pp. 52-53, 1951 (male).

Male (pl. 27, figs. 106-108).—4.0 mm. long.

Head: Eyes very dark reddish brown. Antenna 600 μ long, 11-segmented, slender, tapering; segment $3<1+2$, $3>4+5<11$, $3>11$; scape and pedicel brown, the flagellum black. Palpi black. Clypeus dark brown, white-pruinose, irregularly covered with long, strong hairs.

Thorax: Mesonotum velvety black, with band of white pruinosity on its periphery, interrupted only on the anterior margin where the ends of both arms are directed somewhat posteriorly; long, yellow, scalelike hairs completely covering the mesonotum, denser on the anterior third and longer on prescutellar region; scalelike hairs never in packets; few short, black hairs along anterior margin, longer on prescutellar region. Humeral angles brown, with white pruinosity. Scutellum black, with white pruinosity, several yellow scalelike hairs, and with very long black hairs. Postnotum black, white-pruinose, with a group of yellow scalelike hairs forming a compact cluster near midregion. Pleura brown, white-pruinose. Stem of halter light brown, the knob tan. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1.2:1; Sc pilose along its basal sixth; R_1 pilose and spiny along its distal half; R_{2+3} pilose except for a very short basal section; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.3 mm.; coxa and trochanter yellow; clothed with numerous, somewhat appressed, golden-yellow hairs; femur yellow with small apical black ring, clothed with both golden-yellow hairs and long black ones; tibia yellow with a complete black ring around its apical fourth and with most of its inner face black, the outer face silvery-pruinose with short silvery hairs; tarsus completely black. Leg 2, length, 2.9 mm.; coxa black; trochanter yellow with its apex somewhat darker; femur and tibia as on leg 1; tarsus black except for basal half of basitarsus which is yellow. Leg 3, length, 3.7 mm.; coxa black; trochanter yellow; femur as on legs 1 and 2; tibia black except on its basal fourth and along the basal three-fifths of its inner edge where it is yellow; basal third of basitarsus and of second tarsal segment yellow, the remainder of these segments, as well as all of tarsal segments 3-5, black; relation of basitarsus to second segment, 4.2:1; calcipala well developed, not reaching pedisulcus; pedisulcus well developed at middle of second segment.

ABDOMEN: Tergite of segment 1 brown; pleurites black with many long black hairs reaching the fourth segment. Segment 2 with its tergite black, the pleurites dark brown, anterior margin of anterior segment white-pruinose. Other segments black, the pleural regions of segments 5-7 with patch of white pruinosity; extending laterally from each of the pleurites of segments 2-5 is a tuft of black hairs, shorter than those on segment 1; all tergites evenly clothed with very short black hairs. Sternites tan, the midregion brown.

GENITALIA: Sidepiece (pl. 27, fig. 106) irregularly quadrangular in shape, wider than long, with well-developed dome-shaped expansion from outer posterior angle; dorsal opening broadly quadrangular. Clasper (pl. 27, fig. 106) long and narrow, its length about six times the width; apex blunt and somewhat curved, with strong spine arising from longitudinal furrow near distal end. Body of adminiculum (pl. 27, fig. 107) somewhat rectangular in shape, wider than long, with apical concavity and with longitudinal keel-like structure on its ventral surface; concavity and keel-like structure clothed with numerous hairs; entire ventral surface of adminiculum clothed with minute, appressed hairs; basal processes long, almost equaling the body of adminiculum in length, heavily sclerotized, the apices somewhat pointed; at the middle of the outer margin of each basal process is a small, winglike expansion. Adminicular arms (pl. 27, fig. 108) heavily sclerotized, with 2 long teeth near its midregion, and with one short, blunt tooth and one longer one at the apex, giving a dome-shaped effect; lateral plate quadrangular, slightly sclerotized.

Female (pl. 34, figs. 226-228, and pl. 35, fig. 254).—3.1 mm. long.

HEAD: Dichoptic. Eyes black; fronto-ocular triangle with base about equal to height. Antenna 580 μ long, 11-segmented, tapering; segments $1+2=3>4+5$, $3<11$; scape and pedicel brown, the flagellum black. Palpi black. Frons black, white-pruinose, with 4 irregular rows of black hairs along each margin. Clypeus black, white-pruinose, with 2 irregular rows of black hairs and a few tan hairs. Occipital region black, white-pruinose, with many long black hairs. Cornuae of buccopharyngeal apparatus well sclerotized, expanded and curved; median space hyaline, smooth, without central concavity.

THORAX: Mesonotum velvety black; on either side of midline, contiguous with the anterior margin, is a white-pruinose triangle; posterior to each triangle there is a white-pruinose longitudinal band that unites with the white pruinosity of the prescutellar region; lateral margins also white-pruinose; short, narrow, yellow, scalelike hairs densely covering all of mesonotum, denser on anterior half, not in packets; short black hairs over entire mesonotum, longer in prescutellar region. Humeral angles black, evenly white-pruinose. Scutellum black, with numerous yellowish scalelike hairs, longer than on scutum, and several long black hairs. Postnotum velvety black, evenly white-pruinose. Stem of halter brown, the knob yellowish white. Wings, 3.6 mm. long and 1.3 mm. wide; relation of body length to wing, 1 : 1.2; Sc pilose along its basal fifth; R_1 pilose and spiny along the distal half; R_{2+3} pilose along distal four-fifths; Cu_2 arcuate; discal cell absent.

LEGS: Leg 1, length, 3.2 mm.; coxa and trochanter yellow; femur yellow with slight darkening at distal extremity, clothed with short, flat, yellow hairs and stouter, longer, black hairs; tibia light brown on basal three-fourths, apical fourth dark brown; tarsus black. Leg 2, length, 2.8 mm.; coxa dark brown; trochanter yellow; femur yellow with dark apical ring; tibia yellow along its basal three-fourths, black on the apical fourth; tarsus black with the exception of the basal half of the basitarsus which is yellow. Leg 3, length, 3.9 mm.; coxa black; trochanter yellow; femur and tibia yellow with apical black rings; basal half of basitarsus and of second segment yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.7 : 1; calcipala well developed, not reaching the pedisulcus; pedisulcus well developed on basal third;

claw with well-developed basal heel and with small submedian tooth (pl. 35, fig. 254).

ABDOMEN: Velvety black; tergite of segment 1 and tergites and pleurites of segments 2 and 6 gray-pruinose; posterior margin of pleurites of first segment with fringe of long black hairs which reach the third segment; short black hairs sparsely covering all segments. Sternites tan, with gray pruinosity.

GENITALIA: Cercus (pl. 34, fig. 226) quadrangular, higher than long (wide), clothed with long, strong hairs and small spinelike hairs. Anal lobe (pl. 34, fig. 226) irregularly quadrangular, somewhat curved around the cercus, with a fingerlike extension projecting from posterior ventral angle. Genital rod (pl. 34, fig. 228) with well-marked basal dilatation; entire rod well sclerotized; apical expansions of arms of genital fork triangular in shape and very slightly pigmented; apical angle very blunt and broad, the outer basal angle pointed and sclerotized. Ovipositor (pl. 34, fig. 227) subtriangular in shape, its height equal to the base; apex rounded.

Pupa (pl. 38, fig. 312, and pl. 39, fig. 352).—Granulosity on entire thorax; 4 simple, heavy, spinelike trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in a transverse row across middle of segment, the row being separated in two by a median space; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 each with 8 simple spines in a transverse row, situated somewhat before the posterior margin, each row also being divided into two by a median space; segment 7 with band composed of 12 groups of blunt spines crossing somewhat behind the anterior margin, each of the spines with from 1 to 8 denticles on its apex, these being longer than the usual comblike spines; band separated by median space; segment 8 with uninterrupted band along anterior margin composed of 12-14 blunt spines, each with from 1 to 6 denticles at its apex; lateral to each end of the band are 10-12 comblike groups, each with from 1-6 spines; segment 9 with band of comblike groups across its anterior margin, each group composed of 1-2 spines, with median separation. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 simple spines in transverse row before the posterior margin, the row being divided by a median space; segments 6 and 7 with similar rows of simple spines, but with the two spines on either side of midline more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 312) of either side arising somewhat behind the anterior margin of thorax, near the humeral angles; composed of a dorsal element and a lateroventral element, each hornlike and with pseudoarticulations; both elements tapering, rather pointed at the apex; no "tail" present where the two elements diverge; with transverse wrinkles but without granulosity or minute spicules. Maximum length, 2.3 mm. for dorsal element, 1.6 mm. for ventral element; maximum width, 0.4 mm.

Cocoon (pl. 39, fig. 352): Length of base, 2.4 mm.; maximum length, 4.5 mm.; maximum width, 2.1 mm.; maximum height, 2.1 mm. Cocoon slipper-shaped, with distinct collar and fine parchmentlike texture, threads not visible; rim around anterior aperture only slightly thickened. Cocoon covers abdomen and thorax; attached along half its base.

Larva (pl. 41, fig. 390, and pl. 43, fig. 427).—(First description of larva.) Total length, 7.0 mm. Width of head capsule slightly greater than its length. Width of thorax 1.6 times width of head. Abdominal segments 1-3 subequal in width, somewhat narrower than thorax; segment 4 equal to width of thorax; segments 5-8 expanded, the greatest width being at segments 6 and 7 which are 1.3 times width of segments 1-4; cross section and profile as for *capricornis*. General color gray, without dark patches on ventrolateral regions of segments 6 and 7.

Head: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 390. Each cephalic fan with 34-37 pectinate branches (at times, 40 branches), all the hairs on these branches simple, close together, fairly long, none heavier than the others. Mandible with 2 teeth on its inner margin, both appearing to emerge from the same base, the apical one somewhat longer. Antenna 370 μ long, 5-segmented, light brown, the first three segments reaching end of basal stalk of cephalic fan; segment $1>2>3<4>2$; segment 2 superficially divided into two by median white ring; white rings also present at end of segment 2, and at basal and apical ends of segments 3 and 4; segment 1 with longitudinal striations. Submentum with 9 apical teeth, triangular in shape, the central one much larger than the others; ventrolateral row composed of 12-16 hairs, arranged in irregular line, the most distal seven bifid, the others simple; lateral margin of submentum with 5 toothlike indentations. Occipital cleft somewhat rounded, the apex extending anteriorly (pl. 43, fig. 427).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 36-42 rows of hooks at its apex; postclypeal sclerites long, broad, very well sclerotized, close to each other. Posterior sucker with 160-170 rows of hooks. Anal gills with 3 main divisions, broad and fleshy, the two outer divisions each with 12 slender, blunt, fingerlike branches and the median division with 13 branches; all branches seem to emerge at the same level and are about equal in length. Anterior arms of X-shaped sclerite somewhat obscured by dark patches along the posterior margins; posterior arms well sclerotized; 3 to 4 irregular rows of groups of rectal spines, each group composed of 3-4 spines; 30 to 40 spines on each side between the anterior and posterior arms. No ventral papillae or plaques on eighth segment.

Types.—Holotype (♀), pinned, collected from the Río Los Arcos, near Los Encuentros, Department of Sololá, Guatemala, November 4, 1948; allotype (♂, dissected from pupal skin), on 3 slides, collected from same stream as holotype, December 13, 1948; paratypes, 4 ♀♀, 1 ♂, 27 pupae; ideotypes, 2 ♂♂. The holotype and allotype are in the collection of the United States National Museum; the paratypes and ideotypes are in the collection of Herbert T. Dalmat.

SIMULIUM (HEARLEA) LARVISPINOSUM De León

Simulium (*Hearlea*) *larvispinosum* De León, Impreso No. 56, Inst. Invest. Cient., Univ. San Carlos, Guatemala, pp. 5-23, figs. 1-19, 1948 (original description, ♂, ♀, pupa, and larva).

Simulium (*Hearlea*) *carolinae* De León, Vargas and Díaz, Rev. Inst. Salubr. Enferm. Trop., vol. 9, No. 4, p. 337, 1948 (considers *larvispinosum* synonym of *carolinae*).

Male (pl. 27, figs. 109-111).—3.2 mm. long.

Head: Holoptic. Eyes dark reddish brown. Antenna 550 μ long, 11-segmented, tapering; segment $3<1+2$, $3>4+5$, $3>11$; segment 2 widest; segment 3 long and slender; scape and pedicel brown, flagellum black. Palpi black. Clypeus black, white-pruinose, irregularly covered with long black hairs.

Thorax: Mesonotum velvety black, with narrow band of white pruinosity around the periphery, the band interrupted only in the middle of the anterior margin where it is somewhat diffuse; that part of band which is contiguous with the anterior margin is rather narrow; long, narrow, copper-yellow, scalelike hairs in narrow, irregular band around periphery, never in packets; some long black hairs in prescutellar region. Humeral angles black, with white pruinosity. Scutellum shiny black, with several long, yellow, scalelike hairs and with some long black hairs. Postnotum velvety black, white-pruinose, devoid of hairs. Pleura black, with white pruinosity. Stem of halter black, the knob yellow. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1.1; Sc pilose along basal sixth;

R_1 pilose and spiny along distal half; R_{2+3} pilose along distal five-sixths; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.1 mm.; coxa, trochanter, and femur black; tibia black, its posterior edge near the midregion light brown; tarsus black. Leg 2, length, 2.8 mm.; coxa, trochanter, and femur black; tibia black with light-brown basal ring; basal third of basitarsus yellow, its distal two-thirds black; tarsal segments 2-5 black. Leg 3, length, 3.4 mm.; coxa, trochanter, femur, and tibia with same color patterns as on leg 2; basal third of basitarsus and of second segment light brown, their apical two-thirds black; segments 3-5 black; basitarsus extremely wide; relation of basitarsus to second segment, 3.8:1; calcipala well developed, not quite reaching the pedisulcus; pedisulcus well developed on basal third of second segment.

Abdomen: Tergite and pleurites of segment 1 black, the pleurites with long dark hairs which reach segment 5. Segment 2 black, the anterior border of the tergite, and the pleurites white-pruinose. Other segments black, the posterior borders white-pruinose. Sternites black with white pruinosity.

Genitalia: Sidepiece (pl. 27, fig. 109) rectangular, wider than long, outer posterior angle rounded and somewhat prolonged; dorsal opening occupying about half of dorsal surface of sidepiece. Clasper (pl. 27, fig. 109) long and narrow, more than twice as long as sidepiece; swelling on outer dorsal margin, extending from base to almost the middle; apex rounded, somewhat truncate, with a terminal spine that is bifid from the base, blunt. Body of adminiculum (pl. 27, fig. 110) dome-shaped, the apex pointed; length about equal to width; along ventral surface there is a longitudinal keel-like structure, not very high, which is clothed with numerous hairs; middle two-thirds of ventral surface clothed with hairs; basal processes well sclerotized, pointed. Adminicular arms (pl. 27, fig. 111) with several teeth, two long ones near the base, some long and short ones concentrated at the apex, and a few short ones between the apical and basal teeth; lateral plate irregularly rectangular in shape, wrinkled, somewhat sclerotized.

Female (pl. 34, figs. 229-231, and pl. 35, fig. 256).—2.7 mm. long.

Head: Dichoptic. Eyes black; fronto-ocular triangle very small, its base equal to the height. Antenna 540 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3=4+5$, $3>11$; scape and pedicel brown, flagellum black. Frons, clypeus, and occipital region black, white-pruinose, irregularly covered with long black hairs. Cornuae of buccopharyngeal apparatus short, sclerotized, the apices expanded; median space hyaline, without teeth.

Thorax: Mesonotum velvety black; a triangle of white pruinosity on anterior margin lateral to midline from which arises a longitudinal stripe of white pruinosity that joins posteriorly with the white pruinosity of the prescutellar region; lateral margins also white-pruinose; short, narrow, yellow, scalelike hairs sparsely distributed over entire mesonotum; many long black hairs in prescutellar region. Humeral angles black, with white pruinosity. Scutellum dark brown, shiny, with short, yellow, scalelike hairs and long black ones. Postnotum velvety black, white-pruinose, devoid of hairs. Pleura black with white pruinosity. Stem of halter dark brown at the base, tan toward the apex, the knob yellow. Wings, 3.4 mm. long and 1.4 mm. wide; relation of length of body to wing, 1 : 1.3; Sc pilose except for very small apical region; R_1 pilose and spiny along distal three-fifths; R_{2+3} pilose except for very short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.1 mm.; coxa black; trochanter and femur dark brown; tibia yellow on basal three-fourths, black on apical fourth; tarsus black. Leg 2, length, 2.8 mm.; coxa and trochanter black; femur black with small basal brown area; tibia and basitarsus yellow on basal half, black on apical half; tarsal segments 2-5 black. Leg 3, length, 3.6 mm.; coxa black; trochanter brown; femur black; tibia brown on basal third, black on apical two-thirds; basal half of basitarsus and of second segment yellow, the remainder of these segments, as well as all of segments 3-5, black; relation of basitarsus to second segment, 4.4 : 1; calcipala very well developed, passing the pedisulcus; pedisulcus very well developed on basal fourth of second segment; claw with well-defined heel and with secondary submedian tooth (pl. 35, fig. 256).

Abdomen: Tergite and pleurites of segment 1 black, with white pruinosity, the pleurites with long dark hairs that reach the third segment. Segment 2 black with white pruinosity. Other segments bluish black, shiny, the pleura with brown hairs; last two segments with long black hairs. Sternites tan.

Genitalia: Cercus (pl. 34, fig. 229) almost rectangular in shape, its height twice the length (width), clothed with some long, strong hairs and with numerous minute spinelike hairs. Anal lobe (pl. 34, fig. 229) large, very high, curving somewhat around the cercus, especially at the ventral margin; posterior ventral angle of anal lobe pointed. Genital rod (pl. 34, fig. 231) with triangular-shaped basal dilatation; apical expansions of genital fork triangular in shape, all the angles blunt; only outer basal angle pigmented. Ovipositor (pl. 34, fig. 230) triangular in shape, its height about equal to the base.

Pupa (pl. 38, fig. 313, and pl. 39, fig. 353).—Granulosity on entire thorax, not very pronounced; 5 stout, simple, spinelike trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 5-9 are posteriorly directed; segment 2 with 8 simple spines in a transverse row crossing the segment three-fourths the distance from the anterior margin, the row being divided into two by a median space; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 with 8 simple spines in a transverse row somewhat before the posterior margin, the row being divided into two by a median space; anterior margins of segments 5-9 each with uninterrupted band composed of groups of comblike spines, each group with from 2 to 7 spines. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 simple spines in transverse row about three-fourths the distance from the anterior margin, the row being divided by a median space; segments 6 and 7 with similar rows of spines, but with the two spines on either side of midline more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 313) of either side arising somewhat behind the anterior margin of the thorax, near the humeral angles; antlerlike structure similar to that of *carolinae* but with elements of greater diameter; smaller elements usually divided into 2 or 3 branches near the apex, each with a minute spine at tip; with longitudinal and transverse wrinkles over entire surface, as well as with microscopic spicules. Maximum length (dorsal elements), 1.9 mm.; maximum diameter, 0.3 mm.

Cocoon (pl. 39, fig. 353): Length of base, 3.4 mm.; greatest width, 1.9 mm.; greatest height, 1.4 mm. Cocoon of wall-pocket type, without collar; parchmentlike texture, threads not visible; rim around anterior aperture not thickened. Cocoon covering abdomen and half of thorax; attached along posterior half.

Larva (pl. 41, fig. 391, and pl. 43, fig. 428).—Total length, 8.5 mm. Width of head 1.1 times the length. Width of thorax 1.4 times that of head. Average width of abdominal segments 1-4 equals 1.5 times width of head; segments 5-7 expanded, segment 6 the widest, 1.3 times average of segments 1-4; cross section and profile as for *capricornis*. General color gray, no dark patches on ventrolateral regions of segments 6 and 7.

HEAD: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 391. Each cephalic fan with 57-58 pectinate branches, the hairs on these branches short, close together, interspersed at regular intervals with longer, stouter, bifid hairs. Mandible normal in dimensions (not short and broad as in *carolinae*), with 2 teeth (or 1 bifid tooth) on its inner margin, these apparently emerging from the same base, the more-distal one somewhat broader. Antenna 390 μ long, 5-segmented, yellow, segments 1-3 alone reaching the end of the basal stalk of cephalic fan; segment $1>2>3<4=2$; segment 2 superficially divided into two segments not far from its base, with white patch at the division; segment 1 with white patch near its base and with longitudinal striations; white patch at union of segments 2 and 3. Submentum with 9 apical teeth, triangular in shape, the central tooth and the outermost on either side larger than the others; ventrolateral row composed of 13 hairs plus a small one near the base of submentum; hairs arranged in irregular line, the basal six hairs appear simple, the next four to five hairs trifid, and the apical two bifid; lateral margin of submentum with 3 toothlike indentations. Occipital cleft with its sides almost parallel, the apex strongly concave (pl. 43, fig. 428).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 72-74 rows of hooks at its apex; postclypeal sclerites long, narrow, poorly sclerotized, appearing to be extensions from the posterior junction of the frons-clypeus and epicranial plates. Posterior sucker with 191-195 rows of hooks. Anal gills with 3 main divisions that are short and fleshy, each with from 8 to 10 fingerlike projections that are of different length but more or less of the same diameter, giving a total of 25-28 branches. Anterior arms of X-shaped sclerite well sclerotized, rather short and broad; posterior arms completely encircling the posterior sucker, well sclerotized, slender; lateral to the union with the anterior arms, the posterior arm of each side bears 2 heavily sclerotized and pigmented triangular plates that are erect, with the apex pointing dorsally; also arising lateral to the dorsal ones there is a ventrally directed plate which is strongly serrated as though to form a comb of broad, heavy teeth; simple, minute scales between anterior and posterior arms of either side; rectal scales absent; 2 very broad dark-brown bands, one on either side of the midline, transversely crossing the larva just in front of the anal gills; these extend from near the midline to the base of the ventrally directed plate and can be used to distinguish this species from *carolinae* and from all other Guatemalan species. No ventral papillae or plaques on eighth segment.

Types.—Larva, pupa, ♀, and ♂, the ♀ and ♂ apparently dissected from pupal skins; in collection of J. Romeo de León; collected in a small waterfall on the Finca Olas de Mocá, Chicacao, Department of Suchitepéquez, Guatemala.

Although Vargas and Díaz (1948) synonymized this species with *carolinae*, there seems to be little doubt that the two species are distinct. They can be separated easily in the larval and pupal stages and by the male and female genitalia. The differences have, in part, been brought out in the keys.

SIMULIUM (HEARLEA) MICROBRANCHIUM Dalmat

Simulium (*Simulium*) *microbranchium* Dalmat, Ann. Ent. Soc. Amer., vol. 42, No. 4, pp. 538-544, figs. 1-9, 1949 (original description, ♀, ♂ genitalia, and pupa).

Simulium (*Hearlea*) *microbranchium* Dalmat, Ann. Ent. Soc. Amer., vol. 44, No. 1, pp. 50-52, 1951 (male).

Male (pl. 27, figs. 112-114).—3.0 mm. long.

Head: Holoptic. Eyes reddish brown. Antenna 680 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3>4+5$, $3>11$; black. Palpi black. Clypeus black, white-pruinose, irregularly covered with long black hairs.

Thorax: Mesonotum velvety black, with band of white pruinosity around entire periphery, usually interrupted at middle of anterior margin; at times the lateral arms are so broad that all but the center of the scutum is covered; long, narrow, yellow scalelike hairs in wide band around periphery of mesonotum, the band widest on anterior and posterior margins; these hairs are longer in prescutellar region; long black hairs on prescutellar region; pre-alar group composed of a cluster of long yellow hairs. Humeral angles black, with white pruinosity. Scutellum black, with numerous short, yellow, scalelike hairs and with few long black hairs. Postnotum dark velvety brown, with white pruinosity, devoid of hairs. Pleura dark brown, white-pruinose. Stem of halter dark brown to black, the knob yellow. Wings, 3.4 mm. long and 1.5 mm. wide; relation of length of body to wing, 1 : 1.1; Sc pilose along basal sixth; R_1 pilose and spiny along distal half; R_{2+3} pilose except for very short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.1 mm.; coxa and trochanter light brown; femur light brown with very small black apical ring; outer surface and anterior edge of tibia tan, the inner surface and posterior margin black. Leg 2, length, 2.7 mm.; coxa black; trochanter dark brown, its central region black; femur brown, with very small apical black ring; basal half of tibia and of basitarsus light brown, their apical halves black; tarsal segments 2-5 black. Leg 3, length, 3.5 mm.; coxa black; trochanter brown; femur with basal half to three-fourths brown, the apical portion black; tibia tan on basal third to half, the apical part black; basal half of basitarsus tan, apical half black; tarsal segments 2-5 black; relation of basitarsus to second tarsal segment, 4.3 : 1; calcipala well developed but not reaching pedisulcus; pedisulcus well developed on basal third of second segment.

ABDOMEN: Tergite of segment 1 black, with short black hairs; pleurites black, with long dark hairs reaching segment 5. Tergite of segment 2 black, white-pruinose along anterior margin, with short black hairs; pleurites white-pruinose. Other segments black; pleurites of segments 2-4 with long brown hairs. Sternites tan, the midline black.

GENITALIA: Sidepiece (pl. 27, fig. 112) roughly rectangular in shape, wider than long; dorsal surface with depression near the posterior margin near the articulation with the clasper; outer posterior angle protruding noticeably; dorsal opening occupying less than half of surface of sidepiece. Clasper (pl. 27, fig. 112) long and slender, about one and one-half times the length of sidepiece; apex rounded with a single strong apical spine. Body of adminiculum (pl. 27, fig. 113) quadrangular in shape, wider than long, with apical concavity from which emerge numerous long hairs; on its ventral surface there is a longitudinal keel-like structure, much wider than in other species, clothed with numerous hairs; ventral surface of adminiculum with numerous short, stout spines. Adminicular arms (pl. 27, fig. 114) with many teeth, there being about three large conical ones near the base, apical to which there is a mixture of small and large teeth; lateral plates somewhat oval in shape, wrinkled, partially sclerotized.

Female (pl. 34, figs. 232-234, and pl. 35, fig. 257).—3.2 mm. long.

HEAD: Dichoptic. Eyes black; fronto-ocular triangle very small, relation of base to height, 1.5:1. Antenna 580 μ long, 11-segmented, slightly tapering; segment $3<1+2$, $3<4+5$, $3<11$; scape and pedicel brown, flagellum black. Frons, clypeus, and occipital region black, white-pruinose, clothed with black hairs. Cornuae of buccopharyngeal apparatus only slightly sclerotized, expanded at apices; median space semicircular, without median concavity, hyaline, and with serrated edge.

THORAX: Mesonotum velvety black; white-pruinose patch on either side of midline, contiguous to the anterior margin; behind each patch there extends posteriorly a longitudinal stripe of white pruinosity which joins with the white pruinosity of the prescutellar region; very narrow line of white pruinosity along the midline as well; wide band of white pruinosity along the lateral margins; numerous long, narrow, bronze-colored, scalelike hairs on mesonotum, especially around the periphery, most concentrated on anterior fourth of scutum; several long black hairs on prescutellar region. Humeral angles brown, with white pruinosity. Scutellum shiny black, with some bronze-colored scalelike hairs and a few long black hairs. Postnotum velvety black, completely white-pruinose, devoid of hairs. Pleura black, white-pruinose. Stem of halter dark brown, the knob tan. Wings, 3.4 mm. long and 1.5 mm. wide; relation of body length to wing, 1 : 1.1; Sc pilose along basal two-thirds; R_1 pilose and spiny along distal two-thirds; R_{2+3} pilose except for very small basal region; Cu_2 arcuate; discal cell absent.

Legs: Leg 1, length, 3.1 mm.; coxa, trochanter, and femur light brown; tibia light brown on basal three-fourths, black on apical fourth; tarsus black. Leg 2, length, 2.8 mm.; coxa black; trochanter light brown; femur light brown with very small apical black ring; tibia as on leg 1; basal half of basitarsus and of second segment light brown, their apical halves, as well as all of tarsal segments 3-5, black. Leg 4, length, 3.5 mm.; coxa dark brown; trochanter light brown; femur and tibia light brown on their basal three-fourths, black apically; basitarsus and second segment light brown on basal two-thirds, black apically; tarsal segments 3-5 black; relation of basitarsus to second segment, 5.4 : 1; calcipala well developed, almost reaching pedisulcus; pedisulcus well developed on basal third of second segment; claw with subbasal tooth (pl. 35, fig. 257).

Abdomen: Tergum of segment 1 black, with short black hairs; pleurites black with long black hairs that reach segment 3. Segment 2 black, the anterior half white-pruinose, with short black hairs. Other segments black, the anterior half of pleura on segments 7 and 8 brown; pleura with dark hairs, longest on last segment. Sternites tan.

Genitalia: Cercus (pl. 34, fig. 232) irregularly quadrangular, its height twice the length (width). Anal lobe (pl. 34, fig. 232) much higher than long (wide), ventral extremity narrowed, extending somewhat around the cercus. Genital rod (pl. 34, fig. 234) with well-expanded basal dilatation, somewhat triangular in shape; arms of genital fork branching rather sharply, their apical expansions triangular in shape, all angles blunt, only the inner margin somewhat sclerotized, the rest hyaline. Ovipositor (pl. 34, fig. 233) roughly triangular in shape, the apex well rounded, length somewhat greater than the base, with numerous minute spicules.

Pupa (pl. 38, fig. 314, and pl. 39, fig. 354).—Granulosity on entire thorax; 4 simple trichomes on either side of midline. Dorsal surface of abdominal segments: No granulosity; spines on segments 2-4 are anteriorly directed, those on segments 6-9 are posteriorly directed; segment 2 with 8 simple spines in a transverse row across the middle of the segment, the row divided into two by a median space; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 with 8 simple spines in a transverse row across the segment, three-fourths the distance from the anterior margin, the row being divided into two by a median space; segment 6 with band composed of comblike groups of spines (3-5 spines per comb) along the anterior margin, with median separation; segment 7 with transverse row of 22-24 simple spines across the anterior margin, divided by median space, and with combs (2-8 spines per comb) lateral to the row of spines and intermixed with them; segment 8 with transverse row of 24 simple spines along the anterior margin, divided by median space, and with combs (2-4 spines per comb) lateral to the row of spines and intermixed with them. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 simple spines in transverse row about three-fourths the distance from the anterior margin, the row divided by median space; segments 6 and 7 each with a similar row of spines, the two spines on either side of midline separated more than on segment 5, the distance between them approximately equal to that of the median space; rarely, the two inner spines on segments 5 and 6 are bifid. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 314) of each side arising a little behind the anterior margin of thorax; composed of 2 main elements, the dorsal and ventrolateral, which appear hornlike when viewed from above; the elements of each side form a broad V, the two arms so curved that the broad surfaces are at an angle of 90 degrees to one another; the elements are so thin that unless they are carefully dissected from the cocoon the ventral element may go unnoticed. The dorsal element extends anteriorly from the cocoon for only a short distance; when viewed from above with the aid of only a hand lens, this element is also hardly visible; the ventrolateral curves around the collar of the cocoon near the anterior aperture and remains contiguous with it along its entire extent, except at its distal extremity where it overlaps with the corresponding arm of the opposite side; along its inner ventral surface there is a deep groove; no "tail" extending posteriorly from point of divergence of both elements; with superficial annulation and with microscopic spicules. Length of dorsal element, 0.9 mm.; length of ventral element, 1.6 mm.; maximum width, 0.4 mm.; strongly compressed dorsoventrally.

Cocoon (pl. 39, fig. 354): Length of base, 3.5 mm.; maximum length, 4.7 mm.; maximum width, 2.0 mm.; maximum height, 1.7 mm. Cocoon slipper-shaped, with definite collar; fine parchmentlike texture, threads not visible; rim around anterior aperture thickened. Cocoon covering abdomen and thorax; attached along posterior half of its base.

Larva (pl. 41, fig. 392, and pl. 43, fig. 429).—(First description of larva.) Total length, 7.7 mm. Length of head capsule 1.1 times its width. Width of thorax 1.4 times that of head. Abdominal segments 1-3 slightly narrower than thorax but all these three segments subequal; segments 4 and 5 about 1.1 times width of segments 1-3, and segments 6-8 equal to 1.3 times width of segments 1-3, cross section and profile are the same as for *capricornis*. General color gray, with series of 3 dark lines and 2 dark points on either side of midline in ventrolateral regions of segments 6-8.

Head: Designs on frons-clypeus and epicranial plates shown on plate 41, figure 392. Each cephalic fan with 56-57 pectinate branches, the hairs on these branches short, simple, close together, interspersed at regular intervals with longer, stouter, bifid hairs. Mandible with 2 teeth on its inner margin, the teeth well separated from each other, sharply pointed, the apical one somewhat longer. Antenna 440 μ long, 5-segmented, light yellow, the first three segments reaching the end of the basal stalk of the cephalic fan; segment $1>2>3<4>2$; segment 2 superficially divided not far from its base at which area there is a white patch; white patches also present at apex of segment 3 and base of segment 4; segment 1 with longitudinal striations. Submentum with 9 apical teeth, in shape like one-half of a hexagon, the central tooth and the outermost tooth on either side larger than the others; ventrolateral row composed of 19 hairs in an irregular grouping, the most distal 11 bifid near apex, the others simple. Occipital cleft broadly dome-shaped, the apex with short tubelike extension (pl. 43, fig. 429).

Thorax and Abdomen: Pseudopod (thoracic proleg) with 37-39 rows of hooks at its apex; postclypeal sclerites long, distinct, but poorly sclerotized, formed behind the extremities of the frons-clypeus, well separated from each other. Posterior sucker with 194-206 rows of hooks. Anal gills with 3 principal divisions, each with a fleshy base; each division with 25 fingerlike processes which are slender and rounded at the apices. Anterior and posterior arms of X-shaped sclerite well sclerotized, the anterior arms with somewhat membranous expansions along their outer margin and also between the two arms; 4 simple, minute spines in transverse row just behind each of the posterior arms; rectal scales absent.

Types.—Holotype (♀), on 5 slides, collected from Río Los Arcos near Los Encuentros, Department of Sololá, Guatemala, November 4, 1948; allotype (♂ dissected from pupal skin), on 3 slides, collected from Río Samalá, just beyond Totonicapán, Department of Totonicapán, Guatemala; paratypes, 1 ♀ and 13 pupae; ideotypes, 2 ♂♂. The holotype and allotype are in the collection of the United States National Museum; the paratypes and ideotypes are in the collection of Herbert T. Dalmat.

SIMULIUM (HEARLEA) NIGRICORNIS Dalmat

Simulium (*Hearlea*) *nigricornis* Dalmat, Ann. Ent. Soc. Amer., vol. 43, No. 1, pp. 148-151, figs. 15-20, 1950(b) (original description, ♂ genitalia, ♀ head and genitalia, and pupa).

Male (pl. 27, figs. 115-117).—Only genitalia available.

Genitalia: Sidepiece (pl. 27, fig. 115) broader than long with extremely prominent dome-shaped extension from the inner, posterior corner of the dorsal surface; extension so pronounced that it gives the sidepiece an appearance of being pentagonal. Clasper (pl. 27, fig. 115) long and narrow, with well-developed apical spine arising from short longitudinal furrow near its apex. Adminiculum (pl. 27, fig. 116) with main body broader than long; general shape quadrangular with all margins rounded; basal processes broad, pointed at apex, heavily sclerotized throughout, equal in length to the body of the adminiculum; apical margin of adminiculum in the form of two rounded, lateral expansions, between which projects a median, fingerlike extension clothed with curled hairs; on the ventral surface of the adminiculum, extending anteriorly from the median prolongation, there is a moderately pronounced keel which reaches the anterior margin; keel with row of hairs on both edges; strong, stout spine present on each side of ventral surface. Adminicular arm (pl. 27, fig. 117) heavily sclerotized, with 2 semicircular, hyaline, chitinized processes near its attachment to the lateral plate and 3 rather blunt teeth at its distal end; lateral plate hyaline, without wrinkles, triangular in shape.

Female (pl. 34, figs. 235 and 236).—Only head and genitalia available.

Head: Dichoptic. Antenna 11-segmented, not strongly tapered, the third segment equal in length to the fourth and fifth measured together. Buccopharyngeal apparatus simple, the lateral processes well sclerotized, and with a definite indentation in the margin of the inner space. Base of fronto-ocular triangle 1.5 times its height.

Genitalia: Cercus (pl. 34, fig. 235) quadrangular, higher than long (broad), clothed with numerous spines and with minute, appressed hairs. Anal lobe (pl. 34, fig. 235) elongate, extending ventrad beyond the ventral border of the cercus; with minute, appressed hairs over entire surface and stout spines distributed sparsely only on ventral half; anterior ventral angle clothed with numerous fine hairs. Genital rod (pl. 34, fig. 236) with apical expansions triangular, only the external basal angle rather heavily sclerotized and pointed.

Pupa (pl. 38, fig. 315, and pl. 39, fig. 355).—Granulosity on entire thorax; 2 very thin, simple trichomes on either side of midline of thorax. Dorsal surface of abdominal segments: No granulosity;

spines on segments 2-4 anteriorly directed, those on segments 6-8 posteriorly directed; segment 2 with 8 simple spines in a transverse row across middle of segment, the row being divided in two by a median space; anterior to the outermost spine on either end of the row are 2 hairs; segments 3 and 4 with 8 simple spines in transverse row, situated somewhat before the posterior margin, each row also being separated into two by a median space; segment 6 with a band across the anterior margin that is composed of comblike groups, each with 3-7 spines, the band divided by a median space; segment 7 with 12 spines in transverse row at anterior margin, the row being interrupted by a median space; spines truncate, simple, or with from 2-6 teeth at apex; also with 8-12 combs (2-6 spines each) lateral to the row of spines; segment 8 with 22 simple or bifid spines in transverse row along anterior margin, the row divided in two by a median space; with truncate combs (2-6 spines each) that are either simple or bifid lateral to the row of spines and intermixed with it. Ventral surface of abdominal segments: No granulosity; all spines are anteriorly directed; segment 5 with 4 simple spines in transverse row three-fourths the distance from anterior margin, the row being divided by a median space; segments 6 and 7 with similar rows of simple spines, but with the two spines on either side of midline more separated than on segment 5, the distance between them being approximately equal to that of the median space. Terminal spines absent.

Respiratory apparatus (pl. 38, fig. 315) of each side arising a little behind the anterior margin of thorax; composed of a dorsal element and lateroventral element, both appearing hornlike; dorsal element very broad, compressed dorsoventrally, and black along the distal three-fourths of its length; pseudoarticulations simple on lateroventral element, those on dorsal element appearing to radiate from the midline toward the lateral and anterior margins; both elements with microscopic spicules. Length of dorsal element, 0.9 mm.; length of ventral element, 1.5 mm.; width of dorsal element, 0.2 mm.

Cocoon (pl. 39, fig. 355): Length of base, 2.9 mm.; maximum length, 3.6 mm.; maximum width, 1.4 mm.; maximum height, 1.6 mm. Cocoon slipper-shaped, parchmentlike texture, threads not visible; rim of anterior aperture somewhat thickened; no festoons or prolongations. Cocoon covers abdomen and half of thorax, attached along 0.5 of its base.

Larva.—None available.

Types.—Holotype (♂ dissected from pupal skin), genitalia mounted on slide; allotype (♀ dissected from pupal skin), mounted on 5 slides; paratypes (3 pupae). One paratype in the collection of the United

States National Museum, the holotype, allotype, and other paratypes in the collection of Herbert T. Dalmat.

OTHER *SIMULIUM* SPECIES COMMONLY REFERRED TO IN THE LITERATURE AS BEING PRESENT IN GUATEMALA

Each of the species listed below has been referred to in the literature as existing in Guatemala. *Simulium* (*Hearlea*) *deleoni* Vargas and *Simulium virgatum* Coquillett have been considered by some to be the correct names for synonymous species described from Guatemala. In each case, the valid name for the species is given after the equality sign or in the explanation following the listing of the particular species.

Simulium avidum Hoffmann, 1930(f) = *Simulium* (*S.*) *metallicum* Bellardi, 1859.

Simulium boydi De León, 1944 = *Simulium* (*L.*) *haematopotum* Malloch, 1914.

Simulium (*Hearlea*) *deleoni* Vargas, 1945(b).

Vargas, Martínez, and Díaz (1946) believed *Simulium capricornis* De León, 1944 to be a synonym. However, they later considered the two species to be distinct. *S. deleoni* has not been found in Guatemala to date.

Simulium diazi De León, 1944 = *Simulium* (*Eusimulium*) *aureum* (Fries), 1824.

Simulium guatemalensis De León, 1944 = *Simulium* (*S.*) *jacumbae* Dyar and Shannon, 1927.

Simulium mooseri Dampf, 1927 = *Simulium* (*L.*) *callidum* Dyar and Shannon, 1927.

Simulium pseudohaematopotum Hoffmann, 1930(g) = *Simulium* (*L.*) *haematopotum* Malloch, 1914.

Eusimulium turgidum Hoffmann, 1930(g) = *Simulium* (*D.*) *mexicanum* Bellardi, 1862.

Simulium (*Gigantodax*) *vargasi* De León, 1944 = *Gigantodax wrighti* Vargas, Martínez, and Díaz, 1944.

Simulium virgatum Coquillett, 1902.

Listed as present in Guatemala by various authors. In 1945(a), Vargas listed *Simulium* (*Dyarella*) *rubicundulum* Knab as a synonym of this species and Stone (1948) also considered it as such. In 1946, and to the present, Vargas, Martínez, and Díaz consider *rubicundulum* to be a distinct species, as does the present author. It is this species, and not *virgatum*, that is present in Guatemala. Stone (1948) also considered *Simulium* (*D.*) *acatenangoensis* Dalmat and *Simulium* (*D.*) *mathesoni* Vargas as synonyms of *virgatum* Coq., but the present author considers the three species to be distinct.

DISTRIBUTION OF THE GUATEMALAN SIMULIIDAE

Since the publication of complete distribution records for all Guatemalan species of black flies would require a prohibitive amount of space, records have been shortened, omitting references to the dates on which collections were made as well as the names of the collectors. When the particular species was collected in more than 25 streams in a single region, a statement has been made to show its widespread presence in the Municipality, but mention of specific streams has been eliminated. The data have been presented in two lists. The first includes for each species the names of streams, Municipalities, and Departments [11] in which it was collected; before recording this information, there is given the number (the nearest round number) of specimens that has been collected of the particular species; larvae, and adults caught while biting, are not included in the total. The second list presents for each Department the species found therein. All distribution data recorded below have been derived from the author's personal collections unless otherwise credited. The distribution of the species in relation to the endemic zones of onchocerciasis in Guatemala has been shown graphically on maps 3 through 14.

DEPARTMENTAL DISTRIBUTION ACCORDING TO SPECIES

Cnephia aguirrei Dalmat, 1949—800 specimens
- Department of Chimaltenango
  - Río Panacal, Finca Panacal, Acatenango
  - Río San Vicente Pacúm, Finca San Vicente P., Acatenango
  - Río San Diego, Finca San Diego, Acatenango
  - Río Seco, Finca Socorro, Acatenango
  - Río Segunda Catarata, Finca Santa Emilia, Yepocapa
- Department of El Quiché
  - Stream between the town of San Miguel Uspantán and Río Yesal, between kilometers 257 and 276 on National Route No. 7-W

Cnephia pacheco-lunai (De León), 1944—80 specimens
- Department of Chimaltenango
  - Río Ciprés, Aldea Los Pajales, Acatenango
- Department of Sololá
  - Very small stream between Los Encuentros and Totonicapán on National Route No. 1, about 4 miles from Los Encuentros
  - Another small stream along the same route, about 3 miles from Los Encuentros
- Department of El Quiché
  - Stream between the town of San Miguel Uspantán and Río Yesal (kilometer 276), Route 7-W, Cunén

Cnephia roblesi (De León), 1943—150 specimens
- Department of Sololá
  - Very small stream between Los Encuentros and Totonicapán on National Route No. 1, about 4 miles from Los Encuentros
  - Another small stream along the same route, about 3 miles from Los Encuentros

Gigantodax aquamarensis (De León), 1944—750 specimens
- Department of Quezaltenango
  - Río Aguas Amargas, Zunil

[11] A large political unit in Guatemala.

Gigantodax wrighti Vargas, Martínez, and Díaz, 1946—1,400 specimens
- Department of Chimaltenango
  - Río Laguneta, Finca Tehuyá, Acatenango
  - Río Ciprés, Aldea Los Pajales, Acatenango
  - Río Cocoyá, Finca El Carmen, Acatenango
  - Río Aserradero Santa Elena, Tecpán
- Department of El Quiché
  - Río and Aldea San José Changual, El Quiché
- Department of San Marcos
  - Río La Ciénaga, kilometer 232, National Route No. 1, between Aldea Sta. Irene and San Antonio Sacatepéquez
- Department of Sololá
  - Small stream between Los Encuentros and Totonicapán, National Route No. 1, about 4 miles from Los Encuentros
- Department of Totonicapán
  - Río Zapato de la Señora, between Los Encuentros and Totonicapán
  - Río Chumuluchic, Cumbre María Tecún
  - Río Ladrillera, above Totonicapán
- Department of Huehuetenango
  - Río and Finca Chancol, Chiantla
  - Sierra Cuchumatanes, between Chiantla and Barillas

Simulium (*Notolepria*) *exiguum* Roubaud, 1906—1,300 specimens
- Department of Chimaltenango
  - Numerous streams in the lower region of the Municipality of Yepocapa
  - Río Sacatiya, Finca San Jorge, Pochuta
  - Río Encuentros, Finca La Torre, Pochuta
  - Río Costa Rica, Finca Costa Rica, Pochuta
  - Río and Finca Venecia, Pochuta
  - Río and Finca Mirandilla, Pochuta
  - Río Tujuluté, Finca Recuerdo, Pochuta
  - Río Chorrera, Finca La Torre, Pochuta
  - Río Comalapa, Comalapa
- Department of Guatemala
  - Río Rincón, Finca Rincón, Villa Canales
  - Río Puente Incapié #1155, Route No. 1, Morán
- Department of Sacatepéquez
  - Río Nahualate, Finca Pastores, Antigua
  - Río Nahualate, Road to El Cubo, Antigua
- Department of Escuintla
  - Río Posa del Padre, Finca Las Ilusiones, Santa Lucía Cotz.
  - Río Cuesta de las Cañas, Finca El Zapote
- Department of Santa Rosa
  - Río Progreso, Finca El Progreso, Taxisco
  - Río El Jobo #2, Taxisco
  - Río Chiquimulilla, Municipio Chiquimulilla
- Department of Alta Verapaz
  - Río 30 de Junio, kilometer 180-24, Route No. 5, Tactic
  - Río Cobán, Cobán
- Department of Izabal
  - Río Chinamitas, Bobos, Morales

Department of El Petén
- Río Lacandón, Lacandón
- Buenos Aires, San Francisco
- La Libertad, Petén

Department of Huehuetenango
- Río Michicoy, San Pedro Necta
- Río La Providencia #1, San Pedro Necta
- Río Cayagual, Aldea Cayagual, La Democracia
- Río San Antonio Huista, Municipio San Antonio Huista
- Río La Democracia, Municipio La Democracia
- Río Arroyo, Hacienda Miramar, Nenton

Department of El Quiché
- Río Zarco, Nebáj
- Río Negro, Zacapulas
- Stream between Joyabáj and Zacualpa, Zacualpa

Department of Chiquimula
- Río Puente Esquipulas, Esquipulas

Department of Jutiapa
- Río Las Lajas, Finca Las Lajas
- Río Paz, kilometer 105, Route No. 2, Jutiapa
- Río Los Esclavos, Cuilapa

Department of Zacapa
- Río Teculután, Municipio Teculután
- Río Gualán, Municipio Gualán

Department of San Marcos
- Stream between Malacatán and Ayutla, Ayutla

Department of Suchitepéquez
- Río and Finca Socorro, Chicacao
- Río Mixpiá, Finca San José La Sierra, Chicacao
- Río Presa, Finca San Agustín, Patulul
- Río Castaño, Finca Castaño, Chicacao
- Río El Chorro, Finca Naranjo, Chicacao
- Río and Finca Nahualate, Chicacao
- Río Usú, Finca Veracruz, Patulul
- Río and Finca Medellín, Chicacao
- Río Nahualate, Finca Monte Santo, Chicacao
- Río and Finca Manantial, Chicacao
- Río Cocoyá, Finca Los Tarrales, Patulul
- Río Nicá, Finca La Esperanza, Chicacao
- Río and Finca Trebol, Chicacao
- Río Cutzán, Finca El Jardín, Chicacao
- Río Conchita, Finca Conchita, Chicacao
- Río Cutzán, Finca Monte Santo, Chicacao

Simulium (*Eusimulium*) *aureum* (Fries), 1824—900 specimens

Department of Chimaltenango
- Río Sabalopop, Patzún
- Stream on road between Patzún and Patzicía
- Río Xayá, Finca El Molino, Tecpán
- Río Metabal Cuesta Baja, Zaragoza
- Río Pachoj, Zaragoza

Río Laguneta, Finca Tehuyá, Acatenango
Río La Torre, Finca La Torre, Acatenango
Department of Huehuetenango
Río Chancol, Finca Chancol, Chiantla
Río Coyotes, Chiantla
Paraje Chemal, between Chiantla and Barillas
Department of El Quiché
Río Estansuela, Route No. 15, between Quiché and San Pedro Jocopilas
Stream on Route No. 3, kilometer 8, between Nebáj and Zacapulas
Río El Molino, Finca El Tesoro, Chichicastenango
Río San José Chagual, Aldea San José Chagual, Quiché
Department of Quezaltenango
Río Caquixá, San Carlos Sija
Río Cuesta, kilometer 228, between San Carlos Sija and Chequijel
Department of San Marcos
Río La Ciénega, between Quezaltenango and San Marcos
Department of Sololá
Small stream on National Route No. 1, about 3 miles from Los Encuentros on road to Totonicapán
Río Los Arcos, Los Encuentros, Sololá
Department of Totonicapán
Río Zapato de la Señora on National Route No. 1, between Chumuluchic and Totonicapán (nearer Totonicapán)
Río Samalá, Totonicapán
Río Puente, Totonicapán
Río Desconsuelo, Totonicapán

Simulium (*Byssodon*) *benjamini* Dalmat, 1952—10 specimens
Río Cobán, Cobán

Simulium (*Lanea*) *callidum* (Dyar and Shannon), 1927—9,500 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Yepocapa
Numerous streams in the Municipality of Acatenango
Department of Suchitepéquez
Río Agua de Presa, Finca San Agustín, Patulul
Río Siguacán, Finca Santa Adelaida, Patulul
Río Coyoles, Finca Trinidad, Patulul
Río Callejón, Finca Santa Adelaida, Patulul
Río Beneficio, Finca Trinidad, Patulul
Río Carlota, Finca Esterlina, Patulul
Río Mixpiá, San José La Sierra, Chicacao
Río El Mono, Finca Naranjo, Chicacao
Río Socorro, Finca Socorro, Chicacao
Río Veracruz, Finca Veracruz, Patulul
Río Agua Caliente, Finca Veracruz, Patulul
Río Usú, Finca Hermita, Patulul
Río Los Muertos, Finca Hermita, Patulul
Río Perla, Finca Concepción, Chicacao
Río Carmelo, Finca Camelias, Chicacao
Río Toma, Finca Los Angeles, Chicacao
Río Medellín, Finca Medellín, Chicacao
Río Manantial, Finca Manantial, Chicacao

Río La Perla, Finca La Perla, Chicacao
Río Madre Vieja, Finca La Patria, Chicacao
Río Beneficio, Finca Las Amalias, Chicacao
Toma, Finca Valle de Oro, Chicacao
Río Conchita, Finca Conchita, Chicacao
Toma Esterlina, Finca Esterlina, Chicacao
Río Quebrada, Finca Castaño, Chicacao
Río Panán, Finca La Esperanza, Chicacao
Río Castaño, Finca Castaño, Chicacao
Toma, Finca Concepción, Chicacao
Río El Chorro, Finca Naranjo, Chicacao
Río Mixpiá, Finca Medellín, Chicacao
Toma, Finca San Francisco, Chicacao
Río Armonías, Santa Adelaida, Chicacao

Department of Sololá
Río Balza, Finca Laphina, San Lucas Tolimán
Río Primer Puente Panajachel, Panajachel
Río Toma Sta. Teresa, San Lucas, Tolimán
Río Catarata Panajachel, Panajachel
Río Ceiba, Finca Santa Teresa, San Lucas Tolimán
Río Monte de Oro, Atitlán
Río Metzabal, Finca El Carmen, Atitlán
Río Las Cascadas, Finca Las Cascadas, Atitlán
Río Montequina, Finca Montequina, Atitlán

Department of Alta Verapaz
Río 30 de Junio, kilometer 24, Route No. 5, Tactic
Small stream between kilometer 176 and 177 on Route No. 5, Tactic
Río Puente Agua Caliente between kilometers 82 and 83, Route No. 5, Tactic
Río Frío, kilometer 174, Route No. 5, Tactic
Río Polochic, Finca Actelá, Actelá
Río Cobán, Cobán
Río Polochic, Actelá

Department of Baja Verapaz
Río El Chorro, San Jerónimo
Río El Chol, Finca El Chol, El Chol

Department of Huehuetenango
Río San Pedro, Municipality of San Pedro Necta
Río La Unión, Finca La Unión, Agua Dulce, Cuilco
Río Agua Dulce, Cuilco
Río Ojoslá, in the Municipality of San Antonio Huista
Río Agua Dulce, Aldea Agua Dulce, Cuilco
Río Hoja Blanca, Aldea Hoja Blanca, Cuilco

Department of El Quiché
Río Micovez, Nebáj
Río Chajul, in the Municipality of Chajul
Río Delicias, in the Municipality of Joyabáj

Department of Chiquimula
Small stream between kilometers 223 and 224, Route No. 18, Esquipulas
Another small stream between kilometers 212 and 213, Route No. 18, Esquipulas

Stream along the same route, kilometer 222, Esquipulas
Río Tutumico, Quezaltepeque
Department of Zacapa
Río Hondo, Río Hondo, Zacapa
Department of Quezaltenango
Catarata Zunil, Zunil
Toma, Finca San Luis, Almolonga
Río Aguas Amargas, Aguas Amargas, Zunil
Río Samalá, Zunil
Small tributary of Río Samalá, Zunil
Almolonga, Quezaltenango
Department of Retalhuleu
Río Nima, Finca Helvetia, San Sebastián
Department of San Marcos
Río Puente Nahualá, National Route No. 1, San Marcos
Río Miraflores, Finca La Paz, La Reforma
Department of Sacatepéquez
Río El Cubo, Antigua
Río Pensativo, Antigua
Antigua, Antigua
Department of Escuintla
Río Posa del Padre, Finca Las Ilusiones, Santa Lucía
Río Obispo, Siquinalá
Río Zapote, Finca Zapote, Escuintla
Stream between El Jute and La Trinidad, Escuintla
Río La Eminencia, Finca La Eminencia, Escuintla
Río Monte Rey, Finca Monte Rey, Escuintla
Río Hamburgo, Finca Hamburgo, San Vicente Pacaya
Río La Concha, Finca Hamburgo, San Vicente Pacaya
Department of Santa Rosa
Río El Progreso, Finca El Progreso, Taxisco
Río Grande, Taxisco
Stream at kilometer 102, Route No. 25, Finca Mercedes, Taxisco
Stream on Route No. 2, between Llano Grande and Los Esclavos, Santa Rosa
Río Aguacapa, Nuevo Viñas
Río Blanca, Finca El Rodeo, Route No. 2, Santa Rosa
Río Agua Tibia, Finca Santa Clara, Nuevo Viñas
Río Las Medidas, Aldea La Libertad, Taxisco
Río Taxisco, Municipio Taxisco
Río El Jobo #1, Finca El Jobo, Taxisco
Río Urayalá, Chiquimulilla
Cuilapa, Cuilapa

Simulium (*Lanea*) *colvini* Dalmat, 1952—30 specimens
Department of San Marcos
Río El Chorro, Municipality of Catarina

Simulium (*Lanea*) *downsi* Vargas, Martínez, and Díaz, 1946— 14,000 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Yepocapa
Numerous streams in the Municipality of Acatenango

Department of Guatemala
- Río Noxpy, kilometer 51, Route No. 5, Guatemala
- Río Puente near Morán, Morán, Guatemala

Department of Escuintla
- Río Clarita, in the Municipality of Guanagazapa
- Río Corral, in the same Municipality
- Toma Chiguate, Finca Zapote, Escuintla
- Río San Andrés, Finca San Andrés Osuna
- Río Platanar, Finca Los Diamantes, Santa Lucía
- Río Cuesta de las Cañas, Finca El Zapote
- Río Michatoya, in the Municipality of Palín
- Río Barretal, Finca El Llano, Palín
- Río Limón, Escuintla
- Río El Campamento, Finca El Campamento, Escuintla
- Río El Zapote, Finca El Zapote
- Río Varas Altas, between Taxisco and Escuintla
- Río Posa del Padre, Finca Las Ilusiones
- Río Siquinalá, Municipio Siquinalá
- Río Pantaléon, Finca Pantaleón, Santa Lucía
- Río La Eminencia, Finca La Eminencia, Escuintla

Department of Santa Rosa
- Río Ahuacapa, Nuevo Viñas
- Río Agua Tibia, Finca Santa Clara, Nuevo Viñas
- Río Pajal, Finca Naranjito, Taxisco
- Río Las Medidas, Aldea La Libertad, Taxisco
- Río El Jobo #1, Finca El Jobo, Taxisco
- Río Puente Obispo, Finca Obispo, Taxisco
- Río El Molino, kilometer 73, Route No. 2, Cuilapa
- Río El Progreso, Taxisco
- Río Urinyalá, Chiquimulilla
- Río Chiquimulilla, Municipio Chiquimulilla

Department of Alta Verapaz
- Río Frío, Alta Verapaz
- Río Cahabón, Cobán
- Río 30 de Junio, kilometer 180, Route No. 5, Tactic
- Río Patal, Tactic

Department of Baja Verapaz
- Río San Cristobal, Finca Valparaizo, San Cristobal

Department of El Petén
- Río San Pedrito, Poctún
- Río Santa María, Hacienda Santa María, Poctún
- Río Sakchá, Poctún

Department of Huehuetenango
- Stream on Route No. 9 between Quezaltenango and Huehuetenango

Department of El Quiché
- Copante El Chorro, kilometer 248, Route No. 7-W, Chicamán

Department of Jalapa
- Río Puente Jalapa, Jalapa

Department of Jutiapa
- Río Jutiapa, Jutiapa

Department of Zacapa
- Río Teculután, Zacapa

Department of Retalhuleu
- Río Puente Cemento between Retalhuleu and Mazatenango
- Río Buenos Aires, Finca La Suiza, San Sebastián

Department of San Marcos
- Río Miraflores, Finca La Paz, La Reforma
- Río Suchiate, Ayutla

Department of Sololá
- Río Quixayá, San Lucas Tolimán
- Río Ceiba, Finca Santa Teresa, San Lucas
- Río Primer Puente, Panajachel
- Río Puente, Panajachel

Department of Suchitepéquez
- Río Chichoy, San Antonio
- Río Presa, Finca San Agustín, Patulul
- Río Siguacán, Finca Santa Adelaida, Patulul
- Río Callejón, Chicacao
- Río Beneficio, Finca La Trinidad, Patulul
- Río Siguacán, Finca San Agustin, Patulul
- Río Socorro, Finca Socorro, Chicacao
- Río Usú, Finca Veracruz, Patulul
- Río Agua Caliente, Finca Veracruz, Patulul
- Río Perla, Finca Concepción, Chicacao
- Río Panán, Finca La Esperanza
- Río Madre Vieja, Finca La Patria, Chicacao
- Río San Francisco, Finca San Francisco, Chicacao
- Río Milán, Finca Milán, Chicacao
- Río Siguacán, Finca Panán, Chicacao
- Río Quebrada Grande, Finca San Rafaél P., Chicacao
- Río Bravo, Finca Mi Tierra, Chicacao
- Río Olas de Mocá, Finca Olas de Mocá, Chicacao
- Río Toma, Finca Cacahuate, Chicacao
- Río San José, Finca San José La Providencia, Chicacao
- Río Cocoyá, Finca Tarrales, Patulul
- Río El Trébol, Finca El Trébol, Chicacao
- Río Cutzán, Finca El Jardín, Chicacao
- Toma Finca La India, Chicacao
- Río Castaño, Finca Castaño, Chicacao
- Río Quebrada, Finca Manantial, Chicacao
- Toma, Finca Naranjo, Chicacao
- Toma, Finca Concepción, Chicacao
- Río Camelias, Finca Camelias, Chicacao
- Toma, Finca Los Angeles
- Toma, Finca Valle de Oro, Chicacao
- Río La India, Finca La India, Chicacao

Department of El Progreso
- Río Los Plátanos, Route No. 4, Sanarate

Simulium (*Lanea*) *dugesi* Vargas, Martínez, and Díaz, 1946—2 specimens

Department of Escuintla
- Río Limón, in the outskirts of Escuintla on the road to Siquinalá

Simulium (*Lanea*) *haematopotum* Malloch, 1914—1,500 specimens
- Department of Chimaltenango
  - Finca Santa Sofía, Yepocapa
- Department of Escuintla
  - Río and Finca Varas Altas, between Taxisco and Escuintla
  - Río Michatoya, Finca El Llano, Palín
  - Río Coyolate, Finca La Democracia
  - Río Barretal, on road to San Vicente Pacaya, Palín
- Department of Santa Rosa
  - Río Los Esclavos, Aldea Los Esclavos, Cuilapa
  - Cuilapa
- Department of Alta Verapaz
  - San Pedro Carchá, Carchá
- Department of Izabal
  - Zarco Sioux, Bobos, Morales
  - San Francisco, Morales
  - Stream crossing railroad line, Bananera, Morales
  - Chicaso, Bananera, Morales
  - Río Choctaw, Aldea Choctaw, Bananera, Morales
  - Ruinas Quiriguá, Quiriguá, Morales
  - Río Motagua, Finca Abacá, Morales
  - Río Quiriguá, Ruinas Quiriguá, Morales
  - Bananera, Izabal
  - Chinamito, Bobos, Morales
  - Choctaw, Morales
  - Finca Abacá, Morales
- Department of Huehuetenango
  - Río Arroyo, Hacienda Miramar, Nentón
  - Río Michicoy, San Pedro Necta (Aldea Michicoy)
- Department of Guatemala
  - Stream at kilometer 17, National Route No. 1, Guatemala
- Department of Chiquimula
  - Stream between kilometers 212 and 213, Route No. 18, Esquipulas
  - Río Tacó, at kilometer 201, Route No. 20, Chiquimula
- Department of El Progreso
  - Río Manzanotal, Progreso
  - Río Aguas Salóbregas, Progreso
  - Río El Pato, Sanarate
  - Río Sanarate, Municipio Sanarate
  - Río Agua Dulce, Progreso
- Department of Zacapa
  - Río San Juan, Aldea San Pablo, Gualán
  - Río Hondo, Zacapa
- Department of San Marcos
  - Two streams between Malacatán and Ayutla, Ayutla
- Department of El Petén
  - Finca Buenos Aires, San Francisco

Simulium (*Lanea*) *jacobsi* Dalmat, 1953—1 specimen
- Department of Escuintla
  - Río Michatoya, Finca El Llano, Palín

Simulium (*Lanea*) *samboni* Jennings, 1915—100 specimens
  Department of Escuintla
    Río Varas Altas, between Escuintla and Taxisco
  Department of El Petén
    Río San Pedrito, Poctún
    Río Santa María, Hacienda Santa María, Poctún
    Río Sakchá, Poctún
  Department of San Marcos
    Río Suchiate, Ayutla
  Department of Alta Verapaz
    Cobán, Cobán
  Department of Santa Rosa
    Río El Jobo #2, Taxisco
Simulium (*Lanea*) *trivittatum* Malloch, 1914
  Department of Alta Verapaz
    Río Tzunutz, Municipio San Pedro Carchá
Simulium (*Lanea*) *veracruzanum* Vargas, Martínez, and Díaz, 1946—9,000 specimens
  Department of Chimaltenango
    Río Santa Cristina, Finca Santa Cristina, Yepocapa
    Toma, Finca Nimayá, Yepocapa
    Río Queleyá, Yepocapa
    Río Queleyá, Finca Niágara, Yepocapa
    Río Cañalito, Finca Recreo, Yepocapa
    Río Romana, Finca Candelaria, Yepocapa
    Río Peña Blanca, Yepocapa
    Río Queleyá, Finca Santa Emilia, Yepocapa
    Río Comalapa, Comalapa
    Numerous rivers in the Municipality of Acatenango
    Río Sabolopop, Aldea Sabolopop, Patzún
    Río Pachoy, Municipio Zaragoza
    Río Puente Progreso, Patzicía
    Río on road to Patzún, between Patzún and Patzicía
    Río Ariete Victoria, Finca Victoria, Yepocapa
    Río El Molino, Finca El Molino, Tecpán
    Río Metabal, Zaragoza
  Department of Guatemala
    Río at kilometer 16, National Route No. 1, Mixco
    Río El Retiro, Municipio Fraijanes
    Río and Finca El Rincón, Villa Canales
    Río Puente, Finca Las Limas, Guatemala
    Río Caracol, Municipio San Juan Sacatepéquez
  Department of Sacatepéquez
    Río Nahualate, Finca Herrera, El Cubo, Antigua
    Antigua, Antigua
  Department of Escuintla
    Río and Finca El Campamento, Escuintla
  Department of Santa Rosa
    Río La Blanca, Finca El Rodeo, Route No. 2, Santa Rosa

Department of Alta Verapaz
- Río Patal, Tactic
- Río Frío, kilometer 174, Route No. 5, Tactic

Department of Baja Verapaz
- El Chol, El Chol

Department of Huehuetenango
- Río and Aldea Agua Dulce, Cuilco
- Río and Aldea Hoja Blanca, Cuilco
- Río Los Coyotes, Chiantla
- Río Injerto, Aguacatán
- Río in the outskirts of Ixtahuacán
- Río and Municipio Cuilco
- Río and Municipio San Pedro Necta

Department of El Quiché
- Río Cotzal, Municipio Chajul
- Río El Arco, Municipio Nebáj
- Río Manzano, Municipio Nebáj
- Río Negro, Municipio Sacapulas
- Río Chajul, Municipio Chajul
- Río Azul, Municipio Nebáj
- Río Micovez, Municipio Nebáj
- Río Coral, Municipio Cotzal
- Stream between Cotzal and Chajul
- Río and Aldea San José Chagual, Quiché
- Río between Chicamán and Río Yesal, between kilometers 255 and 275, National Route No. 7-W
- Copante El Chorro, kilometer 248, National Route No. 7-W, Chicamán

Department of Zacapa
- Río Mobé, Finca Santa Clara, Zacapa
- Río Hondo, Municipio Río Hondo

Department of Quezaltenango
- Toma Beneficio, Finca San Luis, Almolonga
- Río Caquizá, San Carlos Sija
- Río Samalá, San Carlos Sija
- Río Pajonal, above San Carlos Sija
- Cumbre del Aire, between Chicabal and Sija

Department of San Marcos
- Río Miraflores, Finca La Paz, Reforma
- Small stream Palazá, San Marcos
- Puente Nahualá, San Marcos
- Río Guatajil, Aldea Chamaco

Department of Sololá
- Toma El Rancho, Panajachel
- Small stream near Puente Panajachel
- Puente Panajachel, Panajachel
- Puente Patanatic, Panajachel
- Río Arco, near Los Encuentros, Sololá

Department of Totonicapán
- Río Puento Totonicapán
- Río Samalá, Totonicapán

Simulium (*Dyarella*) *acatenangoensis* Dalmat, 1951—18,500 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Acatenango
Small stream Poso de la Palma, Yepocapa
Department of Sacatepéquez
Río Pensativo, Antigua
Department of Alta Verapaz
Río Tactic, Tactic
Department of Huehuetenango
Río Ojoslá, San Antonio Huista
Department of Guatemala
Río, at kilometer 16, National Route No. 1, Mixco
Río, at kilometer 17, National Route No. 1, Mixco
Department of Santa Rosa
Río La Libertad, Cuilapa
Río Blanco, Aldea Malpais, kilometer 45, Route No. 2, Cuilapa
Department of El Quiché
Río Estanzuela, on Route No. 15, between Quiché and San Pedro Jocopilas
Río and Aldea San José Chagual
Río and Municipio San Pedro Jocopilas
Stream between Zacualpa and Joyabáj
Stream between Chicamán and Río Yesal, between kilometers 255 and 275, National Route No. 7-W
Copante El Chorro, kilometer 248, National Route No. 7-W, Chicamán
Department of Chiquimula
Río Tutumico, Quezaltepeque
Department of Jutiapia
Río Cementerio, San José Acatempa

Simulium (*Dyarella*) *ardeni* Dalmat, 1953—15 specimens
Department of Alta Verapaz
Río Tzunutz, Cobán

Simulium (*Dyarella*) *carlei* Vargas, Martínez, and Díaz, 1946—900 specimens
Department of Chimaltenango
Río Santa Rosa, Finca Trinidad, Yepocapa
Río Camarón, Finca Miraflores, Yepocapa
Department of Escuintla
Stream close to Finca Hamburgo, Escuintla
Río Posa del Padre, Finca Las Ilusiones, Santa Lucía Cotz.
Río Las Ilusiones, Finca Las Ilusiones, Santa Lucía Cotz.
Río Obispo, Municipio Siquinalá
Department of Santa Rosa
Río Zacuapa, kilometer 107, Route No. 6, Finca San Jacinto, Taxisco
Río Santa Cruz, Municipio Taxisco
Río Itapa, Finca El Rodeo, Cuilapa
Río Chiquimulilla, Municipio Chiquimulilla
Río El Molino, kilometer 73, Route No. 2
Río Los Esclavos, Aldea Los Esclavos, Cuilapa
Department of Jutiapa
Río Las Lajas, Finca Las Lajas, Jutiapa

Department of El Progreso
Río Guastatoya, El Progreso
Department of Suchitepéquez
Río Mixpiá, Finca San José La Sierra, Chicacao
Río Madre Vieja, Finca La Patria

Simulium (*Dyarella*) *mathesoni* Vargas, 1943—20 specimens
Department of Chimaltenango
Río Platanar, Finca Platanar, Acatenango
Río San Rafaél Pancúm, Finca San Rafaél Pancúm, Acatenango
Río Positos, Aldea Quisaché, Acatenango
Río Chorrera, Finca San José Miramar, Acatenango
Department of Sacatepéquez
Río San Lorenzo, Finca San Lorenzo, Antigua
Department of Santa Rosa
Río Los Esclavos, Aldea Los Esclavos, Cuilapa
Department of Totonicapán
Río Samalá, Totonicapán

Simulium (*Dyarella*) *mexicanum* Bellardi, 1862—10,200 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Yepocapa
Numerous streams in the Municipality of Acatenango
Numerous streams in the Municipality of Pochuta
Department of Escuintla
Río Sacatera, Escuintla
Río Pantaleón, Finca Pantaleón, Santa Lucía
Stream between El Jute and La Trinidad, Escuintla
Department of Alta Verapaz
Río Tzunutz, Cobán
Department of Izabal
(Reported by Malloch, 1914)
Department of Huehuetenango
Río Cuilco, Municipio Cuilco
Department of Chiquimula
Río on Route No. 18, near kilometer 222, Esquipulas
Department of Zacapa
Río Hondo, Río Hondo, Zacapa
Department of Santa Rosa
Río Ahuacapa, Finca Viñas, Nuevo Viñas
Department of Sololá
Río and Finca San José La Providencia, Sololá
Río Quixayá, Municipio San Lucas Tolimán
Río Monte de Oro, Finca Monte de Oro, Atitlán
Department of Suchitepéquez
Río Nicá, Finca La Esperanza, Chicacao
Toma, Finca Valle de Oro, Chicacao
Río Cutzán, Finca El Jardín, Chicacao
Toma, Finca La India, Chicacao
Río Siguacán, Finca San Agustín, Chicacao
Río El Trébol, Finca El Trébol, Chicacao
Río and Finca Las Camelias, Chicacao

Río Siguacán, Finca Santa Adelaida, Patulul
Río Mixpiá, San José La Sierra, Chicacao
Río Usú, Finca La Hermita, Patulul
Río Panán, Finca La Esperanza, Chicacao
Río Madre Vieja, Finca La Patria, Chicacao
Río San Francisco, Finca San Francisco, Chicacao
Río Siguacán, Finca Panán, Chicacao
Río Santa Teresa, Finca El Cacahuate, Chicacao
Río Llutiyá, Finca San Lázaro, Chicacao
Department of Quezaltenango
Río Caquixá, San Carlos Sija
Río Samalá, Zunil

Simulium (*Dyarella*) *pulverulentum* Knab, 1914—3,800 specimens
Department of Chimaltenango
Río La Java, Finca Montevideo, Yepocapa
Río Recreo, Finco Recreo, Yepocapa
Río San Antonio, Finca San Antonio, Yepocapa
Río Gobernador, Finca Santa Sofía, Yepocapa
Río Toma, Finca Conchita, Yepocapa
Río Sacayá, Finca Santa Emilia, Yepocapa
Río Sibajá, Finca Sibajá, Yepocapa
Río Sacayá, Finca Niágara, Yepocapa
Río Toma, Finca Argentina, Yepocapa
Río Santa Rosa, Finca Trinidad, Yepocapa
Río Sibajá, Finca Santa Teresa, Yepocapa
Río Santa Teresa, Finca Santa Teresa, Yepocapa
Río Queleyá, Finca Niágara, Yepocapa
Río Encuentros, Finca Santa Emilia, Yepocapa
Río Toma, Finca Morelia, Yepocapa
Río Tempiscal, Finca Morelia, Yepocapa
Río San Antonio, Finca San Antonio, Yepocapa
Río Camarón, Finca Miraflores, Yepocapa
Río Queleyá, Finca Santa Emilia
Río Barranca Seca, Finca Niágara, Yepocapa
Río Panimaché, Finca Montevideo, Yepocapa
Río Chorrera, Finca Buena Vista, Acatenango
Río Quiquillá, Finca Chalabal, Acatenango
Department of Escuintla
Río Michatoya, below Palín, Palín
Río Grande, Finca La Providencia, Guanagazapa
Río San Sebastián, Finca La Providencia, Guanagazapa
Río and Finca San Andrés Osuna, Santa Lucía
Río Colojate, Finca La Democracia
Río Limón, Escuintla
Río Campamento, El Campamento, Escuintla
Río Obispo, Municipio Siquinalá
Río Metapa, San Juan Sinacapa
Río and Municipio Siquinalá
Río Posa del Padre, Finca Las Ilusiones
Río Pantaleón, Finca Pantaleón, Santa Lucía

Department of Santa Rosa
Río and Finca Progreso, Taxisco
Río and Finca El Jobo #2, Taxisco
Río and Municipio Chiquimulilla
Río Negro, Finca Santa Anita Jobo, Taxisco
Río and Finca El Jobo #1, Taxisco
Department of Izabal
Zarco Sioux, Morales
Department of Huehuetenango
Arroyo Sipá, Hacienda Miramar, Nentón
Department of Chiquimula
Río Tutumico, Quezaltepeque
Department of Jutiapa
Río Los Esclavos, Aldea Los Esclavos, Cuilapa
Río Las Lajas, Aldea Las Lajas
Río Paz, at kilometer 105, Route No. 2
Department of El Progreso
Río Guatatoya, Progreso
Río Los Plátanos, kilometer 61, Route No. 4, Sanarate
Department of Zacapa
Río San Juan, Aldea San Pablo, Gualán
Department of Retalhuleu
Río Sís on boundary between Suchitepéquez and Retalhuleu
Río Santo Domingo, San Juan Bautista, Retalhuleu
Department of San Marcos
Stream between Malacatán and Ayutla, Malacatán
Department of Sololá
Río Primer Puente Panajachel, Panajachel
Department of Suchitepéquez
Río Ixtacapa, Finca Esterlina, Mazatenango
Río Puente Panán, at kilometer 175, Route No. 6-W
Río Puente between Retalhuleu and Mazatenango
Río Nahualate, Finca Nahualate, Chicacao
Río Nahualate, Finca Monte Santo, Chicacao
Río Santa Teresa, Finca Nahualate, Chicacao
Río Cutzán, Finca Monte Santo, Chicacao
Río and Finca Socorro, Chicacao
Río Mixpiá, Finca San José La Sierra, Chicacao

Simulium (*Dyarella*) *rubicundulum* Knab, 1914—11,100 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Yepocapa
Numerous streams in the Municipality of Acatenango
Numerous streams in the Municipality of Pochuta
Department of Guatemala
Río Las Vacas, Chinautla
Río Puente, at kilometer 16, National Route No. 1, Mixco
Department of Sacatepéquez
Río San Lorenzo, between Tejar and Pastores, Antigua
Department of Escuintla
Río and Finca El Zapote
Río Michatoya, Finca El Llano, Palín

Department of Santa Rosa
Río Ahuacapa, Municipio Nuevo Viñas
Río and Finca Desojal, Cuilapa
Department of Baja Verapaz
Stream between kilometers 82 and 83, Route No. 5
Department of Huehuetenango
Río and Municipio Aguacatán
Río Campamento, Los Naranjales, Colotenango
Río Ojoslá, San Antonio Huista
Río and Municipio Cuilco
Small stream and Municipio La Democracia
Río Coyotes, Chiantla
Department of El Quiché
Río Estanzuela on Route No. 15 between Quiché and San Pedro Jocopilas
Department of Chiquimula
Río Puente Esquipulas, Esquipulas
Stream, at kilometer 222, Route No. 18, Esquipulas
Department of Jutiapa
Río and Aldea Los Esclavos
Río El Riíto, Aldea San José Acatempa
Río Las Lajas, Jutiapa
Department of El Progreso
Río Guastatoya, Progreso
Department of Sololá
Río Monte de Oro, Finca Monte de Oro, Atitlán
Catarata Santa Anita, Finca Monte de Oro, Atitlán
Puente Panajachel, Panajachel
Department of Alta Verapaz
Río Cotzibal, Finca Las Palmas
Department of Suchitepéquez
Toma Castaño, Finca Castaño, Chicacao
Río Perla, Finca Concepción, Chicacao
Río and Finca Trébol, Chicacao
Río and Finca San Rafaél Panán, Chicacao
Río Mixpiá, San José La Sierra, Chicacao
Río Quebrada, Finca Castaño, Chicacao
Río and Finca Las Camelias, Chicacao
Río and Finca Conchita, Chicacao
Río El Mono, Finca Naranjo, Chicacao
Department of Totonicapán
Río Samalá, Totonicapán
Department of San Marcos
Río Suchiate, Ayutla

Simulium (*Dyarella*) *smarti* Vargas, 1946—1,400 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Yepocapa
Numerous streams in the Municipality of Acatenango
Department of Sacatepéquez
Río Antigua, Antigua

Department of Huehuetenango
Small stream, Municipio San Antonio Huista
Río and Aldea Hoja Blanca, Cuilco
Río Ojoslá, Municipio San Antonio Huista
Río Agua Dulce, Aldea Agua Dulce, Cuilco
Department of El Quiché
Río Negro, Sacapulas
Department of Sololá
Catarata Panajachel, Panajachel

Simulium (*Dyarella*) *yepocapense* Dalmat, 1949—750 specimens
Department of Chimaltenango
Río Tempiscal, Finca Morelia, Yepocapa
Río Queleyá, Finca Santa Emilia, Yepocapa
Río Sacayá, Finca Niágara, Yepocapa
Río Sacayá, Finca Santa Emilia, Yepocapa
Río Cafetal, Finca Morelia, Yepocapa
Río Sacayá, Terreno Tululché, Yepocapa
Río Cascada, Finca Morelia, Yepocapa
Río Encuentros, Finca Santa Emilia, Yepocapa
Río Sibajá, Finca Santa Teresa, Yepocapa
Río Gobernador, Finca Santa Sofía, Yepocapa
Río Arco, Finca Chantunjay, Acatenango
Río Jute, Finca Santa Felisa, Acatenango
Río Beneficio, Finca Chantunjay, Acatenango
Río Quiquillá, Finca Naranjo, Acatenango
Río Positos, Aldea Quisaché, Acatenango
Río Cualiyaj, Finca Delicias, Acatenango
Río Silencio, Finca Delicias, Acatenango
Río Tehuyá, Finca Tehuyá, Acatenango
Río San Diego, Finca San Diego, Acatenango
Río Nicán, Finca California, Pochuta
Department of Huehuetenango
Río Cuilco, Municipio Cuilco
Department of El Quiché
Río Negro or Chixoy, Sacapulas
Department of Suchitepéquez
Concrete bridge between Retalhuleu and Mazatenango (closer to Mazatenango)

Simulium (*Simulium*) *jacumbae* Dyar and Shannon, 1927—650 specimens
Department of Chimaltenango
Río Sacayá, Finca Niágara, Yepocapa
Río Cañalito, Finca Recreo, Yepocapa
Río Recuerdo, Finca Recuerdo, Yepocapa
Río Santa Cristina, Finca Santa Cristina, Yepocapa
Río Queleyá, Finca Santa Emilia, Yepocapa
Río Ariete, Finca Victoria, Yepocapa
Río Beneficio, Finca Amparo, Yepocapa
Río San Antonio, Finca San Antonio, Yepocapa
Río Recreo, Finca Recreo, Yepocapa
Río Poso, Casa La Palma, Yepocapa

Río Ladrillera, Finca Esperanza, Acatenango
Río Chacajá, Finca Española, Acatenango
Small stream in park, Parramos
Río Chajillá, Aldea San Antonio, Acatenango
Río Beneficio, Finca Montevideo, Yepocapa
Río Laguneta, Finca Tehuyá, Acatenango
Río Tehuyá, Finca Tehuyá, Acatenango
Río San Diego, Finca San Diego, Acatenango
Río La Esmeralda, Finca La Esmeralda, Acatenango
Río Ciprés, Aldea Los Pajales, Acatenango
Río Cocoyá, Finca El Cármen, Acatenango
Department of Guatemala
Río Rosita, Municipio Santa Rosita
Department of El Quiché
Río San José Chagual, Aldea San José Chagual
Department of Jalapa
Río Los Llanitos, Aldea Los Llanitos
Río Laguneta, Jalapa
Department of El Progreso
Río Plátanos, Sanarate
Department of Zacapa
Río Gualán, Municipio Gualán
Department of Quezaltenango
Toma Beneficio, Finca San Luis Almolonga
Department of Sololá
Río below María Tecún
Department of Baja Verapaz
Stream at kilometer 4, Route No. 3, Purulhá

Simulium (*Simulium*) *jobbinsi* Vargas, Martínez, and Díaz, 1946—750 specimens
Department of Chimaltenango
Numerous streams in the Municipality of Yepocapa
Numerous streams in the Municipality of Acatenango
Río Aserradero Santa Elena, Tecpán
Department of Guatemala
Río Puente Incapié #1155, Route No. 1 to Morán, Morán
Department of Sacatepéquez
Antigua
Department of Alta Verapaz
Small stream between kilometers 176 and 177 on Route No. 5, Tactic
Department of Baja Verapaz
Río Chorro, San Jerónimo
Department of Huehuetenango
Small stream #2, Aldea Agua Dulce, Cuilco
Río Injerto, Municipio Aguacatán
Department of Quezaltenango
Stream at kilometer 228 between San Carlos Sija and Chequijel
Río Pajonal, kilometer 224, Route No. 9, Quezaltenango
Cumbre del Aire, between Chicabal and San Carlos Sija
Department of San Marcos
Río El Triángulo, Finca La Paz, Reforma

Department of Sololá
- Primer Puente Panajachel, Panajachel
- Río Beneficio, Finca Las Amalias, Atitlán

Department of Suchitepéquez
- Río Castaño, Finca Castaño, Chicacao
- Río Toma, Finca Esterlina, Chicacao
- Río Chorro, Finca Naranjo, Chicacao
- Río Mono, Finca Naranjo, Chicacao
- Río Mixpiá, Finca Medellín, Chicacao

Department of Totonicapán
- Río Chumuluchil, María Tecún, Totonicapán
- Río Zapato de la Señora, Totonicapán

Simulium (*Simulium*) *kompi* Dalmat, 1951—3 specimens

Department of Chimaltenango
- Río Ciprés, Aldea Los Pajales, Acatenango

Simulium (*Simulium*) *metallicum* Bellardi, 1859—21,000 specimens

Department of Chimaltenango
- Numerous streams in the Municipality of Acatenango
- Numerous streams in the Municipality of Yepocapa
- Numerous streams in the Municipality of Pochuta
- Río La Virgen, Parramos
- Balneario Apocentos, Chimaltenango
- Desague Apocentos, Chimaltenango
- Desague Tanque Parramos, Chimaltenango

Department of Guatemala
- Río Puente Incapié #1155, Route No. 1, Morán
- Río Retiro, Municipio Fraijanes
- Río Rosita, Municipio Santa Rosita
- Stream at kilometer 17, National Route No. 1, Mixco
- Fraijanes, Guatemala

Department of Sacatepéquez
- Río Nahualate, Finca Pastores, Antigua
- Río and Finca San Lorenzo, Antigua

Department of Escuintla
- Río Barretal about 1 kilometer from Río Michatoya, Finca El Llano, Palín
- Río Limón, Escuintla
- Río Posa del Padre
- Río El Campamento, Escuintla
- Río Obispo, Siquinalá
- Río El Zapote, Finca El Zapote, Escuintla
- Río Siquinalá in the Municipality of Siquinalá
- Stream between El Jute and La Trinidad, Escuintla
- Río Monterrey, Escuintla
- Small stream Puente El Diablo, Escuintla
- Toma Chiguate, Finca El Zapote, Escuintla
- Toma on north side of Finca Zapote, Escuintla
- Finca San Nicolás, San Vicente Pacaya
- Finca Hamburgo, San Vicente Pacaya
- Finca La Concha, San Vicente Pacaya

Río Platanar, Finca Los Diamantes, Santa Lucía
Río Cuesta las Cañas, Finca Zapote
Río La Democracia, Municipio La Democracia
Río La Eminencia, Finca La Eminencia, Escuintla
Río Camarón, Finca San Nicolás, San Vicente Pacaya
Río Hamburgo, San Vicente Pacaya
Río La Concha, Finca Hamburgo, San Vicente Pacaya

Department of Santa Rosa
Río Las Medidas, Aldea La Libertad, Taxisco
Río Jobo #1, Taxisco
Río and Municipio Taxisco
Río and Finca El Progreso, Taxisco
Río Uroyala, Chiquimulilla
Río and Finca La Cruz, Taxisco
Río Grande, Taxisco
Río and Municipio Taxisco
Río Agua Tibia, Finca Santa Clara, Nuevo Viñas
Cuilapa
Aldea Los Esclavos, Cuilapa

Department of Alta Verapaz
Stream between kilometers 176 and 177 on Route No. 5, Tactic
Río 30 de Junio, kilometer 180, Route No. 5, Alta Verapaz
Río Patal, Tactic
Río Cahabón, Cobán
Polochic, Actilá

Department of El Quiché
Río Puente Joyabáj, Zacualpa
Stream between Chicamán and Río Yesal, between kilometers 225 and 275, National Route No. 7-W
Copante El Chorro, kilometer 248-78, Route No. 7-W, Chicamán

Department of Chiquimula
Small stream between kilometers 223 and 224 on Route No. 18, Esquipulas
Río San Nicolás, kilometer 224, Route No. 20, Chiquimula
Río Schucte, kilometer 210, Route No. 18, Quezaltepeque
Small stream at kilometer 213, Route No. 18, Chiquimula
Río Tutumico, Quezaltepeque
Río Pedregal, Quezaltepeque
Río Puente in the outskirts of Esquipulas, Esquipulas

Department of Jalapa
Río Laguneta, Jalapa

Department of Jutiapa
Río Campos, Hacienda Campos, Quezada
Stream on Route No. 2 between El Llano Grande and Los Esclavos

Department of El Progreso
Río Hiel, Municipio San Agustín
Río Uyus, Finca Manzanotales, Acasaguastlán

Department of Quezaltenango
Cumbre del Aire, between Chicabal and San Carlos Sija

Department of Baja Verapaz
- Small stream at kilometer 4, Route No. 3, Purulhá
- Río El Chol, Aldea El Chol
- Río San Cristobal, Finca El Paraizo
- Río El Chorro, San Jerónimo

Department of Izabal
- Zarco Sioux, Bobos, Morales
- Río Choctaw, Morales

Department of El Petén
- Río Santa María, Hacienda Santa María, Poctún
- Río Sackchá, Poctún

Department of Huehuetenango
- Río and Aldea Hoja Blanca, Cuilco
- Río and Aldea Michicoy, San Pedro Necta
- Río and Aldea La Providencia #1, San Pedro Necta
- Río and Aldea Cayagual, La Democracia
- Arroyo Sipá, Hacienda Miramar, Nentón
- Río Unión, Aldea Agua Dulce, Cuilco
- Stream in the outskirts of Ixtahuacán, Ixtahuacán
- Small stream #3, Aldea Agua Dulce, Cuilco
- Small stream between Aldea Agua Dulce and Cuilco, Cuilco
- Small stream #1, Aldea Agua Dulce, Cuilco
- Small stream, San Antonio Huista
- Río and Municipio Cuilco, Cuilco
- Río and Municipio San Pedro Necta

Department of San Marcos
- Río El Triángulo, Finca La Paz, La Reforma
- Stream El Paredón, on road to Reforma, San Marcos

Department of Retalhuleu
- Río Buenos Aires between Finca La Suiza and Finca Buenos Aires in the Municipality of San Sebastián
- Stream on boundary line between Quezaltenango and Retalhuleu
- Río Chiquito, Finca La Helvetia, San Sebastián
- Río Nimá, Finca La Helvetia, San Sebastián
- Río Pilastrias, Finca La Helvetia, San Sebastián
- Río Alianza, Finca La Helvetia, San Sebastián
- Río Maricón, Finca Maricón, San Sebastián
- Stream between Cuyotenango and Mazatenango
- Río, concrete bridge between Retalhuleu and Mazatenango

Department of Sololá
- Toma, Finca Santa Teresa, San Lucas Tolimán
- Toma, Finca Cacahuate, San Lucas Tolimán
- Río and Finca Cascadas, Atitlán
- Río and Finca Montequina, Atitlán
- Toma, El Rancho, Panajachel
- Río Puente in the outskirts of Panajachel
- Catarata Panajachel, Panajachel
- Very small stream on side of road outside of Panajachel

Department of Suchitepéquez
- Río Siguacán, Finca Siguacán, Chicacao

Río and Finca Las Armonías, Chicacao
Toma and Finca Valle de Oro, Chicacao
Río Coyolar, Finca La Trinidad, Patulul
Río Chorro, Finca Naranjo, Chicacao
Río Mono, Finca Naranjo, Chicacao
Río Usú, Finca Ermita, Patulul
Río Medellín, Finca Medellín, Chicacao
Río and Finca Manantial, Chicacao
Río and Finca San Francisco, Santa Bárbara
Río Quebrada Grande, San Rafael Panán, Chicacao
Río and Finca Olas de Mocá, Santa Bárbara
Río and Finca Socorro, Chicacao
Río Beneficio, Finca Las Amalias, Chicacao
Río and Finca Conchita, Chicacao
Río Trebol, Chicacao
Río Cutzán, Finca Jardín, Chicacao
Río Castaño, Finca Milán, Chicacao
Toma and Finca Esterlina, Chicacao
Río Quebrada, Finca Castaño, Chicacao
Río Carmelo, Finca Camelias, Chicacao
Río Quebrada, Finca Manantial, Chicacao
Río Panán, Finca La Esperanza
Río Castaño, Finca Castaño, Chicacao
Toma Los Angeles, Chicacao
Toma Naranjo, Finca Naranjo, Chicacao
Río Mixpiá, Finca San José La Sierra, Chicacao
Toma and Finca Concepción, Chicacao
Río Mixpiá, Finca Medellín, Chicacao
Toma San Francisco, Finca San Francisco, Chicacao
Río Chichoy in the Municipality of San Antonio Suchitepéquez

Department of Totonicapán

Stream on grade María Tecún, closer to Totonicapán

Simulium (*Simulium*) *ochraceum* Walker, 1861—1,000 specimens

Department of Chimaltenango

Several streams in the Municipality of Yepocapa
Several streams in the Municipality of Acatenango

Department of Guatemala

Río Fraijanes in the Municipality of Fraijanes

Department of Sacatepéquez

Pastores, Antigua

Department of Escuintla

Very small stream beside Río Michatoya, Finca El Llano, Palín
Río El Zapote, Finca El Zapote
Río and Finca Monterrey
Río and Finca Hamburgo, San Vicente Pacaya
El Llano, Palín

Department of Santa Rosa

Cuilapa

Department of Alta Verapaz

Río Actelá, Finca Actelá, Municipio La Tinta

Department of Baja Verapaz
Río El Chorro, San Jerónimo
Department of El Petén
Río Lacandón, Municipio Lacandón
Río Sackchá, Poctún
Department of Huehuetenango
Small stream, San Pedro Necta
Río Unión, Aldea Agua Dulce, Cuilco
Río Hoja Blanca, Aldea Hoja Blanca, Cuilco
Río and Finca La Providencia #2, San Pedro Necta
Río and Aldea Michicoy, San Pedro Necta
Río and Finca La Providencia #1, San Pedro Necta
Department of El Quiché
Río Azul, Nebáj
Río Micovez, "El Puente," Nebáj
Department of Chiquimula
Stream at kilometer 222, Route No. 18, Esquipulas
Department of Jalapa
Río Laguneta, San Luis Jilotepeque
Department of Jutiapa
Aldea Carretera, Acatempa
Department of El Progreso
El Chorro, San Jerónimo, Progreso
Department of Quezaltenango
Stream on road between Mazatenango and Quezaltenango
Department of Retalhuleu
Finca Helvetia, Retalhuleu
Department of San Marcos
Río Triángulo, Finca La Paz, La Reforma
Department of Sololá
Catarata Panajachel, Panajachel
Toma Santa Teresa, Finca Santa Teresa, Atitlán
Río Metzabal, Finca El Carmen, Atitlán
Río Montequina, Finca Montequina, Atitlán
Department of Suchitepéquez
Toma and Finca Castaño, Chicacao
Río Carmelo, Finca Camelias, Chicacao
Río Beneficio, Finca Santa Amalia, Chicacao
Río and Finca Conchita, Chicacao
Río Castaño, Finca Milán, Chicacao
Río Quebrada, Finca Manantial, Chicacao
Río and Finca Castaño, Chicacao
Río El Chorro, Finca Naranjo, Chicacao
Río Mixpiá, Finca Medellín, Chicacao

Simulium (*Simulium*) *parrai* Vargas, Martínez, and Díaz, 1946—900 specimens
Department of Chimaltenango
Río Pila, Finca Montellano, Yepocapa
Río Aguná, Finca Victoria, Yepocapa
Río San Diego, Finca San Diego, Acatenango
Río Socorro, Finca Socorro, Acatenango

Río Silencio, Finca Delicias, Acatenango
Río Chorrera, Finca San José Miramar, Acatenango
Río San Vicente, Finca San Vicente Pacúm, Acatenango
Río Pacoc, Finca Paraizo, Acatenango
Río San Rafael, Finca San Rafael Pacúm, Acatenango
Río La Torre, Finca La Torre, Acatenango
Río Chajillá, Aldea San Antonio, Acatenango
Río Laguneta, Finca Tehuyá, Acatenango
Río Presa, Finca Buena Vista, Acatenango
Río Esmeralda, Finca Esmeralda, Acatenango
Río Monjas, Finca San Rafael, Acatenango
Río Panacal, Finca Panacal, Acatenango
Río Costita, Finca Providencia, Acatenango
Río Chorrera, Finca San Carlos, Pochuta
Río Monjas, Finca Santa Margarita, Acatenango
Río Campana, Finca Chalabal, Acatenango

Department of Sololá
Catarata Panajachel, Panajachel

Simulium (*Simulium*) *tricornis* De León, 1944—450 specimens

Department of Chimaltenango
Río and Finca La Torre, Acatenango
Río Ciprés, Aldea Ciprés, Acatenango
Río Sacate, Finca Tajancarón, Acatenango
Río Seco, Finca Socorro, Acatenango
Río Cocoyá, Finca El Carmen

Department of Guatemala
Stream between kilometers 24 and 25, National Route No. 1, Mixco

Department of Huehuetenango
Stream between kilometers 240 and 241 on Route No. 9
Another stream along the same route, at kilometer 224

Department of San Marcos
Small stream, Palazá, San Marcos
Río Puente Nahualá #1, Route No. 1, San Marcos
Río Guatayil, Aldea Chamaco, San Marcos

Department of Sololá
Río Negro, Panajachel
Río near Los Encuentros, Sololá
Stream about 3 miles from Los Encuentros, on Route No. 1 to Totonicapán, Los Encuentros, Sololá

Department of Totonicapán
Small stream between Encuentros and Totonicapán
Río Samalá, Totonicapán

Simulium (*Hearlea*) *burchi* Dalmat, 1951—150 specimens

Department of Huehuetenango
Río Yulva, Aldea Yulva, Cuilco

Department of El Quiché
Río Micovez, Nebáj
Río Yesal at kilometer 275, National Route No. 7-W, between Cunén and San Miguel Uspantán

Simulium (*Hearlea*) *capricornis* De León, 1944—3,800 specimens

Department of Chimaltenango

Río Queleyá, Finca Santa Emilia, Yepocapa
Río Pocitos, Aldea Quisaché, Yepocapa
Río Queleyá, Yepocapa, Yepocapa
Río Pila, Finca Montellano, Yepocapa
Numerous streams in the Municipality of Acatenango

Department of Guatemala

Stream at kilometer 24, National Route No. 1, Mixco

Department of Sacatepéquez

Río Pensativo, Antigua

Department of Alta Verapaz

Stream between kilometers 176-177 on Route No. 5, Tactic

Department of Huehuetenango

Small stream Agua Dulce, Aldea Agua Dulce, Cuilco

Department of El Quiché

Río El Molino, Finca El Tesoro, Chichicastenango

Department of Sololá

Primera Catarata Panajachel, Panajachel
Río Patanatic #1, kilometer 103, Route No. 1, Panajachel

Department of Totonicapán

Río Samalá, Totonicapán

Simulium (*Hearlea*) *carolinae* De León, 1944—1,000 specimens

Department of Chimaltenango

Río Chorrera, Finca San José Miramar, Acatenango
Río La Torre, Finca La Torre, Acatenango
Río Cocoyá, Finca El Carmen, Acatenango

Department of Guatemala

Catarata Campamento, kilometer 24-25, National Route No. 1, Mixco

Department of Alta Verapaz

Río Actelá, Finca Actelá, La Tinta

Department of Quezaltenango

Catarata Zunil, Zunil
Cumbre del Aire, between Chicabal and Sija
Small tributary of Río Samalá, Zunil

Department of Sololá

Catarata Panajachel, Panajachel
Catarata Santa Alicia, Monte de Oro, Atitlán

Department of Suchitepéquez

Río El Mono, Finca Naranjo, Chicacao

Simulium (*Hearlea*) *delatorrei* Dalmat, 1950—450 specimens

Department of Chimaltenango

Río Ciprés, Aldea Los Pajales, Acatenango
Río Cocoyá, Finca El Carmen, Acatenango
Río Chacayá, Finca La Española, Acatenango
Río Los Pocitos, Aldea Quisaché, Acatenango
Río Tehuyá, Finca Tehuyá
Río Comalapa, Comalapa

Department of Guatemala

Catarata El Campamento between kilometers 24 and 25 on National Route No. 1, Mixco

Department of Huehuetenango
Río Chancol, Finca Chancol, Chiantla
Río Coyotes, Chiantla
Department of El Quiché
Río San José, Aldea San José Chaqual, Quiché
Río Jocopilas, Municipio San Pedro Jocopilas
Department of Quezaltenango
Small tributary of Río Samalá, Zunil
Department of Sololá
Primera Catarata Panajachel, Panajachel
Department of Totonicapán
Río Samalá, Totonicapán
Río María Tecún, Chumuluchic, Totonicapán
Department of San Marcos
Río Guatayil, Aldea El Chamaco, San Marcos

Simulium (*Hearlea*) *ethelae* Dalmat, 1950—150 specimens
Department of Chimaltenango
Río Ciprés, Aldea Los Pajales, Acatenango
Río Cocoyá, Finca El Carmen, Acatenango
Río La Torre, Finca La Torre, Acatenango
Department of Guatemala
Río Campamento, between kilometers 24 and 25, National Route No. 1, Mixco
Department of Huehuetenango
Stream on Route No. 9, between Quezaltenango and Huehuetenango
Department of Quezaltenango
Río Pajonal, kilometer 224, Route No. 9
Department of Sololá
Río Los Arcos near Los Encuentros, Los Encuentros, Sololá
Río Patanatic #3 between Panajachel and Godinez
Catarata Puente above Panajachel on Route No. 1 to Sololá, Panajachel

Simulium (*Hearlea*) *larvispinosum* De León, 1948—500 specimens
Department of Chimaltenango
Río Costita, Finca La Providencia, Acatenango
Río Monjón, Finca Santa Margarita, Acatenango
Río La Torre, Finca La Torre, Acatenango
Río Chorrera, Finca La Torre, Pochuta
Río San Rafael Pacún, Finca San Rafael Pacún, Acatenango
Río Chorrera, Finca San José Miramar, Acatenango
Río Cocoyá, Finca El Carmen, Acatenango
Department of Sololá
Catarata Santa Alicia, Finca Monte de Oro, Atitlán
Department of Suchitepéquez
Catarata El Mono, Finca Naranjo, Chicacao

Simulium (*Hearlea*) *microbranchium* Dalmat, 1949—200 specimens
Department of Huehuetenango
Stream on Route No. 9 between Quezaltenango and Huehuetenango
Department of El Quiché
Río Micovez, "El Puente," Nebáj
Department of Quezaltenango
Cumbre del Aire between Chicabal and Sija

Department of Sololá
Río Los Arcos, near Los Encuentros
Department of Totonicapán
Río Samalá, Totonicapán

Simulium (*Hearlea*) *nigricornis* Dalmat, 1950—15 specimens
Department of Chimaltenango
Río Laguneta, Finca Tehuyá, Acatenango
Río Costita, Finca Providencia, Acatenango
Río Ciprés, Aldea Los Pajales, Acatenango
Río Cocoyá, Finca El Carmen, Acatenango
Río La Torre, Finca La Torre, Acatenango

SPECIES DISTRIBUTION ACCORDING TO DEPARTMENTS

CENTRAL ZONE

Department of Chimaltenango

acatenangoensis	*exiguum*	*ochraceum*
aguirrei	*haematopotum*	*pacheco-lunai*
aureum	*jacumbae*	*parrai*
callidum	*jobbinsi*	*pulverulentum*
capricornis	*kompi*	*rubicundulum*
carolinae	*larvispinosum*	*smarti*
delatorrei	*mathesoni*	*tricornis*
downsi	*metallicum*	*veracruzanum*
earlei	*mexicanum*	*wrighti*
ethelae	*nigricornis*	*yepocapense*

Department of Guatemala

acatenangoensis	*ethelae*	*ochraceum*
callidum	*exiguum*	*rubicundulum*
capricornis	*jacumbae*	*tricornis*
carolinae	*jobbinsi*	*veracruzanum*
delatorrei	*metallicum*	
downsi	*mexicanum*	

Department of Sacatepéquez

acatenangoensis	*jobbinsi*	*rubicundulum*
callidum	*mathesoni*	*smarti*
capricornis	*metallicum*	*veracruzanum*
exiguum	*ochraceum*	

SOUTHERN ZONE

Department of Escuintla

acatenangoensis	*exiguum*	*ochraceum*
callidum	*haematopotum*	*pulverulentum*
downsi	*jacobsi*	*rubicundulum*
dugesi	*metallicum*	*samboni*
earlei	*mexicanum*	*veracruzanum*

Department of Santa Rosa

acatenangoensis
callidum
downsi
earlei
exiguum
haematopotum
mathesoni
metallicum
mexicanum
ochraceum
pulverulentum
rubicundulum
samboni
veracruzanum

NORTHERN ZONE

Department of Alta Verapaz

acatenangoensis
ardeni
benjamini
callidum
capricornis
carolinae
downsi
exiguum
haematopotum
jobbinsi
metallicum
mexicanum
ochraceum
rubicundulum
trivittatum
veracruzanum

Department of Baja Verapaz

callidum
downsi
jacumbae
jobbinsi
metallicum
ochraceum
rubicundulum
veracruzanum

Department of Huehuetenango

acatenangoensis
aureum
burchi
callidum
capricornis
delatorrei
downsi
ethelae
exiguum
haematopotum
jobbinsi
metallicum
mexicanum
microbranchium
ochraceum
pulverulentum
rubicundulum
smarti
tricornis
veracruzanum
wrighti
yepocapense

Department of Izabal

exiguum
haematopotum
metallicum
mexicanum
pulverulentum

Department of El Petén

benjamini
downsi
exiguum
haematopotum
metallicum
ochraceum
samboni

Department of El Quiché

acatenangoensis
aguirrei
aureum
burchi
callidum
capricornis
delatorrei
downsi
exiguum
jacumbae
metallicum
microbranchium
ochraceum
pacheco-lunai
rubicundulum
smarti
veracruzanum
wrighti
yepocapense

EASTERN ZONE

Department of Chiquimula

acatenangoensis	*haematopotum*	*ochraceum*
callidum	*metallicum*	*pulverulentum*
exiguum	*mexicanum*	*rubicundulum*

Department of Jalapa

downsi	*metallicum*
jacumbae	*ochraceum*

Department of Jutiapa

acatenangoensis	*exiguum*	*ochraceum*
downsi	*mathesoni*	*pulverulentum*
earlei	*metallicum*	*rubicundulum*

Department of El Progreso

callidum	*haematopotum*	*ochraceum*
downsi	*jacumbae*	*pulverulentum*
earlei	*metallicum*	*rubicundulum*

Department of Zacapa

callidum	*exiguum*	*mexicanum*
downsi	*haematopotum*	*pulverulentum*
earlei	*jacumbae*	*veracruzanum*

WESTERN ZONE

Department of Quezaltenango

aquamarensis	*ethelae*	*microbranchium*
aureum	*jacumbae*	*ochraceum*
callidum	*jobbinsi*	*rubicundulum*
carolinae	*metallicum*	*veracruzanum*
delatorrei	*mexicanum*	

Department of Retalhuleu

callidum	*metallicum*	*pulverulentum*
downsi	*ochraceum*	

Department of San Marcos

aureum	*exiguum*	*rubicundulum*
callidum	*haematopotum*	*samboni*
colvini	*jobbinsi*	*tricornis*
delatorrei	*metallicum*	*veracruzanum*
downsi	*ochraceum*	*wrighti*
dugesi	*pulverulentum*	

Department of Sololá

aureum	*jobbinsi*	*pulverulentum*
callidum	*larvispinosum*	*roblesi*
capricornis	*metallicum*	*rubicundulum*
carolinae	*mexicanum*	*samboni*
delatorrei	*microbranchium*	*smarti*
downsi	*ochraceum*	*tricornis*
ethelae	*pacheco-lunai*	*veracruzanum*
jacumbae	*parrai*	*wrighti*

Department of Suchitepéquez

callidum	*jobbinsi*	*pulverulentum*
carolinae	*larvispinosum*	*rubicundulum*
downsi	*metallicum*	*smarti*
earlei	*mexicanum*	*yepocapense*
exiguum	*ochraceum*	

Department of Totonicapán

aureum	*mathesoni*	*tricornis*
capricornis	*metallicum*	*veracruzanum*
delatorrei	*microbranchium*	*wrighti*
ethelae	*rubicundulum*	
jobbinsi	*samboni*	

Simulium ochraceum has consistently been considered the principal vector of onchocerciasis in the Western Hemisphere, not only because of its predominantly anthropophilic tendencies, but because of its distribution in relation to that of the disease. Most epidemiological reports on onchocerciasis claim that the distribution of *S. ochraceum* coincides with that of onchocerciasis. It would follow that the species does not exist, or is only infrequently found, outside of the onchocerciasis zones. However, the presence of this species outside of the disease zones, as well as the distribution of other anthropophilic species, rarely is mentioned. Torres Muñoz (1951), representing Mexico at the First International Conference on Onchocerciasis, expressed the common viewpoint that *S. ochraceum* is the important vector of onchocerciasis by virtue of its distribution, which conforms to that of the disease.

A study of map 4 will show that *S. ochraceum* is widely distributed in Guatemala, outside of the onchocerciasis zones as well as inside of them. As stated under the heading "Animal Associations" in the section on epidemiology, there are some regions in the onchocerciasis zones (Huehuetenango) where *S. ochraceum* has not been found and *S. veracruzanum* is the dominant anthropophilic species. It will be noted on map 5 that *S. metallicum* has a distribution similar to that of *S. ochraceum*. Attention should be called to the fact that several other anthropophilic species are distributed throughout large regions of the onchocerciasis zones as well as outside of them. *S. callidum,* although found well distributed in the disease zones (map 6), is always found in numbers so small that its importance in transmission can be discounted.

Although the distribution of *S. ochraceum* in relation to the distribution of onchocerciasis cannot in itself completely incriminate *ochraceum* as the principal vector or explain the limited and circumscribed disease zones, the prevalence or paucity of this species in certain regions may be a better index. It is true that the concentration of *S. ochraceum* is greater in the endemic regions than in regions free of the disease. As mentioned under "The Streams" in the section on epidemiology, *S. ochraceum* abounds in the "infant"-type streams. Such streams or rivulets are more prevalent on the Pacific slopes of the Sierra Madre. Here, in contrast to the Atlantic versant, the inclination of the land is greater, erosion is rampant owing to this inclination and to the type of soil which is composed primarily of volcanic sand and gravel, the slopes of the volcanoes are more extensive before reaching the coastal plane, thereby supporting a larger number of more rapid-flowing streams, the rainfall is greater, and the vegetation is more lush. This region, which boasts of the heaviest population and most extensive cultivation, is also that of greatest endemicity of onchocerciasis. In such areas, *S. metallicum, callidum, exiguum, haematopotum,* and *veracruzanum* may also be present, but because of their stronger zoophilic tendencies, they probably would not play as important a role in transmission as would *ochraceum.* Thus, because of its more anthropophilic tendencies, *ochraceum* would be more likely to be an efficient vector, even when present in much lower concentrations, than the more zoophilic species. As seen in table 6, the natural infection rate in *metallicum* is much greater than in *ochraceum.* This might be explained by the zoophilic tendencies of *metallicum,* its microfilariae possibly representing species infecting horses and cattle, as well as species infecting humans. In regions of the onchocerciasis zones where *ochraceum* does not exist or where it is present in only greatly reduced populations, *metallicum, callidum, exiguum, haematopotum,* and *veracruzanum* probably serve as more important intermediate hosts.

LIFE HISTORY

In studying the life histories of the Guatemalan Simuliidae attention was given primarily to the three principal anthropophilic species in the Yepocapa onchocerciasis zone—*Simulium ochraceum, S. metallicum,* and *S. callidum.*

GENERAL

The Simuliidae, or black flies, are small nematocerous Diptera, the adults rarely exceeding 5.0 mm. in length. They are often called "buffalo gnats" because of the "hump," or arch, that is characteristic of the thorax. The mouthparts are formed for piercing and sucking, but only the females are known to take blood.

The larval stage of all known species is passed in running water, varying from waterfalls to minute trickles, seldom in swampy areas or stagnant water. The larvae feed on minute animals and plants, or on particles of these, that are strained from the water with the aid of the mouth brushes. Thus, the current not only helps in supplying the necessary oxygen to the larvae but also transports food to the mouth brushes and maintains the latter open so that they can readily strain the food.

The larvae are usually found in the shallower parts of the streams, especially where obstructions cause rippling of the water surface. Rocks, stones, leaves, branches, and all sorts of debris serve as substrata for them. The larvae attach themselves to the substrata by means of an anal disc which makes it possible for them to retain their position even in very swift water. They seem to prefer for attachment clean substrata rather than ones that are covered by algae or slimy deposits. Their means of locomotion is very interesting and can be observed easily with the dissecting microscope when they are held in a watch glass, or through the glass walls of an aquarium into which air is pumped. My observations coincide with those given by Puri (1925). The larvae cannot swim or move freely through the water, except when they are carried by a current. Their movement appears very similar to that of the geometrid caterpillars. The larva, attached to the substratum by its anal disc, deposits a patch of viscous saliva with its mouthpart, and into it then fixes its pseudopod (thoracic proleg); as the proleg is being fixed, the larva simultaneously deposits more saliva to the right or left of the proleg and somewhat in front of it and, with a looping movement, frees the anal sucker, bringing it up to the new patch. The proleg is then released and the process is repeated. Although the resultant path of the larva may be in a straight line, each individual movement is at an angle to it. The larva, by means of its salivary glands, also spins silken threads which it uses as a means of quickly moving downstream, especially when it is disturbed. It can crawl back on the threads to its original place of attachment, using the mouthparts and pseudopod.

The larval stage lasts 1 to 9 weeks, depending on the species and the environmental conditions. Thus, the larval stage of *Gigantodax aquamarensis,* found breeding in streams with pH about 5, lasted 9 weeks. The larvae of all Guatemalan species whose development has been observed molt six times. In the larval habitat the last instar spins a silken cocoon in which pupation takes place. The form of the cocoon is commonly used to distinguish the species. The pupal stage varies from 2 to 10 days, depending primarily on the temperature of the water. Upon emergence, the adult rises to the surface of the water and takes to flight, soon after which mating is usually accomplished.

Oviposition usually takes place at the water's surface, or just below it, on some convenient substratum such as bare rock, emergent vegetation, or debris; rarely, the eggs are deposited as much as 3 to 6 inches beneath the surface of the water. Some species lay the eggs singly, but usually they are deposited in groups that are covered by a viscous matrix. A single female may lay as many as 500 eggs. The young larvae hatch from the eggs in 3 to 20 days. The specific oviposition habits of the principal anthropophilic species in Guatemala will be discussed along with their developmental cycle.

METHODS USED FOR STUDYING LIFE HISTORIES

In carrying out the life-history studies, the results of which are presented below, two techniques were used. The first entailed observation of the species in their natural habitat. The known breeding places of the species to be studied were visited regularly until ovipositing females were found. Detailed data were kept and daily checks were made to observe hatching and the development and habits of the larvae and pupae. The second technique was to observe the developmental stages on the laboratory grounds. A small channel was cut through the sloping lawn of the laboratory and enough water was diverted from a large stream to create a small rivulet similar to the natural breeding places. The same emergent and cover vegetation that is found in the streams in which the species breed, was planted in and along the rivulet. When females were observed ovipositing in the field, the egg masses were collected and immediately translocated in the laboratory canal. A series of long, raised, shedlike covers were constructed to protect the canal during heavy rains, thus preventing large numbers of larvae from being washed downstream. With this system, observations could be made on a single species, eliminating the possibility of confusing the larvae and pupae of more than one species or of more than one egg mass.

PRINCIPAL ANTHROPOPHILIC SPECIES

SIMULIUM (S.) OCHRACEUM WALKER

It has been particularly difficult to study the life history of this species because of its characteristic habitat and mode of oviposition. It is found breeding principally in *infant* and *young* streams which flow through "rugged" terrain. These streams are usually concealed by a dense canopy composed of three to four layers of vegetation—emergent vegetation, overgrowth of grasses and other plants preferring a moist environment, shrubs and low trees, and finally, tall trees. Thus the breeding places are difficult to find and somewhat inaccessible. The species has been collected at altitudes ranging from 500 to 6,000 feet, with one collection at 8,200 feet, but most commonly from 3,000 to 5,000 feet. At the breeding areas the streams show the following characteristics (Appendix III, table 31):

Width: Range, 1 in. to 15 ft.; optimum, 1 ft. to 5 ft.
Depth: Range, 1 in. to 3 ft.; optimum, 1 in. to 5 in.
Temperature: Range, 10° C. to 22° C.; optimum, 18° C. to 20° C.
Current: Range, 1 in. per second to 40 in. per second; optimum, 1 in. per second to 10 in. per second.
pH: Range, $<$6.0 to 8.0; optimum, 7.1 to 7.5.

Eggs, larvae, and pupae have been found on parts of the following plants that were floating on the surface of the streams or were emergent from them:

Axonopus compressus (Sw.) Beauv.	*Ipomoea* sp.
Tradescantia commelinoides R. and S.	*Hyptis sinuata* Pohl
Tripogandra cumanensis (Kunth) Woodson	

The immature stages have occasionally been found on debris vegetation, but never on hirsute plants. The following species of black flies are those most commonly found breeding (in order of frequency) in the same streams with *S. ochraceum* (Appendix III, table 33):

S. metallicum	*S. mexicanum*	*S. capricornis*
S. callidum	*S. jobbinsi*	*S. acatenangoensis*
S. rubicundulum	*S. smarti*	*S. parrai*
S. downsi	*S. veracruzanum*	

The adults mate soon after emergence, the spermatozoa being stored in the spermatheca. Development of the eggs to larvae depends on the ability of the female to secure blood meals before she oviposits. The time required for eggs to develop within the female is not known. Fertilization takes place from the spermatheca as the eggs are laid. *S. ochraceum,* unlike the other two species considered here, oviposits by hovering above the less turbulent parts of the stream and dropping relatively few eggs in any one place on the floating emergent vegetation. It deposits three to four eggs in approximately 10 seconds. It is difficult to find eggs if the female is not found in the process of oviposition because so few are laid in any one place. It was not realized for a long time that the hovering female was ovipositing, since all other species observed in this process either entered the water to deposit eggs, or approached or landed on a rock or a floating leaf. The oviposition has been observed most frequently between 12:00 m. and 2:00 p.m. The viscous matrix covering the eggs is of cream color, changing to brown and becoming harder within a few days. Within 3 to 10 days the young larvae emerge and soon migrate to an area where the current passes over the vegetation with somewhat more force. The larvae pass through four stadia, and probably a fifth, in 7 to 15 days. The more mature larvae maintain themselves in the swift currents, but just prior to pupation they migrate to quieter sections of the stream, often on the underside of the leaves or on the shielded parts of stones where they are afforded more protection. Here the larvae spin the cocoons in which they pupate, the process taking about 5 hours. The adult emerges in from 4 to 6 days and the female can live at least 27 days (see "Flight Range and Longevity" in the section on ecology, and Appendix III, table 32).

SIMULIUM (S.) METALLICUM BELLARDI

This species is more adaptable to different types of breeding habitats than is either *S. ochraceum* or *S. callidum*. Larvae are found in *infant, young, adolescent,* and *mature* streams almost indiscriminately, and are often found breeding in temporary streams of only a few weeks duration. The breeding sites range from 350 feet to over 9,000 feet, and are either open to the sun or well shaded by trees and shrubs. Although the species is more commonly found breeding in regions from 2,000 feet to 5,000 feet, it is not uncommonly found in areas both below and above these limits. The following description of the habitat will help one understand the adaptability of the species (Appendix III, table 31):

Width: Range, 1 in. to >15 ft.; optimum, 1 ft. to 8 ft.
Depth: Range, 1 in. to >3 ft.; optimum, <1 ft.
Temperature: Range, 8° C. to 28° C.; optimum, 17° C. to 20° C.
Current: Range, 1 in. per second to waterfalls; optimum, 1 in. to 20 in. per second.
pH: Range, 6.0 to 8.0; optimum 6.6 to 8.0.

The eggs, larvae, and pupae have been found on the following plants:

Axonopus compressus (Sw.) Beauv.
Coix lachryma-jobi L.
Tradescantia guatemalensis C. B. Clarke
Tradescantia commelinoides R. and S.
Tripogandra cumanensis (Kunth) Woodson
Heteranthera reniformis R. and P.
Renealmia sp.
Hyptis sinuata Pohl
Leguminosae
Acanthaceae
Compositae

Species of black flies often found breeding (in order of frequency) along with *S. metallicum* are (Appendix III, table 33):

S. callidum	*S. veracruzanum*	*S. pulverulentum*
S. downsi	*S. jobbinsi*	*S. jacumbae*
S. rubicundulum	*S. smarti*	*S. acatenangoensis*
S. mexicanum	*S. exiguum*	*S. yepocapense*
S. ochraceum	*S. capricornis*	*S. parrai*

Like *S. ochraceum,* the adults mate very soon after emergence, the spermatozoa being stored in the spermatheca. For the eggs to develop into larvae, the females must obtain blood meals prior to oviposition. Fertilization occurs as the eggs pass the opening of the spermatheca in the process of oviposition. The female oviposits in two manners. If the current is very rapid, it approaches the appropriate leaf at the surface of the water and deposits an egg without apparently landing; it then hovers above the leaf and returns to the same spot to deposit the second egg. The eggs are laid one in 2 seconds, contiguous to each other, but forming no general pattern and never overlapping. Should the stream be relatively slow-moving, the fly will actually land on the leaf to deposit the eggs. In this case, after each egg is laid, the fly moves about somewhat before returning to the area to lay the next egg. Often several females, at times as many as 30, have been seen ovipositing on a single leaf of *Renealmia* sp. One fly can deposit from 150 to 500 eggs in one mass. This species prefers the hours from 5 p.m. to 6 p.m. for oviposition, although it has been observed on several occasions as early as 3 p.m. The first-stage larvae emerge in from 3 to 20 days and soon arrange themselves in the smaller currents, most frequently attaching to leaves of plants, but at times to stones and rocks. The larval development follows that of *S. ochraceum,* with pupation occurring after 6 to 20 days. The cocoon is woven on leaves or stones in a manner similar to that of *S. ochraceum.* If the case is on a flat surface, it bears a winglike lateral extension on each side; if on rocks, inserted next to the vein on the underside of a leaf, or on a round twig, it may lack the extensions. The adult emerges in from 4 to 10 days, the females being capable of surviving at least 85 days (see "Flight Range and Longevity" in the section on ecology, and Appendix III, table 32).

SIMULIUM (*L.*) *CALLIDUM* (DYAR AND SHANNON)

Although neither the pupae nor the adults of this species are found in large concentrations, it seems to have adapted itself to many different types of streams far better than *S. ochraceum*. It has been found breeding primarily in streams similar to those in which *S. metallicum* is found. Its unique oviposition habits and the migration of its larvae have made it difficult to study the life history of this species. The streams in which *S. callidum* are found are usually in regions not very heavily wooded, and such streams are only lightly shaded by trees and shrubs, if at all. They are invariably more accessible than the breeding places of *S. ochraceum*. The altitudes at which *S. callidum* has been taken are from 900 to 8,200 feet, but usually between 900 to 6,000 feet. The streams can be characterized as follows (Appendix III, table 31):

Width: Range, 1 in. to >15 ft.; optimum, 1 ft. to 15 ft.
Depth: Range, <1 in. to >3 ft.; optimum, 1 in. to 1 ft.
Temperature: Range, 9° C. to 25° C.; optimum, 17° C. to 20° C.
Current: Range, 1 in. per second to waterfalls; optimum, 1 in. to 30 in. per second.
pH: Range, <6.0 to >8.0; optimum, 6.6 to 8.0.

The eggs, larvae, and pupae have been found on the following plants:

Axonopus compressus (Sw.) Beauv.
Coix lachryma-jobi L.
Tradescantia commelinoides R. and S.
Tradescantia guatemalensis C. B. Clarke
Tripogandra cumanensis (Kunth) Woodson
Renealmia sp.
Ipomoea sp.
Hyptis sinuata Pohl
Leguminosae

Other species commonly found breeding (in order of frequency) in the same streams as *S. callidum* are (Appendix III, table 33):

S. metallicum
S. rubicundulum
S. downsi
S. mexicanum
S. ochraceum
S. veracruzanum
S. smarti
S. jobbinsi
S. capricornis
S. exiguum
S. acatenangoensis
S. jacumbae
S. pulverulentum
S. parrai
S. yepocapense

The mating, egg development, and fertilization of *S. callidum* is similar to that of the two other species just discussed. The females have been seen ovipositing only on sharply inclined surfaces of rocks and stones in parts of the stream where the current is not very strong, but where the water definitely flows over the eggs. The most usual hours were from 3:30 p.m. to 5:30 p.m. The female hovers above the rock, lands only long enough to deposit one egg, then flies away to repeat the process on another suitable surface. On occasion, females may deposit several eggs on one surface in an irregular group which is covered by a dark viscous material to which sand and minute particles of debris become attached. At times, three to five females have been observed in the process of ovipositing in the same area. The individual eggs or egg groups can be found only after long and careful observation, since they are well camouflaged by the dark viscous matrix. The young larvae emerge after 3 to 8 days and then migrate, approximately 50 percent of the larvae attaching to leaves, the other 50 percent choosing stones, twigs, and debris in about equal numbers. The larval stage lasts from 8 to 25 days and the pupal stage lasts from 3 to 6 days, after which the adult emerges. The females of this species can survive at least 20 days in nature (see "Flight Range and Longevity" in the section on ecology, and Appendix III, table 32).

OTHER SPECIES

Since the principal anthropophilic species are those of major importance when considering the transmission of onchocerciasis, studies were made of the developmental cycle of only very few other species. The results are charted below in table 11.

TABLE 11.—*Life history of some Guatemalan Simuliidae*

Species	Feeding preferences	Duration of developmental stages (days)		
		Eggs	Larvae	Pupae
S. (*L.*) *veracruzanum*	Human and other animal hosts	5–6	8–17	4–8
S. (*L.*) *downsi*	Zoophilic, rarely biting man	6–10	7–16	3–8
S. (*D.*) *mexicanum*	Zoophilic	4–18	8–16	3–9
S. (*D.*) *rubicundulum*	Zoophilic	4–21	8–14	3–9
Gigantodax aquamarensis	Zoophilic	?	50–63	5–9

ECOLOGY

In the following discussion, everything related to the habits of the black flies and their relationship to the environment has been included. General discussions of geography and climate, plant associations, animal associations, and stream types found inside and outside of the onchocerciasis zones have already been given in the section on epidemiology, since these factors influence the presence or absence of the disease in particular regions, as well as its spread to new areas. They will again be incorporated in the following discussions, but only insofar as they bear directly on the subject being treated.

ADULT FLIES

ANTHROPOPHILIC SPECIES

The following discussion is concerned almost entirely with the three principal anthropophilic species, *Simulium ochraceum, metallicum,* and *callidum.* Summarized in table 34 of Appendix III are the feeding and resting habits of three other less important species attacking man, *S. veracruzanum, haematopotum,* and *exiguum.*

Host Preferences

To determine which species of Guatemalan black flies preferred human hosts and which preferred other animals, two series of experiments were organized. In the first experiment, several groups of men, composed of two individuals each, were set out in areas where black flies were abundant. One individual of each group served as a subject, removing all clothing from the feet and from the waist up, and rolling up his trouser legs; the other person collected specimens as they began to bite the subject. This type of collection was made at every opportunity—at the same time larval and pupal collections were being made throughout the country, or when groups were specifically designated for that purpose.

Of the 41 species now known to exist in Guatemala (see section entitled "Entomological Studies in Guatemala"), the following 8 have been found to bite man in nature:

S. metallicum	*S. veracruzanum*
S. ochraceum	*S. haematopotum*
S. callidum	*S. downsi*
S. exiguum	*Cnephia pacheco-lunai*

Of this group, *S. downsi* and *Cnephia pacheco-lunai* bite man only rarely, but *S. exiguum, S. veracruzanum,* and *S. haematopotum,* which are widespread throughout large regions of the onchocerciasis zones, are voracious biters of man wherever they exist. It will be seen in table 9 that *S. metallicum, S. ochraceum,* and *S. callidum* are the species that attack man most commonly. Although from the table it might be assumed that *S. metallicum* is more anthropophilic in its feeding habits than *S. ochraceum,* the reverse is actually true. Since *metallicum* is the dominant human biter throughout most of the year, a larger percent of the total number of biting flies collected were of that species. However, considering the preference of *ochraceum* and *metallicum* for human or other animal hosts, the former species will be found to be predominantly anthropophilic while the latter tends to be more zoophilic. Table 10 summarizes the results of a second series of experiments in which flies were collected from both a human and other animal subject, these situated next to each other. It is clearly demonstrated that *S. ochraceum* prefers man to any other animal host. *S. metallicum* prefers horses, mules, donkeys, and cattle, but selects man before pigs, sheep, dogs, cats, or any avian host. *S. callidum* also shows the same host preferences as *metallicum* with the exception that it also attacks goats before man. It should be noted (table 10) that, of the flies collected from any of 19 distinct animal hosts, *S. metallicum* was always the dominant species taken.

Body Regions Preferred

It is sometimes stated that *S. ochraceum* is a more effective transmitter of onchocerciasis to man than either *S. metallicum* or *callidum* because it attacks the upper regions of the body that are more generally exposed and that contain high concentrations of microfilariae in the subcutaneous tissues, while the latter two species bite only on the lower regions where microfilariae are not found. Three series of experiments were carried out, designed to determine the validity of this belief. In the first, a human subject was exposed to the bites of flies, all his clothes removed except his under shorts. Three individuals collected flies from the subject, recording where the flies were biting. Temperature, relative humidity, and light reflected from the subject were determined every 30 minutes. Forty-nine such experiments were carried out, each lasting from 6:30 a.m. until 5 p.m. In the second series, the subject was exposed only from the waist up in half of the experiments, and from the waist down in the other half. In the third series of experiments several groups of flies were fed on various areas of the upper body regions of an infected individual, while other groups were fed on the lower limbs. It will be seen in table 12 that when a person is fully exposed to the bites of the three principal anthropophilic species, *S. ochraceum* shows definite preferences for the upper regions of the body, while *S. metallicum* and *S. callidum* prefer the lower regions. However, as shown in table 13, when the preferred region is covered, any one of the three species will bite any part of the body that is exposed. Actually, workers on the coffee plantations in the onchocerciasis regions are exposed to all three species. The men usually roll up their trousers and shirt sleeves, while the type of clothing worn by the women permit biting on the head and neck, as well as on the feet and legs (pl. 5, fig. 1). To further invalidate the reasoning that *ochraceum* is a better transmitting agent than *metallicum* or *callidum* by virtue of its preferred biting regions, it should be noted that we

TABLE 12.—*Simuliid feeding preference for body parts of human subjects*

Preference for particular body region expressed as percentage of total number of flies biting the subject

(Upper and lower body parts of subject exposed. Observations made on 49 days from 6:30 a.m. to 5 p.m., the meteorological conditions varying throughout the period.)

		Percent biting											
		Body parts										Total percent biting	
		Upper body region						Lower body region					
Species	Total number biting flies	Face	Neck	Waist up, front	Waist up, back	Arm	Hand	Upper leg	Shin	Calf	Foot	Upper body region	Lower body region
ochraceum	14,841	2	3	19	34	9	1	8	6	13	5	68	32
metallicum	6,962	2	1	6	7	4	1	9	12	33	25	21	79
callidum	928	1	1	4	2	2	–	7	5	43	35	10	90

TABLE 13.—*Simuliid feeding in relation to parts of body exposed*

Feeding expressed as percent of total number of flies biting subject on particular body region

(Human subject exposed from the waist up or waist down as indicated for each species. Observations made on 46 days from 6:30 a.m. to 5 p.m., the meteorological conditions varying throughout the period. There were 23 experiments executed with the subject exposed from the waist up and 23 with the subject exposed from the waist down.)

			Percent biting									
			Body parts									
			Upper body region						Lower body region			
Species	Body region exposed	Total number biting flies	Face	Neck	Waist up, front	Waist up, back	Arm	Hand	Upper leg	Shin	Calf	Foot
ochraceum	Waist up	18,079	4.0	5.0	35.7	43.7	11.4	0.2				
	Waist down	8,177							29.2	20.5	35.1	15.2
metallicum	Waist up	1,495	10.4	2.8	32.4	19.1	30.3	5.0				
	Waist down	4,985							17.2	15.2	38.8	28.8
callidum	Waist up	100	11.0	1.0	77.0	6.0	5.0	0.0				
	Waist down	521							10.0	9.5	51.6	28.9

have found that flies fed on the thigh of an infected person will take up at least as many microfilariae as those that were fed on the upper torso.

Since 65 percent of all the flies collected from human subjects were *metallicum* (table 9), and since the natural infection with larval filariae in this species was found to be greater than in *ochraceum* (table 6, p. 41), it would appear that *metallicum* might be the more important vector of onchocerciasis. However, if it could be shown that the natural infection in *metallicum* is probably composed of larval filariae from other animals, as well as from humans, the role of this species in the transmission of human onchocerciasis might not be as important as it appears superficially from examination of data contained in tables 6 and 9. This could only be determined circumstantially, since the developing larvae of *Onchocerca* species from man and other animals still are not distinguishable in the flies. Thus it was decided to learn if *S. metallicum* would feed alternately on human and other animals. Specimens captured while they were feeding on human subjects were fed subsequently on other animals; likewise, ones taken from animals other than man were later fed on human subjects. The species constantly demonstrated indiscriminate feeding habits. Since *metallicum* will alternately bite man and other animals, and since, of the total population of this species, the great majority prefer hosts other than man (table 10), it is quite probable that a large part of the larval filariae found in wild-caught specimens represent *Onchocerca* species of horses or cattle, mammals commonly infected in Guatemala (Gibson, 1951a). To substantiate this, it still remains necessary to discover characteristics by which one can distinguish, in their fly-inhabiting stages, the species of *Onchocerca* that infect man from those that infect other animals.

Since *S. ochraceum, metallicum,* and *callidum* are usually found in the regions where the disease is prevalent, readily feeding on man and becoming infected, and since they are easily collected in the region of our field laboratory, most of our experimental work was done with them. However, this does not preclude the possibility that other species attacking man may be involved in the transmission of onchocerciasis in at least some regions of the disease zones. This was demonstrated experimentally for *S. exiguum, veracruzanum,* and *haematopotum* (see "Animal Associations" in section on epidemiology).

Feeding Time

The transmission of onchocerciasis by means of the bite of *Simulium* flies has been doubted by some workers because so few infective-stage larvae are found in the head region of infected wild-caught flies in comparison to what occurs in the mosquito, *Culicoides* spp., and other insect vectors of filarid worms. Actually, since the natural-infection rate in *Simulium* spp. is itself so low, it should be expected that the great majority of infected flies would contain developmental stages of the filarid larvae in the thoracic muscles rather than infective forms. However, a study of the feeding time of the three principal anthropophilic species does offer a plausible explanation for the paucity of infective larvae in the head region of wild-caught flies.

Numerous observations were made of flies feeding on human subjects. The following information was recorded: Species, activity of the fly on the subject prior to feeding, region of body chosen, and time required for feeding. It was at first thought preferable to include in the data only flies that had fed to repletion, but it was impossible to choose the satiation point since many engorged flies fell off the subject and died. It was therefore decided to use the general feeding time of all flies. In table 14 the time required for feeding indiscriminately on all parts of the body has been averaged for each species. In table 15 is presented the feeding time of flies biting only on preferred regions of the body (i.e., upper body region for *S. ochraceum,* and lower limbs for *S. metallicum* and *callidum*). (See also Appendix III, text fig. 14.)

It can be seen in table 14 that *S. ochraceum, metallicum,* and *callidum* all feed over a comparatively long period of time. The ranges of feeding time for these species are: 1 to 19 minutes, 1 to 31 minutes, and 1 to 15 minutes respectively; the mean feeding times are 4.8, 4.3, and 4.5 minutes respectively. When the feeding times on preferred regions alone are considered (table 15), the means for the three species are more dispersed and the differences between them are statistically valid. In all three species, the feeding time was reduced when the areas attacked contained numerous superficial blood vessels. Since the bite of the black fly is usually not perceived until the feeding has progressed rather far, and since the actual feeding extends over a relatively long period of time, the infective stages in the flies would have ample time to migrate from the thoracic muscles to the mouthparts, from which they can then enter the wound.

Simulium ochraceum differs from *metallicum* and *callidum* insofar as its behavior on the host just prior to, and after, piercing the skin is concerned. In general, *ochraceum* is less "nervous" than the other two species. It will land on a body region without much initial hovering, and after landing it moves about very little before piercing the skin and taking blood. The mouthparts are introduced to a great

TABLE 14.—*Feeding time of the three principal anthropophilic species of Simuliidae*

Expressed as the mean feeding time of flies biting indiscriminately on all parts of the body

(The validity of the difference of mean feeding time of these species is expressed by the standard error of the difference of the means.)

Species	Number of flies	Mean (minutes)	Range (minutes)	Standard deviation	Standard error of mean	Standard error of difference		Validity
						Species involved	Standard error	
S. (*S.*) *ochraceum*	1,012	4.8	1–19	2.57	.081	*ochraceum-metallicum*	0.5 ± 0.12	Valid
S. (*S.*) *metallicum*	803	4.3	1–31	2.55	.090	*metallicum-callidum*	0.2 ± 0.19	Invalid
S. (*L.*) *callidum*	232	4.5	1–15	2.57	.167	*ochraceum-callidum*	0.3 ± 0.19	Invalid

TABLE 15.—*Feeding time of the three principal anthropophilic species of Simuliidae*

Expressed as the mean feeding time of flies biting on the preferred parts of the body of human subjects (*S. ochraceum* biting on the upper torso, *S. metallicum* and *S. callidum* biting on the lower limbs)

(The validity of the difference of mean feeding time of these species is expressed by the standard error of the difference of the means.)

Species	Number of flies	Mean (minutes)	Range (minutes)	Standard deviation	Standard error of mean	Standard error of difference		Validity
						Species involved	Standard error	
S. (*S.*) *ochraceum*	782	5.1	1–19	2.66	0.10	*ochraceum-metallicum*	1.3 ± 0.15	Valid
S. (*S.*) *metallicum*	480	3.8	1–19	2.53	0.11	*metallicum-callidum*	0.6 ± 0.19	Valid
S. (*L.*) *callidum*	197	4.4	1–14	2.2	0.15	*ochraceum-callidum*	0.7 ± 0.18	Valid

depth, and once feeding, the fly will not remove its mouthparts or fly away, even when touched by the fingers, stroked by another object, or covered by a collecting tube. *S. metallicum* and *callidum,* on the other hand, hover about the subject and may land momentarily several times before finding a suitable spot. Once landed, these species move about on the skin before inserting the mouthparts. While feeding, they often move the legs and body. Although these flies will not leave the host when the part they are biting is moving slowly, they will stop feeding and fly away should they be touched, stroked, or crossed by a shadow of a collecting tube. The behavior pattern of *ochraceum* would indicate that this species might be more efficient in transmitting the infective stages to man since its feeding is not easily interrupted, thereby permitting sufficient time for migration of infective stages to the mouthparts. On the other hand, because of its opportunity for noninterrupted blood meals, this species is likely to pick up large numbers of microfilariae, the presence of which might cause the death of the flies.

Effect of Environment on Feeding Habits

In an attempt to learn the effect of some of the environmental factors on the feeding habits of the three anthropophilic species, a large series of experiments was carried out. On 95 days, from the hours of 6 to 6:30 a.m. until 5:30 p.m., subjects were exposed in the field to the bites of the flies, each subject being accompanied by three observers. In some of the experiments the subject rotated with the movement of the sun, in others he kept stationary. The following factors were notated every 10 minutes: Time, temperature, reflected light (from chest and back), relative humidity (every 30 minutes), general weather conditions (clouds, clarity of sun, etc.), the species of fly biting, part of body attacked by fly, and whether the biting fly was in the sun or shade. Relative humidity data were taken during 69 experiments only.

Relation of time of day to biting habits.—In table 16 a summary of the relation of time of day to the biting habits of *S. ochraceum, metallicum,* and *callidum* has been given. *S. ochraceum* appears to bite from about 7 a.m. until 4 p.m., few feeding before or after these extremes. The most active feeding period is from 8 a.m. to 10:00 a.m. The effect of the time of day seems to be the same for flies feeding on shaded regions or those exposed to the sun, although less actual feeding takes place in the sun. *S. metallicum* starts feeding in the morning at about the same time as *ochraceum,* preferring the hours of 8-10 a.m., but it continues to feed in good numbers until 5:30 p.m. *S. callidum* differs from both *ochraceum* and *metallicum* in that it prefers to bite from dawn to about 9 a.m. and again from 3 or 4 p.m. until twilight, with very little activity during the middle of the day. (See also Appendix III, text fig 15.)

Relation of air temperature and relative humidity to biting habits.— It can be seen in table 17 that *S. ochraceum* feeds in the sun at air temperatures from 15° C. to >40° C., with its optimum between 34° C. and 35° C., above which there is a marked reduction in activity. In the shade, this species will start feeding at slightly lower temperatures than in the sun. *S. metallicum* starts actively feeding at

TABLE 16.—*Relation of time of day to biting habits of adult Simuliidae*

Expressed as number of flies biting per observation period

(Flies collected while feeding on human subjects who were exposed to bites on 95 days from 6:30 a.m. until 5:30 p.m. Sun or shade readings indicate that the flies were biting on a part of the body that was either shaded or exposed to the sun.)

Hour	Number of observation periods	Total number of flies	*ochraceum*		*metallicum*		*callidum*	
			Shade	Sun	Shade	Sun	Shade	Sun
6– 7......	74	983	4.7	2.7	2.5	0.5	2.4	0.3
7– 8......	95	5,526	29.9	14.3	6.2	3.4	3.4	1.0
8– 9......	95	8,605	44.1	24.1	12.2	7.9	1.9	0.3
9–10......	95	8,029	39.4	23.4	12.7	8.0	1.0	0.1
10–11......	95	6,272	31.2	17.8	11.2	5.4	0.4	0.1
11–12......	92	5,220	28.5	14.7	8.8	4.1	0.5	0.1
12– 1......	87	5,142	29.7	15.4	9.8	3.7	0.4	0.1
1– 2......	83	4,727	27.7	14.6	10.3	3.4	0.6	0.2
2– 3......	80	4,149	26.9	11.9	9.4	3.0	0.6	0.1
3– 4......	69	3,479	25.1	10.1	10.9	2.9	1.3	0.1
4– 5......	65	2,290	16.8	5.2	9.0	2.8	1.2	0.3
5– 6......	43	1,529	14.2	5.3	10.0	2.5	2.8	0.8

about 22° C. in the sun and at 17° C. in the shade, and then continues to feed with almost equal avidity until above 40° C. There is a slight rise in activity between 27° C. and 28° C. in the sun and between 25° C. and 27° C. in the shade. *S. callidum* starts feeding actively at temperatures well below 13° C., especially when in the shade, and continues almost evenly until 30° C. in the sun and 34° C. in the shade, above which it does not feed at all. This would explain its lack of activity during the great part of the day when the temperatures are above its optimum.

Considering only the relationship of relative humidity to the biting activity of the flies, the following observations can be derived from table 18: At high relative humidities, *ochraceum* is much more active than at lower humidities, its optimum appearing to be between 81 and 90 percent; there is marked reduction in biting activity above 90; at higher humidities, especially in its optimum range, this species defi-

TABLE 17.—*Relation of air temperature to biting habits of adult Simuliidae*

Expressed as number of flies biting per observation period

(Flies collected while feeding on human subjects who were exposed to bites on 95 days from 6:30 a.m. until 5:30 p.m. Air temperature was recorded every 10 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was either exposed to the sun or shade.)

Temperature (° C.)	Number of observation periods		Number of flies biting per observation period					
			ochraceum		*metallicum*		*callidum*	
	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade
<13	19	22	0.9	2.0	0	0.3	0.05	0.6
13	11	26	0.6	2.2	0	0.7	0.09	0.5
14	55	58	0.6	3.6	0	0.9	0.02	0.9
15	72	82	2.3	3.8	0.3	0.9	0.09	0.6
16	107	157	1.6	2.6	0.3	0.9	0.09	0.4
17	142	283	2.2	3.0	0.2	1.1	0.06	0.9
18	268	419	1.7	4.7	0.3	1.3	0.08	0.4
19	251	482	2.3	4.8	0.7	1.1	0.2	0.2
20	360	700	2.0	4.2	0.7	1.6	0.1	0.2
21	304	533	2.4	2.5	0.8	1.7	0.03	0.2
22	318	671	3.1	4.6	1.6	2.3	0.07	0.2
23	257	436	3.4	5.9	1.0	2.0	0.03	0.1
24	215	345	5.7	7.1	1.9	2.0	0.07	0.3
25	259	266	5.3	5.9	1.4	2.8	0.03	0.1
26	222	227	6.7	5.5	1.8	2.3	0.03	0.1
27	139	150	6.9	7.1	2.5	3.8	0.02	0.1
28	117	124	6.2	6.8	2.2	2.0	0.01	0.1
29	41	41	7.6	5.7	2.1	1.5	0.04	0
30	50	50	7.1	10.6	1.9	1.5	0.02	0.02
31	40	40	4.1	5.2	1.5	1.9	0	0.05
32	41	41	7.8	7.6	2.0	1.3	0	0.02
33	31	31	5.6	7.5	1.2	1.9	0	0
34	28	28	16.7	17.6	0.6	0.4	0	0.03
35	48	48	15.6	19.4	1.2	0.6	0	0
36	19	19	7.9	2.9	1.2	0.7	0	0
37	15	15	3.0	2.3	0.7	0.9	0	0
38	12	12	3.1	1.3	2.1	0.5	0	0
39	7	7	5.0	1.0	1.8	0.5	0	0
40	13	13	2.6	1.6	1.2	2.2	0	0
>40	22	22	2.0	1.6	1.1	1.3	0	0

nitely prefers biting in the sun; from 41-80, it prefers feeding on shaded parts of the subject, except between 51 and 60, when the feeding is almost indiscriminate on regions exposed to the sun or shade; in the shade, fewer flies bite in relative humidities within the optimum range and between 41 and 70; at less than 40, the biting activity is the same in the sun and shade.

Simulium metallicum seems to bite almost as actively in low relative humidity as in high humidity, although its optimum also falls between 81 and 90; there is a slight reduction in activity at relative humidities above 90, but not as marked as for *ochraceum;* this species generally prefers to bite on shaded regions, except at relative humidities below 40, when the preference is definitely for areas exposed to the sun (no biting at all in shaded areas), and within its optimum range of 81 to 90, when it slightly favors these sun-exposed areas.

TABLE 18.—*Relation of relative humidity to biting habits of adult Simuliidae*

Expressed as number of flies biting per observation period at different ranges of relative humidity

(Flies collected while feeding on human subjects who were exposed to bites on 69 days from 6:30 a.m. until 5:30 p.m. Relative humidity was recorded every 30 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was either shaded or exposed to the sun.)

Relative humidity (percent)	Number of observation periods		Number of flies biting per observation period					
			ochraceum		*metallicum*		*callidum*	
	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade
91–100......	254	600	9.9	9.2	3.2	3.5	0.2	0.6
81– 90......	74	221	41.3	23.4	8.8	7.9	0.2	0.6
71– 80......	114	214	13.7	19.3	3.2	6.0	0.1	0.8
61– 70......	81	139	26.9	34.8	6.9	8.2	0.1	0.9
51– 60......	54	58	26.0	25.6	5.0	5.7	0.9	0.6
41– 50......	11	11	22.0	29.4	7.8	8.3	0.0	0.4
31– 40......	2	2	3.5	3.5	7.5	0.0	0.0	0.0

Simulium callidum differs from *ochraceum* and *metallicum* in that its preference for biting on shaded regions over regions exposed to the sun ranges from 3-9: 1, while in the latter two species it never quite reaches 2: 1 (table 18); this preference for the shade is demonstrated in all ranges of relative humidity except between 51 and 60, where there is a favoring of regions exposed to the sun; this latter range is also its optimum for biting; *callidum* does not bite below 31-40, but its activity between 91 and 100 is almost equal to that shown at any other range of relative humidity, except from 51 to 60; the negative data on feeding below 40, as seen in table 18, may be due to the small number of observations made in this range of relative humidity, as well as to the relatively low population of *callidum* as compared with *ochraceum* or *metallicum.*

Table 19 presents the relationship of both air temperature and relative humidity to the biting activities of *S. ochraceum, metallicum,* and

TABLE 19.—*Relation of both relative humidity and air temperature to biting habits of adult Simuliidae*

Expressed as number of flies biting per observation period at different combinations of relative humidity and air temperature. "M" signifies the median point, above and below which 50 percent of the flies fall

(Flies collected while feeding on human subjects who were exposed to bites on 69 days from 6:30 a.m. until 5:30 p.m. Relative humidity was recorded every 30 minutes and air temperature every 10 minutes. No distinction was made as to whether flies were biting in sun or shade.)

Temperature (° C.)	Number of observation periods	Relative humidity 91-100 percent			Number of observation periods	Relative humidity 81-90 percent			Number of observation periods	Relative humidity 71-80 percent			Number of observation periods	Relative humidity 61-70 percent		
		ochraceum	*metallicum*	*callidum*		*ochraceum*	*metallicum*	*callidum*		*ochraceum*	*metallicum*	*callidum*		*ochraceum*	*metallicum*	*callidum*
10–11...	0	0	0	0	1	3.0	0	0	0	0	0	0	0	0	0	0
12–13...	12	1.8	0.7	0.6	9	1.3	0.4	0.2	7	2.7	0.4	0.3	0	0	0	0
14–15...	14	2.3	0.6	0.3	10	2.7	1.1	0.2	11	3.1	0.2	0.1	0	0	0	0
16–17...	128	5.7	0.6	(M)0.4	96	1.3	0.7	0.3	55	3.3	0.4	0.2	5	22.4	0.4	0.6
18–19...	315	3.0	0.8	0.3	171	2.4	0.8	(M)0.1	89	5.6	0.9	(M)0.2	81	11.6	1.4	0.2
20–21...	595	2.6	1.1	0.2	141	5.2	2.5	0.3	96	4.0	0.8	0.2	79	17.5	2.6	(M)0.1
22–23...	363	4.9	2.1	0.2	233	4.5	2.1	0.04	141	6.1	2.1	0.2	117	11.9	3.9	0.8
24–25...	245	5.0	2.4	0.3	196	6.3	(M) 1.7	0.1	132	10.4	3.6	0.1	86	15.9	3.4	0.01
26–27...	144	7.2	(M) 3.1	0.1	158	7.4	3.4	0.1	80	7.6	6.7	0.2	58	(M)20.6	4.2	0.03
28–29...	70	5.2	2.6	0.1	64	10.3	1.6	0	24	11.0	1.8	0.04	30	12.5	(M)5.1	0
30–31...	36	6.4	2.3	0.1	22	14.1	2.1	0	29	(M)9.8	2.4	0	16	6.1	0.9	0
32–33...	12	4.2	2.4	0	15	(M)19.8	0.1	0.2	21	16.7	(M) 2.9	0	11	10.8	4.7	0
34–35...	11	(M)47.3	1.2	0	35	48.1	0.4	0	23	13.8	2.1	0.04	7	22.0	2.4	0
36–37...	7	1.6	0.6	0	7	19.0	0.9	0	12	6.7	2.4	0	11	4.2	1.5	0
38–39...	15	3.9	1.9	0	6	1.2	0	0	7	3.3	0.3	0	4	2.8	1.5	0
40–41...	6	1.0	2.2	0	4	4.3	0.3	0	3	7.7	7.7	0	6	3.2	1.2	0
42–43...	3	0	1.7	0	4	2.0	0	0	0	0	0	0	1	16.0	2.0	0
44–45...	0	0	0	0	2	3.5	2.0	0	3	7.3	1.0	0	2	3.0	4.5	0
46–47...	0	0	0	0	0	0	0	0	3	3.0	4.7	0	1	2.0	0	0
48–49...	0	0	0	0	0	0	0	0	2	1.0	7.0	0	0	0	0	0

(Continued)

TABLE 19.—*Relation of both relative humidity and air temperature to biting habits of adult Simuliidae*—Concluded

Temperature (° C.)	Number of observation periods	Relative humidity 51-60 percent			Number of observation periods	Relative humidity 41-50 percent			Number of observation periods	Relative humidity 31-40 percent		
		ochraceum	*metallicum*	*callidum*		*ochraceum*	*metallicum*	*callidum*		*ochraceum*	*metallicum*	*callidum*
10–11...	0	0	0	0	0	0	0	0	0	0	0	0
12–13...	1	1.0	0	0	0	0	0	0	0	0	0	0
14–15...	8	4.9	0.9	0	0	0	0	0	0	0	0	0
16–17...	0	0	0	0	0	0	0	0	0	0	0	0
18–19...	28	4.1	0.8	(M)1.9	0	0	0	0	0	0	0	0
20–21...	34	4.4	1.9	0.6	5	5.2	1.0	0	0	0	0	0
22–23...	60	14.6	(M)55.2	0.1	8	20.0	6.8	0	0	0	0	0
24–25...	45	9.8	2.3	0	4	15.0	5.0	0	1	2.0	3.0	0
26–27...	19	(M) 17.2	1.9	0	2	(M) 5.0	(M)3.5	0	3	1.0	1.0	0
28–29...	22	11.9	3.1	0.2	9	11.3	4.4	0	0	(M) 0	(M) 0	0
30–31...	9	28.5	1.5	0	6	18.2	3.0	0	1	9.0	9.0	0
32–33...	13	6.0	2.5	0	7	8.6	3.0	0	0	0	0	0
34–35...	3	10.7	4.0	0	3	7.7	2.7	0	0	0	0	0
36–37...	0	0	0	0	2	7.5	2.0	0	0	0	0	0
38–39...	0	0	0	0	0	0	0	0	0	0	0	0
40–41...	0	0	0	0	0	0	0	0	0	0	0	0
42–43...	0	0	0	0	0	0	0	0	0	0	0	0
44–45...	0	0	0	0	0	0	0	0	0	0	0	0
46–47...	0	0	0	0	0	0	0	0	0	0	0	0
48–49...	0	0	0	0	0	0	0	0	0	0	0	0

callidum. Under the ranges of relative humidity, the median point, or reading above and below which 50 percent of the flies fall, is indicated for each species. The following observations appear significant: The medians of the three species are at different levels of temperature in almost every range of relative humidity, especially in the high ones; *S. callidum* definitely bites at a significantly lower temperature than either *metallicum* or *ochraceum;* at relative humidities between 81 and 100, *ochraceum* seems to bite at considerably higher temperatures than *metallicum* or *callidum; callidum* has a threshold relative humidity between 51 and 60, below which the species does not bite (also borne out in table 18) ; while the medians for biting incidence of *metallicum* and *ochraceum* vary considerably between each range of relative humidity, the median of *callidum* remains fairly constant (except between 31 and 40, for which range the number of observations was too small to be significant). (See also Appendix III, text figs. 16-21.)

Relation of light intensity to biting activity.—As stated in the introductory paragraphs on the effect of environment on feeding habits, readings of light reflected by the human subjects were taken every 10 minutes during the experiments designed to determine the effect of various environmental factors on the feeding activity of the flies. It was found that the three principal anthropophilic species would bite when the reflected light readings (taken with a General Electric exposure meter) ranged from 0-20 footcandles, the optimum being between 4 and 10. The intensity of reflected light, as would be expected, is related to the time of day, the clarity of the sky, quantity of vegetation giving shade, and the color of the subjects' skin. Light-skinned subjects reflected much more light, at times three or four times more, than did dark-skinned subjects. In the early morning and in the evening, when the light readings were zero, few if any flies would bite the dark individuals, while they would readily bite the fairer-skinned ones. However, during the middle of the day, when the light intensity increased, there was little difference between the number of bites received by the light- and dark-skinned subjects. In open areas with clear bright sun, the light intensity is often such that only dark-skinned individuals are bitten.

It has often been said that *Simulium* species will not bite indoors, supposedly owing to inadequate light. However, *Simulium ochraceum* frequently, and *S. metallicum* on occasion, have been found biting inside of our laboratory during the night at light intensities that were greatly reduced although apparently sufficient for fly activity. The lighting in the rooms where fly biting occurred consisted of two 20-watt fluorescent bulbs which were ample to give a reading of light, reflected from a fair-skinned subject, of 2 footcandles.

Flight Range and Longevity

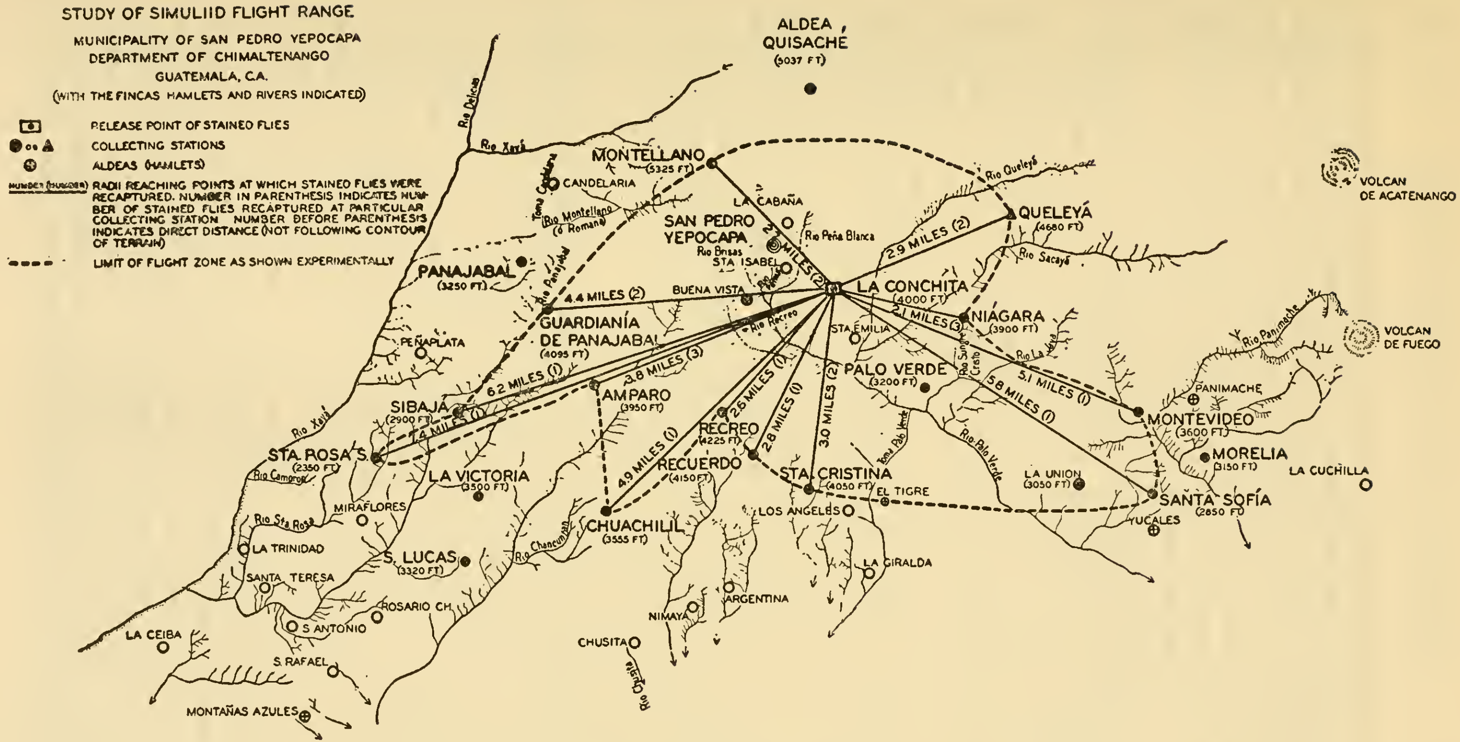
In discussing the epidemiological role of black flies in relation to onchocerciasis the following three important problems must be considered: First, whether the flight range of the anthropophilic species is sufficient to permit the introduction and subsequent establishment of vector species into areas supposedly free of onchocerciasis. Second, the length of life of the females should be known in order to correlate it with the first point, thereby giving additional weight to the possibility that the disease may extend beyond its present boundaries. Third, it must be determined whether or not infection with the larval stages of *Onchocerca volvulus* adversely affects the flight range and longevity of the flies. If infection greatly reduces flight range and life span, it may partially explain the restriction of the disease zone to its presently known limited confines. From the standpoint of insecticide control of the anthropophilic species of black flies, the first two mentioned considerations would indicate to what extent infiltration by the flies from nontreated to treated areas might be expected. This information would serve in establishing the size of the area that must be treated in order to achieve adequate control.

Flight-range studies.—In 1949, Dalmat (1950c) reported the first experimental studies on the flight range of black flies. They were carried out in the Municipality of San Pedro Yepocapa, Chimaltenango, Guatemala, in the region of the Onchocerciasis Field Laboratory. In general, wild-caught flies were stained and set free, after which collections were again made at fixed stations with the hope of recapturing stained flies. Metallic dusts, fluorescent dyes, and radioactive substances were ruled out as possible fly markers owing to the difficulty of handling them under strenuous field conditions. In the case of fluorescent dyes, the necessity of making initial field checks to determine whether or not fluorescent particles occur naturally in the region was considered an additional drawback. Instead, aniline dyes and certain natural dyes were used as markers, after they had been proved efficient in preliminary tests. Twenty collecting stations were established in all directions from 2 to 8 miles from the release point of the stained flies. All captures were made from men who served as bait. Records were kept of precipitation, relative humidity, temperature, and winds. The only meteorological factor that could probably have influenced the distance from the release point at which stained flies were recaptured was the wind. When these experiments were under way, the winds were irregular and changeable during the hours of greatest fly activity. The finding of flies in all directions from the release point indicated that the winds probably had not had much effect on the flight of the flies.

On 75 days of the 94-day-long experiment 19,580 female flies were stained and released. Collections were begun the day following initial release of stained flies. In all, 18,707 flies were collected during 711 visits that were made to the various stations around the release point. These were observed through a dissecting microscope as they were passed, one at a time, into a solvent composed of absolute alcohol, glycerine, and chloroform in the proportion of 3 to 2 to 1. Of the total, 21 were stained flies. These included 9 *ochraceum*, 8 *metallicum*, and 4 *callidum*. They were recovered at distances ranging from 2.1 miles up to 7.4 miles from the release point (map 15). These, of course, do not represent the actual distances traveled by the recaptured flies. Considering the extreme irregularities of the terrain, some of the ravines traversed being over 500 feet deep and over a mile across, it is quite probable that the flies had landed several times and that the distances noted should actually be much greater. One stained *metallicum* was recovered 3.8 miles from the release point the day following initial release of stained flies. This suggested a very rapid flight and the likelihood that the flies travel great distances.

Since the results of these flight-range studies were rather surprising, Dalmat (1952a) repeated the experiment in another area (Municipality of Acatenango, Chimaltenango, Guatemala) to confirm the original findings. The techniques were the same as in the first study. During the period of the experiment, the winds shifted a good deal but generally prevailed toward the northeast. Since stained flies were recaptured as much to the south and west of the release point as to the north or east, it was considered that the flight of the flies was either not affected or only negligibly affected by the winds. A total of 66,544 female flies was stained and released. In all, 52,685 flies were collected during 1,510 visits to the 33 collecting stations. Of this number, 31 were stained flies, one being *ochraceum* and all the others *metallicum*. The flies were recovered from 1.0 to 9.7 miles from the release point, as compared with 2.1 to 7.4 miles in the 1949 experiment, the distances being measured as straight lines on the map. Diagrammatic profiles, drawn to scale from actual measurements of the contours of the ground, were presented (Dalmat, 1952a) in order to give a more accurate representation of the terrain traversed by the flies, as well as of the actual distances between the release point and the various stations at which stained flies were recaptured.

Longevity study.—Dalmat (1952a) presented the first experimental data concerning the longevity of female Simuliidae. The experiment



Map 15.
(Taken from Dalmat, 1950c.)

was carried out in Yepocapa in the same region as was the first flight-range study. The precipitation, relative humidity, temperature, and winds were recorded. The methods were similar to that for the flight-range study with the following modifications: Six aniline dyes were used as markers, each during a 2-day period, resulting in a total of only 12 days on which flies were stained. This procedure made possible the tracing of recaptured flies with an error no greater than one day. Collecting stations were established closer to the release point at the beginning of the study and more distant from it toward the end. Collections were not begun until 3 days after the last release date.

In all, 40,083 female flies were stained and released. In the 365 visits made to the 31 collecting stations on 72 days of the study, 23,315 flies were collected, of which 91 were stained. Fifty-four of these were *metallicum,* 29 *ochraceum,* and 8 *callidum.* One of these, a *metallicum,* was a fly stained and released in Acatenango (second flight-range study, being carried on concurrently). The longevity of the flies, calculated from the time of the release to recapture, was from 3 to 85 days. Table 20 presents the longevity of the recaptured stained flies. The data also include three flies that had been released in this study and were recaptured in Acatenango. Obviously, the findings represent only an approximation of the natural longevity of the flies, since it is unknown how long these wild flies had been living prior to staining, or how much longer they would have survived had they not been killed for examination after recapture.

Flight range and longevity of infected flies.—To determine whether or not infection with larvae of *Onchocerca volvulus* affects the flight range and longevity of the black flies, similar studies to those reported in the two preceding sections, but using infected female flies, were carried out by Dalmat and Gibson (1952). The area used was the Municipality of San Pedro Yepocapa, site of two of the previous investigations. The field experiments lasted 83 days, during which period records were kept of precipitation, relative humidity, temperature, and winds. Flies were marked with six dyes, each on 2 consecutive days, resulting in a total of only 12 days on which flies were stained. This procedure made possible the tracing of recaptured flies with an error no greater than one day.

The human subjects used as bait for collecting flies that were to be stained and released had all been previously shown to have heavy infections of microfilariae of *Onchocerca volvulus* and had all demonstrated their ability to infect wild flies. In order to secure adequate human subjects for infecting the flies, two criteria were adopted: (1) The individual had to show active microfilariae in at least two of four cutaneous biopsies; and (2) flies which were fed on the individual had to ingest microfilariae of *Onchocerca volvulus* and support normal development of the parasite for at least 72 hours under laboratory conditions. In all, 213 individuals were examined by the skin-biopsy technique, of whom only 16 satisfied the first criterion of two positive

TABLE 20.—*Longevity of anthropophilic simuliids*

Longevity (days)	Number of stained flies recaptured		
	Simulium (S.) metallicum	*Simulium (S.) ochraceum*	*Simulium (L.) callidum*
3	2	—	2
5	1	12	—
7	9	5	1
9	1	—	—
10	3	1	1
11	7	—	—
12	—	1	—
13	1	1	—
14	—	2	—
17	1	—	—
20	—	—	1
21	1	2	—
24	1	—	—
25	16	4	—
26	2	—	—
27	1	1	—
38	1	—	—
39	1	—	—
41	3	—	—
52	1	—	—
64	1	—	—
66	1	—	—
68	1	—	—
72	2	—	—
75	1	—	—
77	1	—	—
85	1	—	—
Totals	60	29	5

biopsies among the four which were taken. These 16 individuals were then tested for their ability to infect flies by allowing approximately 100 simuliids to feed on each person. The flies were then maintained in the laboratory. Those flies that died before the third day were discarded; those that lived 3 days or more were dissected immediately after they died to determine if they had become infected. On the basis of these dissections, the six individuals who produced the highest proportion of infected flies were chosen as subjects for the flight-range and longevity study.

Since it was desired to determine how long infected adults can live in nature, as well as how far they are able to fly, in comparison with noninfected flies, it was decided to postpone the recapture of stained flies until several days after staining was begun. Had captures been initiated concurrently with release of the flies, the population of stained flies probably would have been unnecessarily reduced. A total of 669 visits was made on 60 nonconsecutive days to the 21 collecting stations that had been established in all directions and at varying distances from the release point. Collected flies were examined under the dissecting microscope as they were introduced singly into an alcohol-glycerine-chloroform solvent. Flies found to be stained were then identified as to species, fixed, embedded, serially sectioned in the sagittal plane, and prepared as stained mounts. These were examined microscopically to determine if the flies were infected and the degree of development reached by the ingested filarid larvae.

Altogether, 40,474 simuliid flies, which had fed on onchocercotic patients, were released after being marked with the aniline dyes. During a 2-month period subsequent to the release of these flies, 144,708 simuliids were captured at the 21 collecting stations, of which 55,366 were *S. ochraceum,* 81,475 *metallicum,* and 7,867 *callidum.* Among these were 42 flies that had been stained by one of the aniline dye markers. Sectioning of these 42 marked flies revealed only three infections. A study of the developmental stages left no doubt that the flies became infected on the day they were marked and released. One of the infected flies (*S. ochraceum*) had flown 2.9 miles from the release point in 2 or 3 days; the other two (one *ochraceum* and one *callidum*) had flown 2.7 miles in 3 or 4 days. Of the flies that were not infected, some had flown as far as 9.6 miles.

Although only a small number of infected flies were recovered, it can be concluded that infected black flies can, and do, travel some distance from the point of infection. From past experience with numerous infection experiments (Gibson, 1951a), it is known that approximately one-half of the flies that take blood meals from a heavily infected person ingest microfilariae and subsequently become infected. On this basis it can be presumed that approximately one-half of the 40,474 flies that were fed, stained, and released in the present study became infected. If no mortality occurred, it would therefore be expected that infections should be found in one-half of the 42 flies that were recovered. Since only three infected flies were recovered, the possibility is suggested that infection with *Onchocerca volvulus* may have a deleterious effect upon the flies and thereby cause the early death of many of them. It has been repeatedly observed in the laboratory that simuliids infected wtih *O. volvulus* larvae show a high mortality rate during the first 4 days after the infective meal; furthermore, they die more rapidly than uninfected flies under laboratory conditions. Thus, because so few infected flies were recovered in the present experiment, none of which had survived more than 4 days after infection, it is probable that the high postinfection mortality observed in the laboratory also occurs in the field.

Lebied (1950), in his studies of the development of *Onchocerca volvulus* in *Simulium damnosum,* concludes that pathological changes caused by "sausage" forms developing in the fibers of the indirect flight muscles presumably restrict the flght range of infected flies, thereby limiting the spread of onchocerciasis.

In summarizing the findings on flight range and longevity of both noninfected and infected flies, the following observations can be made:

Uninfected flies are capable of flying (without the aid of prevailing winds) at least 9.7 miles, measured as a straight-line distance. If the extremely irregular nature of the terrain were to be taken into account, this flight capacity should undoubtedly be increased.

The longevity of uninfected flies, calculated from the time of release to recapture, is from 3 to 85 days. This represents only an estimate of the natural longevity, since it is impossible to determine how long these wild flies had been living prior to being stained, or how long they would have survived after the recapture date had they been free in nature.

Thus it has been shown that the females of the principal anthropophilic species of Guatemalan Simuliidae have a high potential for survival and for traversing relatively great distances under normal conditions. Therefore, in any control program aimed at the reduction of anthropophilic species, whether infected or not, relatively large areas would have to be included to minimize infiltration of flies from outside of the treated region.

Since infection with *Onchocerca volvulus* does reduce the flight capacity and longevity of the flies, a program directed solely against infected flies, with a view toward preventing their migration to neighboring noninfected regions, would not have to be as extensive. From the limited data obtained in the studies of the flight range and longevity of infected flies, it can be seen that these flies can travel at least 2.9 miles in 2 or 3 days. Therefore, measures for the control of infected *Simulium* would have to be extended at least 2.9 miles beyond the area to be protected. In any program for the control of human onchocerciasis in Guatemala, it would seem advisable to attack both the infected and uninfected flies.

Resting Places and Height Range of the Adults

It is common knowledge that different groups of insects, as well as different species within a single group, may have different resting habits and habitats. Thus, before considering a control program directed against adult black flies, it was of prime importance to learn on what surfaces they alight. Much money and effort may be spent uselessly by treating with insecticides areas where the black flies will not be affected.

Since no data concerning the resting places of adult Simuliidae had been published up to the time of these studies, it was deemed advisable to initiate appropriate investigations. The first hint as to where the flies rest at night was obtained indirectly and quite by chance. In an attempt to establish a self-perpetuating colony of black flies (see "Colonization of Black Flies" in this section), a very large metal-screen cage was constructed and placed over a water channel that was diverted so that it passed through the laboratory property. Some of the same plants found at the breeding places of the flies and in the fields of the coffee plantations were planted within the cage. Thousands of flies were introduced into the cage where they were presented with human subjects for blood meals, in the hope that they would oviposit in the running water below.

In the course of observations, it was found that caged flies that were active during the day were not visible at night. A careful search did not reveal them. In the morning following, a large number of flies were again seen in the cage. Continuous observations throughout the day disclosed that as the sun set, the flies migrated to lower levels in the cage until at nightfall the flies actually worked their way down to the bases of plant stems close to the ground level or, at times, slightly beneath the surface. Repetition of these observations stimulated further field studies.

Teams of men, equipped with Coleman lanterns, white cloth, and collecting tubes, were placed in areas of the plantations known to harbor heavy black-fly populations. It was found that after a 10- to 15-minute initial wait, small numbers of flies were attracted to the brilliant light and could be collected from the white cloth which had been placed beside the lamp. Females as well as a few males were taken in this fashion. After numerous observations of this sort, it was finally possible to establish that the flies were emerging from their night resting places close to the surface of the ground.

In considering the daytime resting places, cognizance was given to past field experience of several of the laboratory workers who had reported being bitten by black flies while they were climbing trees. Thus, observation stations were established at different altitudes above the ground level, where individuals remained for varying periods of time to take notice of the activity of the flies. All observations were made during the daylight hours. Records were kept of biting flies, as well as of those that were actually resting. The results are given in tables 21 and 22.

TABLE 21.—*Height range of principal anthropophilic species*

Expressed as number of biting flies captured per hour at different heights above the ground. "Hours spent" represents a summation of the total hours during which collections were made in trees at particular heights above the ground.

		Height range					
		ochraceum		*metallicum*		*callidum*	
Height in trees (feet)	Hours spent	Number	Number/hour	Number	Number/hour	Number	Number/hour
Ground.....	172.7	4,961	29	7,453	43	380	2
0– 10.....	3.7	277	75	133	36	19	5
11– 20.....	91.3	3,970	43	5,540	61	215	2
21– 30.....	61.8	1,959	32	3,137	51	218	4
31– 40.....	108.7	3,090	28	4,290	39	201	2
41– 50.....	31.7	452	14	903	28	38	1
51– 60.....	38.0	129	34	756	19	51	1
61– 70.....	39.3	676	17	1,042	27	62	2
71– 80.....	—	—	—	—	—	—	—
81– 90.....	7.7	42	5	108	14	5	1
91–100.....	4.7	69	15	124	26	0	0
101–110.....	28.3	17	1	551	19	28	1
111–120.....	4.0	3	1	100	25	3	1

It will be noted in table 21 that *Simulium ochraceum, metallicum,* and *callidum* will all bite man from the ground level up to at least 120 feet. *S. ochraceum* appears to prefer altitudes from the ground level to about 70 feet, above which few were found to feed. On the other hand, *metallicum* and *callidum* seemed to bite almost indiscriminately from the ground level to the highest established stations, with only a slight preference shown for stations closer to the surface of the ground. From table 22 it can be seen that all three species rest in the trees, at times for long periods. It was difficult to secure abundant and accurate information relative to resting periods, since flies that were close enough to be observed would usually take to wing owing to unavoidable movements of the observer.

It might be reasoned that flies found biting in the trees were attracted there by the desire for a blood meal. However, the finding of flies actually resting in the trees would indicate that they naturally occur in this habitat. This should be expected since flies would probably choose such sites for stops during the long flights of which they

Table 22.—*Record of flies resting in trees*

Data represent the duration of resting periods of flies observed at various altitudes in trees and on different surfaces

	Altitude (feet)	Surface on which resting	Number of specimens	Duration of resting period (minutes)	Altitude (feet)	Surface on which resting	Number of specimens	Duration of resting period (minutes)
ochraceum	13	Branch	1	5.0	40	Branch	1	0.07
	16	Leaf	1	2.0	40	"	1	0.5
	18	"	1	2.0	41	Leaf	1	1.0
	18	"	1	5.0	43	"	1	3.0
	18	Branch	1	7.0	43	"	1	0.4
	19	Leaf	1	4.0	45	"	1	3.0
	19	"	1	5.0	46	"	1	4.6
	24	"	1	0.08	46	"	1	0.5
	27	"	1	1.0	46	"	1	4.5
	27	"	1	4.0	46	Branch	1	0.15
	27	"	1	6.0	47	Leaf	1	5.0
	28	"	1	0.07	50	Branch	1	0.47
	29	Branch	1	0.1	50	"	1	30.0
	29	"	1	0.27	50	Leaf	1	0.08
	32	Leaf	1	3.0	51	"	1	0.4
	36	"	1	16.0	55	"	1	7.5
	36	"	1	2.0	112	"	1	3.0
	37	Branch	3	0.08				
metallicum	19	Branch	1	8.0	40	Leaf	1	0.66
	28	Leaf	1	0.4	46	"	1	0.25
	35	"	1	1.0	47	"	1	0.4
	37	"	2	3.0	47	"	1	3.0
	39	"	1	2.0	51	Branch	1	0.21
callidum	43	Leaf	1	5.0				

are capable (see "Flight Range and Longevity" in this section). Thus, in planning control of adult flies, the ground surface, as well as all levels of vegetation, should be taken into consideration. It would appear to be plausible to use airplane treatment to reach the resting flies. However, the very rugged terrain in the onchocerciasis regions, irregularly interrupted by deep gorges and high cliffs, makes such methods almost impossible. In addition, the dense canopy of vegetation would probably prevent insecticides from filtering to the resting places at lower levels.

Colonization of Black Flies

At the inception of the work in this laboratory, one of the important aims was the establishment of a self-perpetuating colony of anthropophilic black flies. It was hoped that such a colony would supply "clean," or uninfected, flies for use in the study of the developmental stages of *Onchocerca volvulus*. This project, undertaken at the field laboratory in San Pedro Yepocapa, was continued during a $3\frac{1}{2}$-year period. Although the successful establishment of a colony was not achieved, the techniques and some of the results are interesting, and may prove of some value for future experimentation.

Using practically any method, eggs could be reared through to adults without much difficulty. Previous workers in Guatemala had simulated a cascade by arranging a series of inclined pans in such a manner that the water dropped from one into another. The pans were stocked with larvae which readily pupated, the adults emerging in 3 to 5 days. This system had a number of drawbacks, the principal ones being: (1) that emerging adults were not confined for further use, (2) the cocoons did not appear normal, being rather translucent and exceedingly soft, and (3) the young larvae could not easily be confined in the pans.

To rear adults from pupae for taxonomic studies (see section on "Taxonomy of the Guatemalan Simuliidae"), we used lengths of glass tubes, both ends of which were stoppered with slightly moistened cotton. This technique yielded successful results, especially when the holding tubes used were large enough to permit the adults sufficient room for movement without having to press against the moist glass. Adults reared in this manner emerged in perfect condition and, therefore, could be employed in the colonization studies. Another device employed in our work was an "incubator-aerator," first described by Thomas (1946). It consisted of a series of baffles, arranged in descending order to form a riffle board, over which a constant source of water flowed (pl. 20, fig. 1). The structure was enclosed in canvas which was constantly being moistened. The evaporation of the water on the canvas sides of the apparatus served as a method for cooling the interior. Extending from the wood frame at one end are a series of vials, the mouths of which pass through an opening in the board. Emerging flies, attracted to the light source near the vials, enter them and can then easily be collected.

One other artifact was constructed at the laboratory for use in rearing adults. It consisted of an open bamboo node, one or both ends of which were replaced with fine screening (pl. 21, fig. 1). A longitudinal section was cut off one wall and it, in turn, had its midregion cut out so that it formed a frame. This open region was covered with screening which had a single outlet over which a vial was held in place. The apparatus was stocked with leaves containing eggs, larvae, and pupae and then arranged in any body of running water so that the current passed through one end of the node and came out the other. When adults emerged they would be attracted by the daylight entering through the screening on the upper surface of the structure, and would work their way through the outlet into the vial. This system was not very practical in the streams of the Yepocapa regions since the bamboo node soon was filled with sand which killed the larvae and pupae.

However, the problem was not to rear adults, but rather to establish a self-perpetuating colony. With this in view, during the last half of 1948 a large outdoor screen cage, 8′ x 6½′ x 5′, was constructed in the laboratory patio over a cement channel through which a stream was diverted. Some of the plants found in and about the natural haunts of the flies were planted within the cage. These were: banana, coffee, *Grevillea robusta* Cunn., *Ricinus communis* L., and *Polymnia maculata* Cav. Two herbaceous plants on which the flies commonly oviposit in this region, *Renealmia aromatica* (Aubl.) Griseb. and *Tradescantia commelinoides* R. & S., were planted along the borders of the stream in such a manner that the leaves and stems floated on the surface with the current. Temperature and humidity within the cage fell well within the natural range of the region. The mottled shade and sun, usually found on the coffee plantations, was approximated by attaching lengths of rather sheer black cloth to the outside of the cage where the sun hit directly. This reduced light intensity, and the movement of the cloth in the air currents afforded additional aeration of the interior of the cage. At a later date an exhaust fan was installed in the roof.

Many combinations of flies were introduced into the cage: wild-caught females, wild-caught females with laboratory-reared males, laboratory-reared females and males, and females and males reared in artifacts in the field. Pupae were also introduced into the water channel so that the adults could emerge naturally within the cage, thus reducing unnecessary handling. The foods presented to the flies were human subjects, defibrinated human blood, blood plasma, plant juices, mashed banana or raisins, and honey and sugar solutions absorbed by cotton.

Most of the flies died within 5 days, but a small number lived as long as 18 days. Less than 1 percent of the flies fed, and only one *S. metallicum* oviposited. This fly deposited approximately 300 eggs, 200 of which developed into larvae. Of the entire group, only five adults emerged, three of which were males. The males fed on sugar solution, but the females refused all foods. No mating or oviposition was observed in the second generation and the adults finally died. The great majority of the larvae had been washed away by the fluctuation of the current owing to a breakdown of the water system.

In an attempt to stimulate female flies to feed, they were introduced into another mechanism (pl. 21, fig. 2) before being loosed in the oviposition cage. It was an apparatus that had previously been used for feeding mosquitoes (Greenberg, 1949). Each lantern-globe cage, in which a number of flies were held, was kept humid by moist blotting papers in the Petri dish attached at its base. The upper end of the globe was covered with adhesive tape except for the central region through which the food was presented to the flies. Above each globe, extending from an asbestos board, there was a cylindrical heating unit which could be regulated to bring any substance passed through it to body temperature. A tube of appropriate diameter, containing liquid food and topped with a membrane (Baudruche), was passed through the heating unit and brought to rest on the lantern globe so that its membrane coincided with the opening in the adhesive tape. The most successful food was a mixture of blood plasma and sugar. The apparatus did stimulate approximately half the flies to feed, but these did not oviposit any better than did the flies that had not fed.

During January 1950, a system was initiated whereby flies were treated with carbon-dioxide gas before being released in the oviposition cage (Dalmat, 1950a). The flies were first placed in a museum jar into which carbon-dioxide gas was introduced through a rubber tube extending from a standard gas cylinder. An oxygen manometer valve was used to control the quantity of gas passing through the tubing to the fly chamber.

Since the actual volume of gas necessary to immobilize the flies was not measurable with the equipment used, the end point of treatment was arrived at by observation of the fly activity. The flies were at first stimulated to greater activity, and then they would topple over as if dead. At the latter point, the treatment was halted and the jar left open until the flies revived. The actual treatment lasted less than 20 seconds; the flies usually revived in about 3 to 4 minutes.

It appears that the gas treatment has an immediate effect upon the behavior of the flies. Upon returning to consciousness, a few flies were observed mating, and numerous females assumed a position as though they were biting. It was first believed that the position of the females, with the mouthparts directed perpendicular to the jar, was merely an attempt to establish equilibrium. However, when the flies were released into the large outdoor cage, a high percentage of the flies attacked the human subject and took blood voraciously. Within 4 to 6 hours, a number of the flies that had fed also oviposited.

With more hopeful prospects for success in the establishment of the colony, another cage, about one and one-half times the size of the first, was constructed over a natural stream in which *Simulium ochraceum* and *S. metallicum* were breeding (pl. 20, fig. 2). This cage was also stocked with various combinations of flies, and similar foods were presented. With the inauguration of the second cage, flies were generally exposed to the carbon-dioxide treatment or to refrigeration before being introduced into the oviposition cage.

Of over 20,000 *S. ochraceum, metallicum,* and *callidum* that had been chilled prior to being introduced into the cages, about 30 percent took blood meals, although none oviposited. In 460 trials run with carbon-dioxide treatment, more than 65,000 flies of the same species were treated. About 40 percent took blood meals, and of these, about 20 percent oviposited. Some of the females deposited up to a thousand eggs (an abnormally high number), but none of the eggs developed to form larvae. This may indicate that the eggs were sterile or that they were adversely affected by the gas.

Approximately 8,800 reared adults of *S. exiguum* were introduced into the laboratory and field cages, both without treatment and after exposure to carbon-dioxide gas or refrigeration. Of 3,400 that had been treated, 31 pairs of flies mated, 7 flies took blood, and 290 fed on sugar. Of the 5,400 that had not been treated, 27 pairs mated, but none took blood or sugar. No flies of this species oviposited in captivity. Representatives of other definitely zoophilic species did bite man readily after exposure to carbon-dioxide gas. One such species was *S. rubicundulum*. However, no egg deposition took place.

In 1951, when other experiments and duties precluded the possibility of continuing with the problem of establishing the colony, it was reluctantly abandoned. Apparently, the anthropophilic species of black flies of the Yepocapa region, like so many other insects that do not normally inhabit confined areas, resist colonization. Perhaps some simple expedient will, in the future, revolutionize this problem. However, the use of carbon dioxide to induce oviposition by captive *Simulium* species does signal a way toward further possible experimentation with this group of flies and with other insects that have resisted colonization.

ZOOPHILIC SPECIES

The preceding discussion in the section on ecology has been concerned only with the anthropophilic species of black flies. Included were those species that could possibly serve as vectors of onchocerciasis because they either preferred biting man to other animals, or because they commonly attacked man as well as other animals. Since there is no species that attacks only humans, and since many of the species that prefer animal hosts also attack man, it becomes evident that no clearly defined distinction can be drawn. Thus, we can talk of a species as being more anthropophilic or more zoophilic in its feeding habits than another species. For the purpose of the present discussion, those species that prefer biting animals other than man have been allocated to the category of zoophilic species. According to this definition, *Simulium metallicum, callidum, exiguum,* and *veracruzanum* should all be included, since only *S. ochraceum* is a strongly anthropophilic species. However, since these species were already discussed under the category of anthropophilic species, they will not be treated here.

Table 9 (p. 45) summarizes our data concerning the host preferences of some of the zoophilic species, as well as similar data on the anthropophilic species. Unfortunately, relatively little time could be given to the zoophilic species since they were not involved in the transmission of onchocerciasis. From the table it can be seen that there are some definitely zoophilic species—that is, they bite only animals other than man. *S. acatenangoensis, mexicanum, pulverulentum rubicundulum,* and *smarti* are such species. The strictly zoophilic nature of these species can be considered reliable since, were the species to bite man, they would have attacked the collectors while the latter were capturing flies from animal bait, which they did not do.

It would appear from the table that *Cnephia pacheco-lunai* might bite man to the exclusion of other animals. This species has been encountered almost entirely in a region above 8,000 feet, uninhabited by man. During the warmer daylight hours, sheep are taken up to the region for grazing, so these animals probably represent the principal host of *pacheco-lunai.* Unfortunately, since no collections of biting flies were made from sheep or other animals in the region where *pacheco-lunai* abounds, the hosts of this species could not be determined. The single fly listed, which was fortuitously captured while biting a man, can hardly be considered significant. The data on *S. haematopotum* are also misleading since they appear to indicate that dogs are the principal hosts of this species and humans the secondary ones. The fact is that, other than man, only dogs were used as bait in the region where *haematopotum* is abundant. Probably several other animals could have been shown to be equally suitable hosts had they been exposed to the bites of the flies.

It would seem from table 9 that *S. exiguum* and *veracruzanum* seldom bite man. This erroneous impression is given since the table does not actually compare the preference of a particular species of black fly for various hosts, but rather gives the relative frequency with which the various species of black flies attack a particular host. Actually, *exiguum* and *veracruzanum* will attack man voraciously in areas where these species are abundant (see "Reservoirs and Vectors" in the sections on epidemiology and distribution of Guatemalan Simuliidae).

Simulium ochraceum and *metallicum* not only are the principal anthropophilic species, but they are also the species that most commonly attack animals other than man. When these species are presented with both human and other animal bait, side by side (table 10, p. 46), *ochraceum* proves to be definitely anthropophilic while *metallicum* is seen to be more zoophilic in nature. In table 9, of the total number of flies collected from man, 30 percent were *ochraceum* while 65 percent were *metallicum*. This can be accounted for when it is realized that, although *metallicum* is definitely zoophilic, it will attack man freely and it is by far the dominant species (in numbers) of those that bite humans in the onchocerciasis zone where the majority of these investigations were made.

Numerous experiments were conducted to determine the preferences of various *Simulium* species for different body parts of the animals they attacked. These data have been presented in Appendix III, table 35.

IMMATURE STAGES

Since the members of the family Simuliidae all feed on animals, to collect sufficient adult material of all species for taxonomic studies or to discover their distribution throughout Guatemala for ecological and life-history studies, would require an intimate knowledge of their host preferences. Since the majority of species are not anthropophilic, and since their host preferences are not completely known, it was found most convenient to collect the immature stages and rear them to adults. This was done, using the techniques already described in the first part of the section on taxonomy of the Guatemalan Simuliidae. Along with each collection made, certain information concerning the breeding place was recorded. These data included: (1) Date of collection; (2) name of river, finca, municipality, department, etc.; (3) width of stream; (4) depth of stream; (5) temperature of water; (6) speed of current; (7) altitude of region; (8) pH of water; (9) if the stream is open to the sun or covered by vegetation; (10) description of the stream bed—muddy, sandy, rocky, quantity and type of plants present; (11) depth at which eggs, larvae, and pupae are found; (12) substratum of the various stages collected—small or large stones, rocks, sand, mud, branches, twigs, roots, narrow or wide leaves, etc.; and (13) if the larvae or pupae are found in parts of the stream that have a normal grade, or ones with cascades or waterfalls. To secure these data, each collecting group carried with it the necessary equipment which included an altimeter, extensible rule, corks for floating on surface of water in calculating current speeds, chronometer, pH meter, thermometer, and a vasculum for carrying plant samples.

The data were transferred to the books in which all collections were chronologically accessioned, along with the identifications of the individual specimens. They were subsequently digested according to species so that statistical information could be derived from them. The following paragraphs summarize the findings.

ALTITUDE PREFERENCES

Table 23 presents in condensed form the data concerning the altitudes of those parts of streams in which the Guatemalan black flies were found to breed (see also Appendix III, table 36). It will be noticed that the truly coastal species are few in number—*Simulium earlei, exiguum, pulverulentum,* and *samboni*. Of the four species, *exiguum* and *pulverulentum* do attack man, but because of their abundance primarily in low regions, where onchocerciasis is not widespread, their over-all importance in the transmission of the disease could not be very great. Of course, they may serve as the only vectors in certain areas where they exist to the complete exclusion of *ochraceum, metallicum,* or *callidum*. On the other hand, the number of species preferring high altitudes (above 6,000 feet) is great. It includes *Gigantodax aquamarensis* and *wrighti; Simulium aureum, burchi, carolinae, delatorrei, ethelae, kompi, microbranchium,* and *tricornis; Cnephia pacheco-lunai* and *roblesi*. Of these, *S. aureum, C. pacheco-lunai,* and *C. roblesi* are found almost entirely over 7,000 feet above sea level. None of these high-altitude breeders is anthropophilic.

The vast majority of species live within the altitude range from 2,000 to 6,000 feet above sea level. The principal anthropophilic spe-

TABLE 23.—*Altitude preference of Guatemalan Simuliidae*

Data expressed as percentage of total number of pupae of each species collected in each altitude zone

Species	Total number pupae collected	Altitude zone: Coast-2,000	2,000-3,000	3,000-4,000	4,000-5,000	5,000-6,000	6,000-7,000	>7,000
	Total number collections in each zone	363	878	1,658	2,358	761	252	125
		Percent of total pupae						
aquamarensis	542					41.9	29.2	28.9
aureum	597		4.0	1.2		4.9	1.0	88.9
acatenangoensis	7,121		0.1	6.8	44.7	37.6	10.7	0.19
aguirrei	553			1.6	1.8	96.6		
burchi	65						81.5	18.5
callidum	7,300	5.7	7.9	25.0	46.8	13.3	0.6	0.7
capricornis	2,974	1.3		5.9	50.0	33.9	8.6	0.3
carolinae	461	1.1				41.9	57.0	
downsi	13,121	8.3	27.1	42.2	20.7	1.5	0.01	0.19
delatorrei	151		1.3			20.5	51.7	26.5
ethelae	131					26.0	74.0	
earlei	824	31.8	12.3	3.0	52.9			
exiguum	1,057	27.0	25.3	12.8	27.1	7.8		
haematopotum	299	12.0	29.8		8.7	49.2		0.3
jobbinsi	831	8.2	1.7	9.6	36.5	34.3	6.7	3.0
jacumbae	362		7.7	4.4	57.5	23.2	6.9	0.3
kompi	2						100.0	
larvispinosum	44			47.8	13.6	13.6	25.0	

(*Continued*)

TABLE 23.—*Altitude preference of Guatemalan Simuliidae*—Concluded

Species	Total number pupae collected	Altitude zone						
		Coast-2,000	2,000-3,000	3,000-4,000	4,000-5,000	5,000-6,000	6,000-7,000	>7,000
		Total number collections in each zone						
		363	878	1,658	2,358	761	252	125
		Percent of total pupae						
mexicanum	10,580	1.4	11.9	58.1	27.8	0.5	0.28	0.02
metallicum	13,694	4.0	18.4	17.8	50.7	6.9	2.1	0.1
mathesoni	13			7.7		84.6	7.7	
microbranchium	81					9.9	69.1	21.0
nigricornis	3				66.7	33.3		
ochraceum	593	1.3	3.5	34.6	54.6	5.2		0.8
pacheco-lunai	88		2.3		5.6			92.1
parrai	818		0.2	3.1	14.8	81.8	0.1	
pulverulentum	2,890	44.7	25.6	15.9	3.3	0.5	9.9	0.1
rubicundulum	10,565	3.0	3.1	18.2	64.4	9.8	1.2	0.3
roblesi	54							100.0
samboni	183	98.4	1.6					
smarti	1,078	0.6	1.4	20.7	51.3	23.0	3.0	
tricornis	168			0.6		0.6	69.6	29.2
veracruzanum	6,319	1.0	0.04	1.5	27.9	51.7	9.4	8.46
wrighti	1,203	1.2	1.0				59.1	38.7
yepocapense	925	0.5	1.0	89.1	9.0	0.4		

cies, *S. ochraceum, metallicum,* and *callidum,* all seem to breed most prolifically between 4,000 and 5,000 feet. However, while *metallicum* and *callidum* will breed in good numbers from almost the coast to altitudes over 6,000 feet, *ochraceum* confines its breeding rather strictly to the zone between 3,000 and 5,000 feet. This region of maximum *ochraceum* breeding also corresponds to the zone of maximum infection with onchocerciasis.

S. veracruzanum, another strongly anthropophilic species within its range, breeds principally in the altitude zone from 4,000 to 6,000 feet, much preferring regions between 5,000 and 6,000 feet. Since the region above 5,000 feet is not important insofar as onchocerciasis is concerned, and since *veracruzanum* is not very abundant in most areas below 5,000 feet, its importance in the transmission of the disease could be only slight.

STREAM TEMPERATURES IN RELATION TO SPECIES BREEDING

As would be expected, those species that prefer higher altitudes (table 23) are also those that are found breeding in streams with lower water temperatures (table 24), and conversely, those that prefer lower altitudes are found in streams with higher temperatures. Thus, in considering the principal anthropophilic species, *S. metallicum* and *callidum,* which were found in abundance in lower-altitude zones than *S. ochraceum,* prefer water temperatures between 16° C. and 21° C., while *S. ochraceum,* more restricted to higher altitudes, is found in abundance in streams with 14° C. to 21° C. All three species have optimums between 18° C. and 19° C.

pH OF STREAMS IN RELATION TO SPECIES BREEDING

Almost all species prefer breeding in streams with pH between 7.1 and 7.5 (table 25). Several species appear to be able to breed in waters with a wide range of pH, but only one, *Gigantodax aquamarensis,* breeds exclusively in water with a pH lower than 6. As stated in the general part of the section on life history, this species is found breeding in streams with pH about 5. These streams flow in a region with numerous sulfur springs and obviously are carrying large amounts of sulfuric acid. No other insect or larger animal life was found breeding in the same streams, and the larval stage of *aquamarensis* was prolonged up to 9 weeks, probably owing to the effect of the acidity.

Considering the principal anthropophilic species, the range of pH in which *S. callidum* breeds most frequently is extensive, that of

TABLE 24.—*Preference of Guatemalan species of Simuliidae in relation to temperature of streams*

Expressed as percentage of total collections made in streams with stated temperature

(A collection indicates a period during which specimens were collected at a particular place.)

Species	Number of collections	Temperature (degrees C.) Percent of total collections								
		<10	10-11	12-13	14-15	16-17	18-19	20-21	22-23	>23
aquamarensis	6		33.0	17.0	50.0					
aureum	34	14.0	24.0	18.0	9.0	9.0	14.0	12.0		
acatenangoensis	265		5.0	10.0	18.0	28.0	26.0	10.0	3.0	
aguirrei	34				44.0	17.0	26.0	9.0	4.0	
burchi	4				25.0	75.0				
callidum	1,009	0.2	6.3	6.9	8.3	17.0	37.0	21.0	3.0	0.3
capricornis	200		18.0	10.0	14.0	22.5	26.2	9.0	0.2	0.1
carolinae	29	3.0	3.0	17.0	39.0	24.0	14.0			
downsi	824	0.1	0.7	1.0	4.0	15.0	35.0	36.0	6.1	2.1
delatorrei	50	2.0	14.0	24.0	22.0	26.0	8.0	4.0		
ethelae	19	16.0	11.0	26.0	16.0	21.0	10.0			
earlei	17				6.0	6.0	6.0	41.0	29.0	12.0
exiguum	101			2.0	4.0	9.0	20.0	50.0	9.0	6.0
haematopotum	11		9.0		9.0			18.0	27.0	37.0
jobbinsi	160	3.0	11.0	9.0	12.0	17.0	36.0	11.0		1.0
jacumbae	74		7.0	7.0	21.0	20.0	19.0	22.0	4.0	
kompi	2					100.0				
larvispinosum	10		40.0	10.0	20.0	10.0	10.0	10.0		
mexicanum	545		4.0	4.0	4.0	14.0	43.0	26.0	4.0	1.0
metallicum	1,314	0.3	4.4	6.0	7.0	16.0	33.0	20.0	4.3	9.0

(*Continued*)

TABLE 24.—*Preference of Guatemalan species of Simuliidae in relation to temperature of streams*—Concluded

Species	Number of collections	Temperature (degrees C.)								
		<10	10-11	12-13	14-15	16-17	18-19	20-21	22-23	>23
		Percent of total collections								
mathesoni	4						50.0	25.0		25.0
microbranchium	11	27.0	18.0	37.0	9.0	9.0				
nigricornis	3				67.0			33.0		
ochraceum	158		4.0	6.0	15.0	11.0	39.0	22.0	3.0	
pacheco-lunai	8	25.0	36.0	13.0	13.0	13.0				
parrai	66		18.0	11.0	9.0	18.0	30.0	14.0		
pulverulentum	110	1.0	3.0	2.0		11.0	28.0	38.0	8.0	9.0
rubicundulum	696	1.0	7.0	7.0	8.0	17.0	35.0	19.0	5.0	1.0
roblesi	4	25.0	50.0	25.0						
samboni	7						28.0	43.0	29.0	
smarti	122		7.0	11.0	10.0	17.0	36.0	16.0	3.0	
tricornis	42		17.0	19.0	29.0	29.0	4.0	2.0		
veracruzanum	248	3.0	12.0	16.0	18.0	19.0	25.0	6.0	1.0	
wrighti	64	14.0	20.0	16.0	14.0	31.0	2.0	3.0		
yepocapense	88			1.0	7.0	14.0	40.0	33.0	3.0	2.0

TABLE 25.—*Preference of Guatemalan species of Simuliidae in relation to pH of streams*

Numbers represent percentage of total specimens collected in streams with stated pH

Species	Total number pupae collected	pH: <6.0	6.0-6.5	6.6-7.0	7.1-7.5	7.6-8.0	>8.0
		Percent of total pupae					
aquamarensis	542	100.0					
aureum	597	10.6	42.7	23.6	23.1		
acatenangoensis	7,121			17.7	81.2	1.1	
aguirrei	553	17.2	27.5	41.6	13.7		
burchi	65			18.5		81.5	
callidum	7,300	0.7	5.5	12.9	60.3	19.6	1.0
capricornis	2,974		0.1	19.7	71.4	7.6	1.2
carolinae	461	13.7		13.7	62.5	10.1	
downsi	13,121	0.5	3.1	18.8	56.5	20.2	0.9
delatorrei	151	2.6	2.0	47.7	45.7	2.0	
ethelae	131		2.3	51.1	46.6		
earlei	824		12.2	1.9	50.7	35.2	
exiguum	1,057	5.3	0.1	23.8	52.3	18.5	
haematopotum	299			12.0	85.6	2.4	
jobbinsi	831		1.3	46.8	41.3	10.2	0.4
jacumbae	362		0.8	34.6	63.8	0.8	
kompi	2				100.0		
larvispinosum	44			36.4	63.6		
mexicanum	10,580	0.6	3.0	10.6	43.0	38.4	4.4
metallicum	13,694	1.6	2.1	22.9	59.6	13.3	0.5
mathesoni	13				100.0		

(*Continued*)

TABLE 25.—*Preference of Guatemalan species of Simuliidae in relation to pH of streams*—Concluded

Species	Total number pupae collected	pH: <6.0	6.0-6.5	6.6-7.0	7.1-7.5	7.6-8.0	>8.0
		Percent of total pupae					
microbranchium	81			14.8	40.7	44.5	
nigricornis	3				100.0		
ochraceum	593	1.2	2.4	9.3	72.8	12.8	1.5
pacheco-lunai	88	3.4	62.5	11.4	4.5	18.2	
parrai	818	0.9		51.3	47.2	0.6	
pulverulentum	2,890	0.1		6.8	63.8	28.9	0.4
rubicundulum	10,565	1.6	0.5	13.0	71.0	13.2	0.7
roblesi	54	59.3	37.0	3.7			
samboni	183			2.2	97.8		
smarti	1,078		13.7	16.1	62.9	7.3	
tricornis	168		0.8	19.0	79.6	0.6	
veracruzanum	6,319	0.14	0.8	15.3	69.25	14.5	0.01
wrighti	1,203	0.6	14.6	38.3	46.5		
yepocapense	925	0.1	10.6	8.4	45.2	35.7	

metallicum is somewhat more restricted, while that of *ochraceum* is most limited.

WIDTH AND DEPTH OF STREAMS IN RELATION TO SPECIES BREEDING

Considering only the three principal anthropophilic species, it will be seen in tables 26 and 27 that *Simulium ochraceum* is more restricted in its stream habitats than either *metallicum* or *callidum*. While *metallicum* and *callidum* breed freely in streams as deep as 3 feet and as wide as 15 feet or more, *ochraceum* definitely prefers water courses narrower than 5 feet, with a depth ranging from 1 inch to 1 foot, the optimum being between 1 inch and 5 inches. Such *ochraceum*-breeding streams are commonly found along the slopes of the volcanoes in the onchocerciasis regions (see "Classification of Permanent Streams by Morphological Age" in the section on epidemiology). Here the streams are very young, formed by the union of several underground springs. They emerge where the underground water table is intersected by the natural curvature of the land. Although *metallicum* and *callidum* do breed in such streams along with *ochraceum,* they are not as restricted to such habitats as is the latter species.

Cnephia roblesi and *Cnephia pacheco-lunai* breed almost entirely in minute trickles of water that pass over a swampy area supporting large quantities of vegetation. Such rivulets usually dried up during the months of November through March, when neither larvae nor pupae of these species could be collected. Although *S. larvispinosum* is found associated with waterfalls (table 30), it actually breeds at the extreme sides of the current where there are narrow, shallow branches from the main falls that have a greatly reduced volume. This is indicated in tables 26 through 29.

Simulium haematopotum, earlei, exiguum, pulverulentum, samboni, yepocapense, and *mexicanum,* on the other hand, show definite preferences for streams over 15 feet wide. Of these species, *haematopotum* and *exiguum,* both of which attack man in good numbers, are found in the lower regions of the volcanic slopes, where the streams are morphologically older and, therefore, wider.

The width and depth of a stream are most important in determining the species breeding therein insofar as they affect the volume (rate of flow) of the particular water course.

VELOCITY (CURRENT SPEED) AND VOLUME (RATE OF FLOW) OF STREAMS IN RELATION TO SPECIES BREEDING

In calculating the current speed, a very simple but effective method was used. A floating cork was dropped onto the surface of the stream

TABLE 26.—*Preference of Guatemalan species of Simuliidae in relation to width of streams*

Numbers represent percentage of total number of specimens found at stated widths of streams

Species	Total number pupae collected	Width of streams: <6″	6″-1′	1′-3′	3′-5′	5′-8′	8′-15′	>15′
		Percent of total pupae						
aquamarensis	542		5.4		74.9	19.7		
aureum	597	5.7	63.8	5.9	8.5	5.2	9.2	1.7
acatenangoensis	7,121	3.4	7.8	63.5	13.1	7.6	4.6	
aguirrei	553		1.1	18.1	80.8			
burchi	65			81.5	4.6	13.9		
callidum	7,300	0.8	3.2	23.5	31.7	24.9	12.7	3.2
capricornis	2,974	0.2	15.1	74.1	5.5	5.0	0.1	
carolinae	461	2.4		34.4	28.0	26.5	2.8	5.9
downsi	13,121	1.1	1.8	18.0	43.6	20.2	10.2	5.1
delatorrei	151	8.6	19.9	33.8	2.0	4.6	29.8	1.3
ethelae	131		0.8	45.0	26.7	4.5	23.0	
earlei	824	12.1				26.3	8.5	53.1
exiguum	1,057		0.9	5.9	7.6	16.6	17.6	51.4
haematopotum	299	1.3		2.0	3.7	4.7		88.3
jobbinsi	831	0.8	4.0	51.5	23.9	17.0	2.6	0.2
jacumbae	362	4.7	42.3	36.7	11.3	3.3	1.7	
kompi	2			100.0				
larvispinosum	44	29.5		59.1	11.4			
mexicanum	10,580	0.3	0.7	5.5	10.6	9.9	41.8	31.2
metallicum	13,694	0.6	8.5	41.7	27.9	14.2	5.5	1.6

(Continued)

TABLE 26.—*Preference of Guatemalan species of Simuliidae in relation to width of streams*—Concluded

Species	Total number pupae collected	Width of streams: Percent of total pupae						
		<6″	6″-1′	1′-3′	3′-5′	5′-8′	8′-15′	>15′
mathesoni	13			92.3		7.7		
microbranchium	81			50.6	2.5	18.5	28.4	
nigricornis	3			100.0				
ochraceum	593	2.5	3.0	47.2	38.5	5.6	2.9	0.3
pacheco-lunai	88	65.9	10.2	4.6	19.3			
parrai	818	2.9	14.1	40.2	17.5	24.6	0.7	
pulverulentum	2,890		0.1	5.1	18.5	9.0	16.1	51.2
rubicundulum	10,565	0.1	7.3	28.0	26.3	18.1	10.9	9.3
roblesi	54	100.0						
samboni	183			1.1		1.7	48.6	48.6
smarti	1,078		3.0	29.2	27.5	15.6	23.7	1.0
tricornis	168	4.8	1.2	51.2	36.3		6.5	
veracruzanum	6,319	0.3	0.4	10.9	34.7	17.2	13.2	23.3
wrighti	1,203	19.5	59.5	19.6	0.6	0.7	0.1	
yepocapense	925		0.1	0.1	5.1	11.0	50.9	32.8

TABLE 27.—*Preference of Guatemalan species of Simuliidae in relation to depth of streams*

Numbers represent percentage of total specimens collected at stated depths of streams

Species	Total number pupae collected	Depth of stream: <1″	1″-5″	5″-1′	1′-3′	>3′
		Percent of total pupae				
aquamarensis	542		61.1	38.9		
aureum	597		49.7	45.7	4.6	
acatenangoensis	7,121		91.8	4.7	3.5	
aguirrei	553		1.4	98.4	0.2	
burchi	65		4.6	13.8	81.6	
callidum	7,300	0.03	59.5	35.2	4.4	0.87
capricornis	2,974	3.4	93.2	2.9	0.5	
carolinae	461		65.9	27.6	6.1	0.4
downsi	13,121		55.2	39.3	5.4	0.1
delatorrei	151		26.5	62.9	10.6	
ethelae	131		74.0	26.0		
earlei	824		12.1	52.2	0.6	35.1
exiguum	1,057		22.2	37.3	34.2	6.3
haematopotum	299	1.0	8.7		60.5	29.8
jobbinsi	831		85.9	12.9	0.5	0.7
jacumbae	362		67.4	32.0	0.6	
kompi	2		100.0			
larvispinosum	44		75.0	25.0		
mexicanum	10,580		19.8	55.9	22.4	1.9
metallicum	13,694		68.2	27.6	3.3	0.9

(*Continued*)

TABLE 27.—*Preference of Guatemalan species of Simuliidae in relation to depth of streams*—Concluded

Species	Total number pupae collected	Depth of stream				
		<1″	1″-5″	5″-1′	1′-3′	>3′
		Percent of total pupae				
mathesoni	13		92.3	7.7		
microbranchium	81		24.7	27.2	48.1	
nigricornis	3		100.0			
ochraceum	593		80.8	16.9	1.0	1.3
pacheco-lunai	88	63.6	28.4	8.0		
parrai	818		29.1	46.6	24.3	
pulverulentum	2,890		9.0	26.7	52.1	12.2
rubicundulum	10,565	0.2	65.8	26.3	7.5	0.2
roblesi	54	96.3	3.7			
samboni	183			2.2		97.8
smarti	1,078		70.0	27.6	2.4	
tricornis	168		84.5	6.6	8.9	
veracruzanum	6,319		63.0	24.4	12.4	0.2
wrighti	1,203		37.0	62.9	0.1	
yepocapense	925		19.5	76.6	3.9	

TABLE 28.—*Preference of Guatemalan species of Simuliidae in relation to current of streams*

Numbers represent percentage of total number of pupae collected in parts of streams with stated currents

Species	Total number pupae collected	Current (inches per second)						
		1"-10"	11"-15"	16"-20"	21"-30"	31"-40"	>40"	Waterfalls
		Percent of total pupae						
aquamarensis	542	65.1	34.9					
aureum	597	62.1	20.9	5.9	3.7	4.9	0.3	2.2
acatenangoensis	7,121	54.6	27.5	8.9	3.9	4.3	0.8	
aguirrei	553	76.5	2.2	21.3				
burchi	65			13.8	86.2			
callidum	7,300	27.1	33.0	23.1	13.1	1.9	1.4	0.4
capricornis	2,974	38.5	32.3	23.8	2.5		1.4	1.5
carolinae	461	3.7	10.2	4.3	0.4		5.9	75.5
downsi	13,121	29.1	29.2	23.7	9.8	5.2	3.0	
delatorrei	151	19.2	52.3	11.9	12.6	2.0		2.0
ethelae	131	61.8	13.7					24.5
earlei	824	12.1	11.4	15.3	7.0	0.2	54.0	
exiguum	1,057	13.4	14.8	31.8	14.9	8.9	16.2	
haematopotum	299	3.7	7.7	1.0	15.7	10.7	61.2	
jobbinsi	831	17.1	36.3	36.4	9.3	0.4	0.1	0.4
jacumbae	362	67.4	18.0	6.1	4.1	4.1		0.3
kompi	2		100.0					
larvispinosum	44	61.4	27.3					11.3
mexicanum	10,580	10.5	13.5	23.1	29.6	8.1	15.2	
metallicum	13,694	38.9	31.1	19.6	7.9	1.37	1.05	0.08

(*Continued*)

TABLE 28.—*Preference of Guatemalan species of Simuliidae in relation to current of streams*—Concluded

Species	Total number pupae collected	Current (inches per second)						
		1"-10"	11"-15"	16"-20"	21"-30"	31"-40"	>40"	Waterfalls
		Percent of total pupae						
mathesoni	13	7.7	76.9	15.4				
microbranchium	81	6.2	30.9	17.3	44.4			1.2
nigricornis	3	33.3	66.7					
ochraceum	593	63.4	18.2	11.6	4.1	2.0	0.7	
pacheco-lunai	88	65.9	23.9	2.3	7.9			
parrai	818	78.4	5.7	15.3	0.6			
pulverulentum	2,890	14.2	12.9	9.6	20.4	15.6	27.3	
rubicundulum	10,565	26.2	35.4	18.4	9.7	1.6	8.5	0.2
roblesi	54	96.3	3.7					
samboni	183		2.7	96.2	1.1			
smarti	1,078	21.5	28.6	21.4	16.0	2.7	0.2	9.6
tricornis	168	28.6	50.6	11.3	1.2	8.3		
veracruzanum	6,319	13.7	40.3	27.8	13.9	1.3	2.3	0.7
wrighti	1,203	29.3	42.6	14.1	11.6			2.4
yepocapense	925	0.8	16.1	26.2	32.2	18.4	6.3	

TABLE 29.—*Preference of Guatemalan species of Simuliidae in relation to volume of streams*

Numbers represent percentage of total number of pupae collected in parts of streams with stated volumes

Species	Total number pupae collected	Volume (gallons per second) <1	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	>100	Water-falls
		Percent of total pupae												
acatenangoensis	14,474	15.6	67.9	9.5	3.3	0.5	0.8	0.3	0.6	0.4	0.07	0.03	1.0	
aguirrei	707	0.4	62.5	37.1										
aquamarensis	723		70.8	24.8		4.4								
aureum	743	12.7	57.1	6.5	1.2	8.3	4.7		1.5				7.9	0.1
burchi	82		86.6					13.4						
callidum	9,029	3.5	37.3	21.9	11.9	7.9	3.8	3.2	1.6	1.7	1.3	0.4	5.1	0.4
capricornis	4,013	27.3	66.1	3.3	1.7	0.04	0.08	0.08					0.2	1.2
carolinae	310	1.6	8.0	9.6		6.1	0.9							73.8
delatorrei	422	2.6	60.2	23.0	2.1		5.0		0.2				6.9	
downsi	12,984	1.9	30.5	23.4	15.9	7.7	2.7	1.9	4.2	1.1	0.3	0.4	10.0	
carlei	656	15.2			1.2		5.8		1.3	0.1	0.4		76.0	
ethelae	141	0.7	27.7	2.8	4.9		4.3							59.6
exiguum	1,226		6.3	2.7	8.0	3.4	0.6	1.6	9.5	0.4	3.3	0.7	63.5	
haematopotum	349	1.2	3.8	0.8					0.3	4.0		89.9		
jacumbae	463	55.9	36.7	3.0	0.7				1.5		0.7		1.5	
jobbinsi	707	3.6	68.3	17.6	6.3	0.8		0.4	1.0	0.1	0.3	0.4	1.2	
kompi	3		100.0											
larvispinosum	389	7.7	10.3											82.0
mathesoni	13		92.3			7.7								
metallicum	20,271	9.5	54.8	14.1	7.5	4.6	2.5	1.2	1.1	0.5	0.5	0.3	3.3	0.1

(*Continued*)

TABLE 29.—*Preference of Guatemalan species of Simuliidae in relation to volume of streams*—Concluded

Species	Total number pupae collected	Volume (gallons per second)												
		<1	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	>100	Waterfalls
		Percent of total pupae												
mexicanum	10,703	0.8	5.3	5.6	4.4	2.8	3.2	3.9	6.1	0.9	4.2	4.7	58.1	
microbranchium	202		51.5	31.6		7.4	0.5	7.0					1.5	0.5
nigricornis	4		100.0											
ochraceum	681	19.4	59.7	13.9	2.1	0.9	0.2	0.1			1.4		2.3	
pacheco-lunai	119	56.3	42.8	0.9										
parrai	816	26.1	55.8	3.1	0.1	0.8	0.1	0.4	0.4			13.2		
pulverulentum	2,925	0.8	11.0	0.4	7.4	0.2	0.1	0.3	4.0	1.4	0.03	0.07	74.3	
roblesi	154	98.7	1.3											
rubicundulum	11,856	9.4	38.4	16.5	6.8	2.9	5.7	1.0	1.5	0.8	0.9	0.5	15.4	0.2
samboni	188		1.6	1.0					2.1				95.3	
smarti	1,134	7.1	35.7	13.1	8.2	13.3	3.1	0.3	2.4		0.1	0.1	7.5	9.1
tricornis	361	4.1	81.9	11.1		0.6			0.6				1.7	
veracruzanum	8,186	2.0	29.9	22.9	8.3	5.3	3.7	10.9	0.9	0.1	0.3	0.4	15.2	0.1
wrighti	1,303	16.7	79.5	0.1	0.1	3.5							0.1	
yepocapense	600	2.4	3.2	1.7	0.7	3.8	2.5	9.8	2.5	0.8	14.3	7.5	50.8	

TABLE 30.—*Preference of Guatemalan species of Simuliidae in relation to substratum and type of stream*

Preferred substratum expressed as percent of total number of pupae of each species collected on particular supporting surface; water flow preferred indicated by percent of total number of each species collected in either normal current, cascade, or waterfall.

Species	Total number of specimens	Substratum: Stones and rocks	Substratum: Leaves	Substratum: Stems and twigs	Substratum: Mud and sand	Character of water flow: Normal	Character of water flow: Cascade	Character of water flow: Waterfall
		Percent of total pupae				Percent of total pupae		
acatenangoensis	7,121	05.3	2.6	2.1		98.0	2.0	
aguirrei	553	91.7	5.8	2.5		100.0		
aquamarensis	542	100.0				100.0		
ardeni	7		100.0			100.0		
aureum	597	26.8	24.8	48.4		100.0		
burchi	65	20.0		80.0		100.0		
callidum	7,300	22.3	49.2	28.5		99.3	0.4	0.3
capricornis	2,974	87.2	7.4	5.4		95.0	4.0	1.0
carolinae	461	98.9	0.2	0.9		46.0	13.0	41.0
colvini	49		100.0			100.0		
delatorrei	151	84.1	10.6	5.3		99.0		1.0
downsi	13,121	0.4	90.1	9.5		99.8	0.2	
earlei	824	66.0	2.2	31.8		100.0		
ethelae	131	73.3		26.7		73.0	18.0	9.0
exiguum	1,057	1.2	71.8	27.0		100.0		
haematopotum	299		33.1	66.9		100.0		
jacumbae	362	13.8	71.0	15.2		96.0	2.0	2.0
jobbinsi	831	10.1	34.4	55.5		99.0		1.0

(*Continued*)

TABLE 30.—*Preference of Guatemalan species of Simuliidae in relation to substratum and type of stream*—Concluded

Species	Total number of specimens	Substratum: Stones and rocks	Substratum: Leaves	Substratum: Stems and twigs	Substratum: Mud and Sand	Character of water flow: Cascade	Character of water flow: Normal	Character of water flow: Waterfall
		Percent of total pupae				Percent of total pupae		
kompi	2		100.0			100.0		
larvispinosum	44	84.1	2.3	13.6		75.0		25.0
mathesoni	13	92.3		7.7		100.0		
metallicum	13,694	4.7	86.8	8.5		99.7	0.1	0.2
mexicanum	10,580	26.4	26.2	47.4		100.0		
microbranchium	81	44.4		55.6		90.0		10.0
nigricornis	3		100.0			100.0		
ochraceum	593	14.9	56.8	28.3		100.0		
pacheco-lunai	88	55.7	35.2	9.1		100.0		
parrai	818	89.0	8.8	2.2		99.0		1.0
pulverulentum	2,890	7.7	27.9	64.4		99.0	1.0	
roblesi	54		85.2	14.8		100.0		
rubicundulum	10,565	72.2	12.3	15.5		98.0	1.0	1.0
samboni	183	4.4		95.6		100.0		
smarti	1,078	70.0	22.6	7.4		94.0	1.0	5.0
trivittatum	5		100.0			100.0		
tricornis	168	85.7	5.9	7.8	0.6	93.0	7.0	
veracruzanum	6,319	12.2	48.7	39.1		99.0		1.0
wrighti	1,203	55.8	13.5	28.2	2.5	96.0	2.0	2.0
yepocapense	925	88.4	7.6	4.0		100.0		

at a known point and was collected after a measured period of time, the distance traveled being recorded. When, owing to numerous rocks, floating debris, or other obstacles, the cork could not continue in its path for the standard time interval, the cork was collected at that point where it was halted by the natural barriers, and the time was then measured. Reducing the figures to inches traveled by the cork per second, we obtained the velocity of flow at the surface of the stream. The mean velocity of the entire stream (average of velocities taken at an infinite number of depths) was calculated by multiplying the surface velocity by the known factor, four-fifths. The volume of the stream, or rate of flow, in gallons per second is the number of cubic feet of water passing in a given section of a stream multiplied by the number of gallons in a cubic foot (7.48). This was computed by multiplying the mean velocity (reduced to feet per second) by the average width of the measured section of the stream, by the average depth of the measured section, by 7.5. The technique for measuring the velocity of the stream was checked with a specialized apparatus for measuring water currents, a pygmy current meter, and found to be accurate enough to warrant continuing the cork method rather than using the heavy and cumbersome meter.

Since the width and depth of a water course influence its rate of flow, it is easily understood that there is not necessarily a direct relationship between the velocity of a stream and its volume flow. A wide, deep stream with a low velocity might have a lower volume than a narrow, shallow stream with a very high velocity. Therefore, certain species of black flies that prefer streams with a high rate of flow may be found in narrow, shallow streams as well as in wide, deep ones, depending primarily upon the velocity. Of course, those streams that are wide and deep most commonly do have a greater rate of flow than the narrow, shallow streams. Thus, when determining which species potentially could breed in a particular water course, it is necessary to consider its width and depth as well as its velocity (current speed). The interrelation of factors affecting the breeding of *Simulium* species is well illustrated in tables 28 and 29.

It can be seen in table 29 that, although *S. ochraceum* prefers breeding in streams with a rate of flow (volume) ranging from less than 1 gallon per second to 20 gallons per second, it will also breed in streams with a rate of flow up to 60 gallons per second, and occasionally in streams with an even greater flow (up to 100 gallons per second). In table 28, the optimum velocity for *S. ochraceum* is given as from 1 to 10 inches per second, although it also breeds freely in streams with a velocity up to 20 inches per second, and occasionally in streams with a current speed up to 40 inches per second.

The higher-volume streams in which *ochraceum* were found can undoubtedly be accounted for by investigating the width and depth of such breeding places. At times this species was found in streams over 5 feet wide and over 1 foot deep (tables 26 and 27). In such breeding places, although the velocity (current speed) may be within the optimum range for *ochraceum*, the volume (rate of flow) will be greater than in smaller streams. From observations made by the author, it appears that the current speed is a more important factor in determining the presence of this species in a particular stream than are the width, depth, or rate of flow.

Although the optimum rate of flow for breeding of *S. metallicum* is the same as for *ochraceum* (1-10 gallons per second), its preference is not nearly as marked as is that of *ochraceum*. Considering the velocity, only 38.9 percent of the *metallicum* pupae were collected from streams with current speeds of 1 inch per second, while 63.4 percent of the *ochraceum* pupae were collected from streams within this range.

The optimum stream volume for *S. callidum* breeding also falls between 1 and 10 gallons per second, but this species is also commonly found breeding in streams with much higher volumes. It is only rarely found in streams with a volume flow less than 1 gallon per second, habitats where *S. ochraceum* abound. It is also less discriminatory than either *ochraceum* or *metallicum* in its choice of the current speed of its breeding places, being found in streams the velocities of which vary from 1 inch per second to that of a waterfall.

Tables 28 and 29 demonstrate the specificity of certain species for streams with comparatively narrow ranges of velocity and rate of flow (*aguirrei, aquamarensis, burchi, carolinae, jacumbae, ochraceum, pacheco-lunai, parrai, roblesi,* and *samboni*) and the more universal presence of other species in streams with a wide range of velocity and rate of flow (*acatenangoensis, callidum, downsi, delatorrei, earlei, exiguum, jobbinsi, metallicum, pulverulentum, rubicundulum, smarti, veracruzanum,* and *yepocapense*.

SUBSTRATUM AND STREAM TYPE IN RELATION TO SPECIES BREEDING

More marked than the preference for streams with a particular depth, width, current speed, volume flow, pH, or temperature, is the specificity of the substratum used by the larvae and pupae of the various species of black flies. Table 30 illustrates this point. Certain species like *Simulium acatenangoensis, capricornis, carolinae, ethelae, mathesoni, rubicundulum, tricornis,* and *yepocapense, Cnephia aguirrei,* and *Gigantodax aquamarensis* show definite preference for stones and rocks. The other species favor leaves, stems, and twigs as substrata.

Of all the species listed, only *aquamarensis* is 100 percent specific insofar as the substratum to which the larvae and pupae attach (stones and rocks). This is probably due to the nature of its breeding places which do not support leafy plants owing to the very low pH. Pupae of *Gigantodax wrighti* and *S. tricornis,* although usually found attached to stones, rocks, leaves, stems, and twigs, were also sometimes found loose in the mud at the bottom of the streams. They were collected by passing water over the mud which was held in a coarse strainer.

The three principal anthropophilic species, *S. ochraceum, metallicum,* and *callidum,* all preferred leaves for attachment of their larvae and pupae, although they were frequently collected from stones and rocks.

Since rapids and sudden drops in level are so prevalent in almost all the smaller streams of the Pacific slope, it may be that several of the larvae and pupae included under normal streams should have been listed as having been collected in cascades. However, for the purpose of this study, a cascade was defined as a small waterfall having at least a 5-foot drop.

No species was found exclusively in waterfalls. Of all the species listed in table 30, only *S. carolinae, larvispinosum, microbranchium,* and *ethelae* had been taken frequently in this habitat. At the time he described *S. carolinae,* De León (1944) considered the heavily sclerotized, pigmented plates associated with the X-shaped sclerite of the larvae as an adaptation for life in the waterfalls where the larvae would be subjected to the force of the torrents. However, the structure of these plates, as well as observations of the larvae in their natural habitats, do not corroborate his beliefs. Since the fixation of the larvae to the substratum is by means of the anal disc (posterior sucker), and since the sclerotized plates are situated at a marked angle to the disc, the plates would not be able to enter the substratum. Also, since almost 99 percent of the larvae of this species attach to rocks, the plates would, at best, be of use to only the small number attaching to vegetation. It would be expected that many more than 41 percent of the larvae and pupae of this species would be found in waterfalls, if this adaptation was evolved to serve the function De León assigned to it. Only 25 percent of the larvae and pupae of *S. larvispinosum,* which has a still more elaborate arrangement of sclerotized plates around the anal disc, were found in waterfalls.

SPECIES ASSOCIATIONS

When collecting larvae and pupae of a particular species, it is often interesting to know what other species might be expected to be found in the same stream. Knowing the type of stream (width, depth, substratum, temperature, current speed, and volume flow) and the altitude of the region, a study of tables 23 through 30 should enable the collector to make a provisional list of such species. The probabilities could then be checked by referring to table 33 in Appendix III, and a more accurate prediction made. Table 33 was prepared from the findings of the author after making approximately 4,000 collections of larvae and pupae in over 500 streams throughout Guatemala. Each species has been listed along the vertical and horizontal margins of the table. To the right of each species listed along the vertical margin, there has been given the number of times it was collected with species listed along the horizontal margin. Likewise, the number given below each species listed along the horizontal margin will tell how many times that species was collected with the species listed along the vertical margin. Thus, by mere observation the relative probability of finding a particular species in the same stream with all other species can be determined. For example, along with *S.* (*D.*) *acatenangoensis*, *S. aureum* was found on 6 occasions, *C. aguirrei* on 3, *S. callidum* on 30, *capricornis* on 23, *carolinae* on 4, *downsi* on 18, *ethelae* on 3, *rubicundulum* on 32, etc. Therefore, it can probably be said that *S. acatenangoensis* will be more likely to be found associated with *callidum, capricornis,* and *rubicundulum* than with *C. aguirrei, S. carolinae,* or *ethelae.*

It will be seen in table 33 that along with *S. ochraceum,* in its rather specialized habitat, the other species most commonly found are *metallicum* and *callidum.* However, although *metallicum* and *callidum* do breed along with *ochraceum,* they are much more likely to be found in larger young to adolescent streams in which there is prolific breeding of *downsi, rubicundulum,* and *mexicanum.*

RELATION OF OXYGEN CONTENT OF STREAMS TO SPECIES BREEDING

The dissolved oxygen content of 62 streams in the Municipality of San Pedro Yepocapa was determined by the Winkler method (Amer. Publ. Health Assoc., 1936) five times during the period of a year. It was found that all streams in this region were very high in oxygen, especially at the end of the rainy season. The lowest oxygen content was recorded during the month of April, at the end of the dry season. Since the seasonal variation in dissolved-oxygen content was found to be very slight, it is unlikely that it affects the normal development of the Simuliidae. A comparison of the dissolved oxygen in the mountain streams of the Yepocapa region with that of the streams in the coastal region or other sections of the country might show a relationship between oxygen content and the ability of the various species to breed. Such a study was not carried out because of the impracticability of doing the oxygen determinations under field conditions in most parts of Guatemala.

RELATION OF DISSOLVED SALT TO BREEDING OF BLACK FLIES

The same 62 streams that were used for dissolved-oxygen determinations, were also tested for salt content. A simple salimeter was employed from which readings could be made directly according to its displacement of water. Since no streams in the Yepocapa region exhibited salt content, the study of this factor was discontinued.

EFFECT OF FOREIGN SUBSTANCES IN STREAMS ON BREEDING OF BLACK FLIES

In general, it has been observed that no species of Simuliidae will breed in streams that have been polluted by large quantities of agricultural or chemical wastes. This was particularly noticeable in the Río Guacalate at Pastores, Sacatepéquez, where *Simulium exiguum* normally breeds in great abundance. During the months of the corn and coffee harvests, large quantities of waste cane and leaves and coffee pulp are dumped into the stream. Within a few days the larvae and pupae of *S. exiguum* disappeared from the stream and did not return until the rainy season once again cleared the debris and permitted more normal oxygenation. The streams of Guatemala are commonly used by the rural population for washing clothes. The large amount of soap that is introduced into the streams does not seem to affect the breeding of the Simuliidae except in the immediate vicinity of its release. Wherever sewage or garbage is discharged into streams, no black-fly breeding will be found for long distances downstream.

ECOLOGICAL NOTES

The following ecological notes refer to species which were not discussed in the first seven parts of the subsection entitled "Immature Stages" or included in tables 23 through 30.

Simulium (*Byssodon*) *benjamini* Dalmat.—This species has been found in only two streams, Río Sokchá, Poctún, Petén, and a stream (name not known) in Cobán, Alta Verapaz, both being part of the

Atlantic watershed. The collections were made at altitudes of 1,500 feet and 5,000 feet. At the point of collection, the Río Sokchá was 39 inches wide, 3 to 15 inches deep, with a current of 20 inches per second; the temperature was 20° C. and the pH, 7.2. The collections were both made during the month of November, at the beginning of the dry season. Other species found developing in the same streams were *S.* (*S.*) *metallicum*, *S.* (*L.*) *samboni*, *S.* (*S.*) *ochraceum*, and *S.* (*L.*) *downsi*.

Simulium (*Lanea*) *colvini* Dalmat.—This species has been found at an altitude of 260 feet in only one stream (name unknown) between Malacatán and Ayutla, Department of San Marcos, near the Río Suchiate which divides Guatemala from Mexico. The larvae and pupae were found on narrow leaves, approximately 1 inch beneath the surface of the water. Other species that were found in the same stream were *S.* (*D.*) *pulverulentum*, *S.* (*S.*) *metallicum*, and *S.* (*L.*) *downsi*.

Simulium (*Lanea*) *dugesi* Vargas, Martínez, and Díaz.—The pupae of this species were found only once in a single stream, Río Limón, Escuintla. They were collected at 1,050 feet altitude, at a part of the stream having a width of 15 feet; depth, 12 inches; temperature, 24° C.; current (velocity), 36 inches per second (290 gallons per second); pH, 7.0. The river bed was sandy, with small and large stones, and with few plants. The breeding area was open to the sun. The collection was made at the beginning of the dry season. Other species collected in the same part of the stream were *S.* (*D.*) *pulverulentum*, *S.* (*L.*) *downsi*, *S.* (*N.*) *exiguum*, and *S.* (*S.*) *metallicum*.

Simulium (*Lanea*) *jacobsi* Dalmat.—The stream in which this larva was found had a pH of 7.6, temperature of 26° C., current speed of 4¾ feet per second and volume of 3,130 gallons per second. The width of the stream was approximately 42 feet, its depth 2 feet. Its bed was composed of sand with numerous large and small stones, and with very little emergent or trailing vegetation. The altitude of the region was 4,000 feet. The larva was collected from a twig floating on the surface of the water. The collection was made in June, during a lull in the rainy season.

Simulium (*Lanea*) *trivittatum* Malloch.—The pupae of this species were collected in the Department of Alta Verapaz, in a single stream located on the northern slope of the Chuacús-Minas-Mico range which forms the most northern chain of mountains in Guatemala. The altitude of the region is about 4,600 feet. The river was about 5 to 10 feet deep, with crystal-clear water and with little to no trailing vegetation; the current was swift, but with few rapids. The river passed through a narrow limestone gorge with banks 5 to 20 feet high. In general, *Simulium* spp. were scarce, the pupae of the specimens described being found on sticks and dead roots in a few existent rapids. The only other species found in the same stream were *S.* (*D.*) *mexicanum* Bellardi and *S.* (*D.*) *ardeni* Dalmat.

Simulium (*Dyarella*) *ardeni* Dalmat.—Found in the same stream as *S.* (*L.*) *trivittatum* (see above).

SEASONAL FLUCTUATION IN POPULATIONS

In considering programs for the control of either the larvae or adults of the Simuliidae, it is of utmost importance to know how many generations are produced during the year and when the peaks of population occur. With this information the frequency of treatment can be determined and the budgets prepared for necessary labor and insecticides.

Prévost (1947) states: "We have gone beyond the hope of Fairchild and Barreda (1946) that 'three or four treatments per year' would give control of blackfly larvae for, with a single treatment of a very low concentration of DDT at a critical time when only larvae were present, we have eliminated blackfly larvae for a period whose limit we have not yet reached, as those brooks treated a year and a half ago have not yet been recontaminated." He also speaks of "the failure of Fairchild and Barreda to achieve lasting results with the same type of treatment" because "the treatment must be performed at a time when only larvae are present in the brooks."

From the remarks of Prévost it becomes apparent to the present author that the life cycle and number of generations per year must differ considerably between different species of black flies in different parts of the world. Also, the streams to be treated must vary a good deal in their physical character. In Guatemala, where Fairchild and Barreda worked, it would be impossible to carry out a control program at a time when larvae alone are present in the streams. Let us consider only *Simulium ochraceum, metallicum,* and *callidum,* the three principal anthropophilic species of black flies in Guatemala. Owing to the moderate temperatures and rather heavy precipitation, the streams in which these species breed run throughout the year and always contain sufficient vegetation and other substances to furnish food and substrata for the immature stages. Since the life cycle of these species can be completed in approximately one month and since the duration of each stage varies within rather broad limits (see section on life history), it can be understood why eggs, larvae, and pupae can be found in the same stream or in neighboring streams at any one time throughout the year. It is true that at certain periods larvae may predominate, but they are never present to the complete exclusion of the other stages. Thus the type of control Prévost advocates would be impossible in the onchocerciasis zones of Guatemala.

The life cycle of *S. ochraceum, metallicum,* and *callidum* has already been presented in the section on life history. The longevity of the adult females was also mentioned in the same section and subsequently discussed more amply under "Flight Range and Longevity" in the section on ecology. There now follows a discussion of the population trends of these species throughout the year.

To study the fluctuations in adult populations, collecting stations were established at 27 fincas of the Yepocapa region. Each month, an average of 135 collections of adult flies were made at these stations, using human bait. Each collection period lasted 20 minutes, the first 10 minutes serving to attract flies to the subject, and the second 10 minutes being used to collect flies while biting. In studying the seasonal variation in the larval and pupal populations, the number of specimens of the particular species collected throughout the country was determined. Each collection required approximately an hour's search for the immature stages at a particular stream. From this, the number of larvae or pupae per collection period was calculated. An average of 7 collections per month were made of *S. ochraceum* larvae and pupae, 125 of *metallicum,* and 90 of *callidum.* The data on the seasonal variation of the larvae, pupae, and adults were combined on a single graph for each of the three species.

It can be seen on the graph (text fig. 11) that larvae, pupae, and adults of *S. ochraceum* are found throughout the year. However, there are two peak periods of adult population, the higher one in January and the second in August, and also two peaks in larval production which follow after those of the adults, the greater one being in April and the less-pronounced one in October. The principal peak of the adult population occurs during the middle of the dry season, at the time of the coffee harvesting and processing (greatest finca activity) when field workers are most exposed to the bites of black flies. The secondary peak occurs during a regularly experienced dry spell in the midst of the rainy season. The peaks of larval population occur either before or after the heavy rains. As would be expected, when the adult population is at its maximum, the larval population falls to its lowest level. Since the pupal stage usually lasts only 3 to 5 days, the period of its abundance should almost coincide with that of the adults which emerge from them. This, in general, is borne out by the data given in the graph, although the very small numbers of pupae involved do not permit a very clear representation of this point.

Text figure 12 (graph) presents the same information for *S. metallicum*. The peaks in population of this species are not nearly as well marked as for *ochraceum*. This substantiated our repeated observations that *S. metallicum* is present in large numbers throughout most of the year, while *ochraceum* is more cyclical in appearance. However, there is a gradual reduction in adult population from June through December, a sharp drop in May at the beginning of the heavy rains,

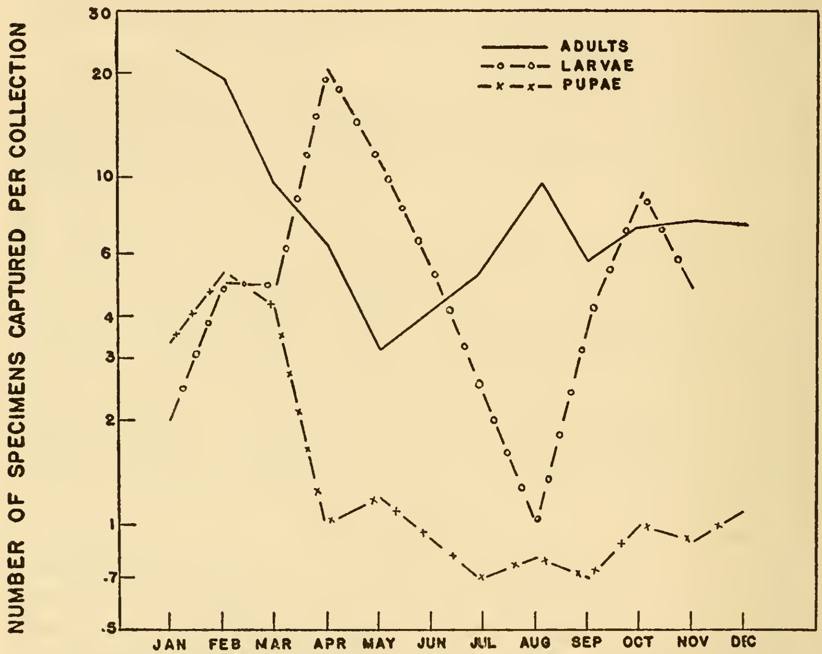


Fig. 11.—Fluctuation in population of *S.* (*S.*) *ochraceum* throughout a year period, expressed as the average number of specimens captured per collection during month periods. (Prepared on 3-cycle semilogarithmic paper.)

and a rise during January through April. The larval population varies accordingly, the maximum larval population coinciding with the low in adult population. Again, the population trend of the pupae more or less approximates that of the adults.

As for *ochraceum*, the adult *callidum* population (graph, text fig. 13) is highest during the middle of the dry season (January and February) and reaches a secondary peak in August, during a lull in the rains. The fluctuations in population appear more numerous than for *ochraceum* or *metallicum*, indicating the possibility that *callidum* passes through more generations in a year than do the other two species. The fluctuations in the larval population of *callidum* vary inversely with those of the adults. When the adult population is at a peak, the larval population is at a low level, and vice versa. Although the pupal trend most nearly coincides with that of the adults, it can be seen that the graph for the adult population is more erratic than that for the pupae. This should be expected since the adult population was relatively small and any variations in meteorological or other environ-

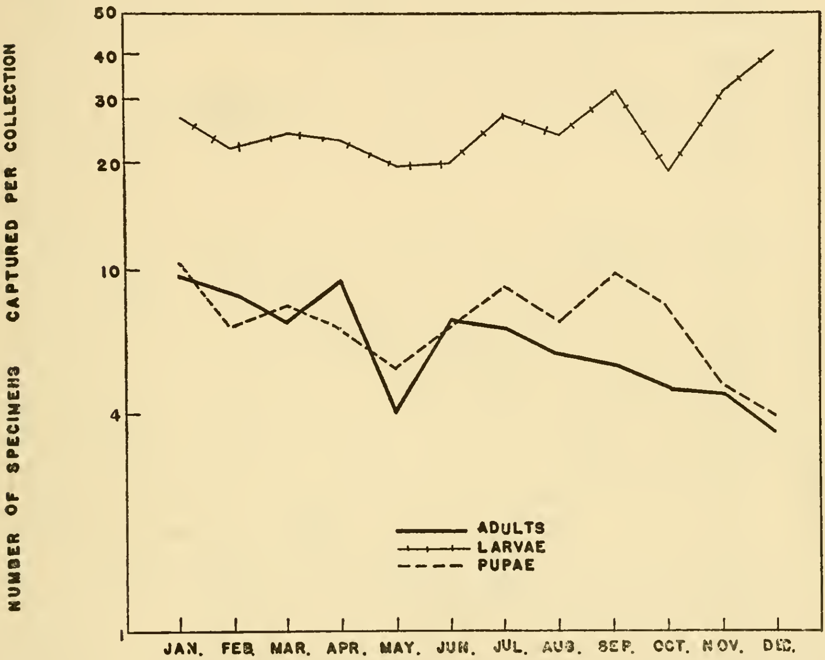


FIG. 12.—Fluctuation in population of *S. (S.) metallicum* throughout a year period, expressed as the average number of specimens captured per collection during month periods. (Prepared on 3-cycle semilogarithmic paper.)

mental conditions might very well bring about temporary absence of biting adults, which would be magnified on the graph. On the other hand, the pupal population would not be similarly affected by temporary changes in environmental conditions.

With our present knowledge of the seasonal variation in population of the three principal anthropophilic species, it would be necessary to develop a larval control program in the onchocerciasis region based on the following information. If only *S. ochraceum*, the principal anthropophilic species, is to be controlled, streams must definitely be treated during April and October, as well as somewhat before and after these months, to take full advantage of the larval peaks. However, since the larvae of this species are always present, thorough control would require stream treatment throughout the year, based on the 14- to 31-day life cycle. Should control of *S. metallicum* and *callidum* also be undertaken, stream treatment would have to be repeated

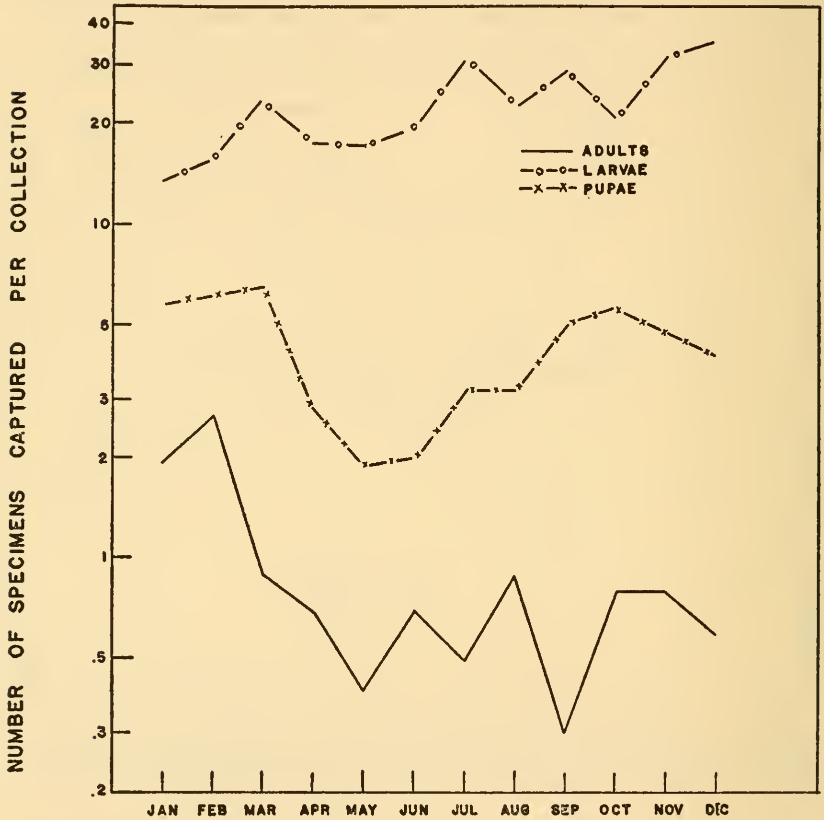


FIG. 13.—Fluctuation in population of *S. (L.) callidum* throughout a year period, expressed as the average number of specimens captured per collection during month periods. (Prepared on 3-cycle semilogarithmic paper.)

regularly, at about 28-day intervals. From the standpoint of onchocerciasis control in the Yepocapa region, it is believed that both *ochraceum* and *metallicum* control should be taken into consideration.

NATURAL INFECTION OF ADULTS WITH *ONCHOCERCA VOLVULUS*

To determine which of the anthropophilic species play an important role in the transmission of human onchocerciasis, it was necessary to determine which become infected in nature and to support the development of the filarid larvae to the infective stage. Gibson (1951a) showed experimentally that *S. ochraceum, metallicum,* and *callidum* were all capable of ingesting microfilariae from infected individuals as well as of supporting their subsequent development. He also determined the rates of natural infection with *Onchocerca* spp. to be 0.38 percent in *S. ochraceum,* 1.04 percent in *metallicum,* and 0.62 percent in *callidum.* Gibson found that during a 2-year period the natural-infection rate in all three species was zero from October through December (1951b and 1952) when the finca workers are most exposed to the bites of the flies. Since such findings appeared contrary to what was anticipated, it was decided to repeat Gibson's studies, at least through the period when natural infection was not found, dissecting larger samples of flies.

Approximately 200 flies were collected every month from each of nine fincas in the Municipality of Yepocapa. These were brought to the laboratory where they were dissected in physiological saline, the head, thorax, and abdomen being examined separately. Since the characters whereby the developing forms of *Onchocerca volvulus* in the flies can be distinguished from those of other *Onchocerca* species still have not been discovered, all *Onchocerca* larvae found in the three species of *Simulium* dissected were considered to be *O. volvulus.* This investigation was carried on from August 1952 through April 1953, when the Onchocerciasis Laboratory was terminated. The results have been summarized in table 5 (p. 30).

Naturally infected flies were caught during all months of the investigation with the exception of December. The rate of natural infection in October was higher than in any other month of this study and the November rate was at least as high as the average. Since the general *Simulium* population increased, on an average, almost sixfold during the months of October through April, the infected fly population undoubtedly was substantially diluted. Thus the probability of collecting naturally infected flies would be reduced, unless the fly samples dissected were to be proportionately increased. This was achieved to a small extent in January, February, and March, but not in December, at the peak of fly abundance. Perhaps on this account, no naturally infected flies were collected during December, while small numbers were encountered from January through April.

It can be seen in table 5 that the infection rate in flies fluctuates markedly from month to month and from finca to finca. This may be due to the small samples of flies that were dissected and/or to the variability in the infection rate between the different localities involved.

It is likely that Gibson's negative natural infection data for the beginning of the dry season (October-December) result from the fact that his fly population samples were collected from only two localities, and that his average monthly total of flies dissected did not exceed 250 flies. Erroneous conclusions could easily be drawn under such conditions. For example, if one were to consider the natural-infection rates of flies on fincas Conchita, Buena Vista, Sibajá, and Santa Teresa only (table 5), where the natural-infection rate is generally low throughout the year, the dissection of only small samples of flies would probably uncover natural infection during the rainy season, when the dilution factor is reduced, but not during the dry season, when the infected flies would be lost in the tremendously increased total population. According to the data in table 5, these fincas show low natural-infection rates in the flies for August, September, October, January, March, and April, but no infection for November, December, or February. On the other hand, if the fincas Montevideo, Recreo, and Recuerdo, where the naturally infected population is higher throughout the year, were to be used for the natural-infection studies, it would be more likely that infection would be found at any time during the year, even if only small samples of flies were dissected. Table 5 shows a relatively high infection rate during August, September, October, and November, a lower infection rate during January, February, March, and April, and none during December. The probable reason for zero infection in December has already been given. However, it should be noted that the natural-infection rate of the flies is much higher during the months of August, September, and October on these fincas than at Conchita, Buena Vista, Sibajá, and Santa Teresa; also, more naturally infected flies were found at Recreo and Recuerdo in January, February, and March than were found at the Conchita-Buena Vista group of fincas. Thus, it can be seen how important it is to include in natural-infection studies regions that will definitely yield infected flies, and to dissect sufficiently large numbers of flies, especially during the period of great abundance when infected ones are more likely to be encountered.

Although Gibson (1951a) did find natural infection in *S. callidum,* the extremely low and sporadic population of this species in the onchocerciasis zones and the absence of infection in it in the present study indicate that it does not play a significant role in the transmission of onchocerciasis. The relative importance of *S. ochraceum* and *S. metallicum* will be discussed more fully in the following section.

TRANSMISSION OF HUMAN ONCHOCERCIASIS IN GUATEMALA

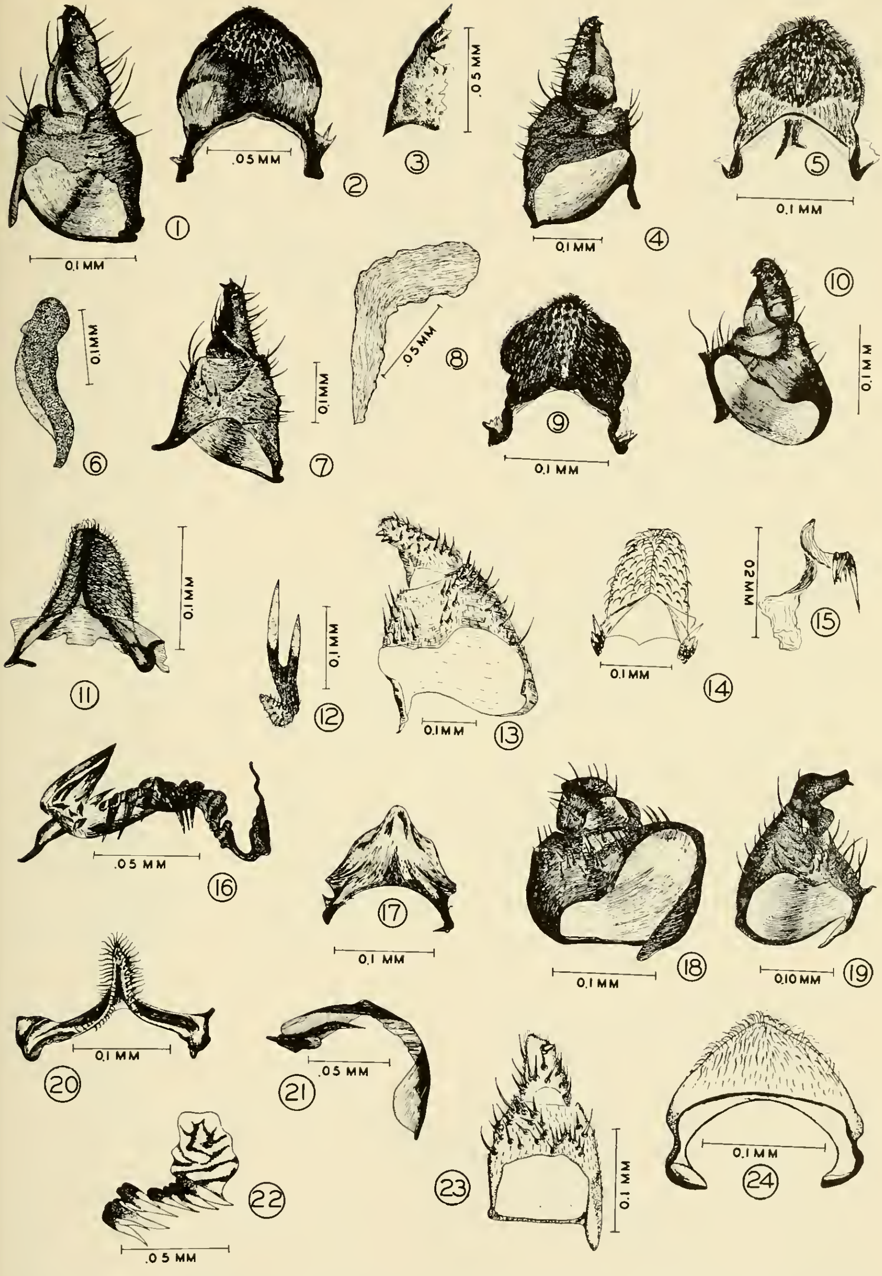
Since Robles' hypothesis (1919) concerning the transmission of human onchocerciasis in Guatemala by *Simulium* flies, and Blacklock's experimental proof that *Simulium damnosum* transmits the disease in Africa (1926a and b), it has been generally accepted that these Diptera are the vectors. The investigations of Strong (1931a, b, and c), Hoffmann (1930a, b, c, d, e; 1931a), De León (1940a, b), Vargas (1948), and Gibson (1951a), all working in Guatemala or Mexico, have corroborated the evidence of Robles and Blacklock that *Simulium* species do transmit onchocerciasis. Upon epidemiological grounds, *S. ochraceum, S. metallicum,* and *S. callidum* have been considered the probable vectors. Based principally on the anthropophilic nature of *Simulium ochraceum* and the apparent coincidence of its geographic distribution with the endemic regions of onchocerciasis, this species has been adjudged the principal vector.

It is true that *Simulium* species do abound in all regions with endemic onchocerciasis and that the transmitting species would necessarily have to be one that attacks humans. However, in Guatemala and Mexico there are several species that bite man, and it is therefore advisable to weigh all available evidence to determine which of the species actually transmit the disease.

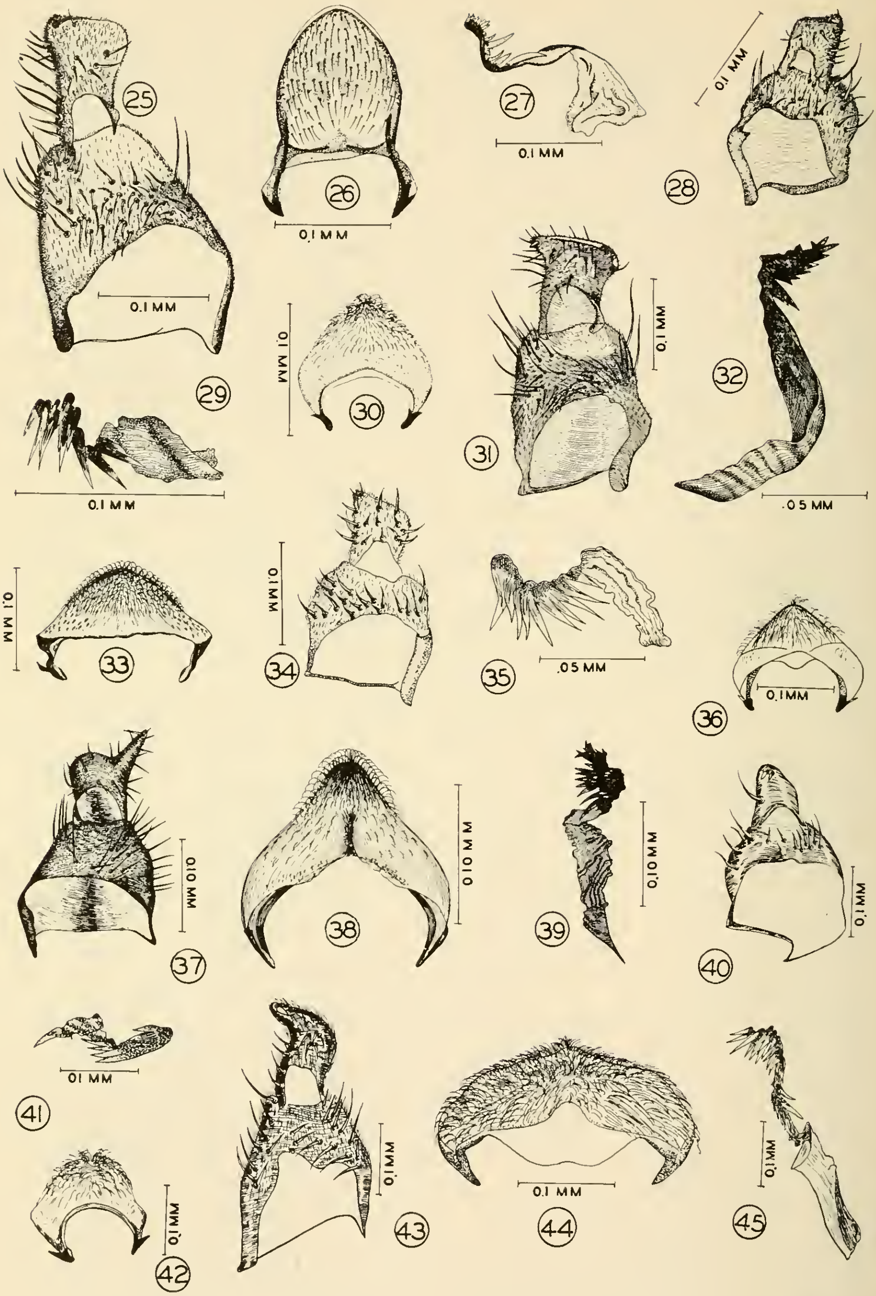
Simulium ochraceum, metallicum, callidum, haematopotum, exiguum, and *veracruzanum* are the species that readily attack man and, therefore, can be considered possible vectors of onchocerciasis. In considering the distribution of these species (see "Distribution of the Guatemalan Simuliidae"), only *S. ochraceum, metallicum,* and *callidum* inhabit the highly endemic sections of the disease zones along the Pacific slopes of the volcanic cordillera. *S. exiguum* and *haematopotum* are more restricted to the lower limits of the zones, and *veracruzanum* to the upper limits. Since *callidum* is only found sporadically throughout its range, and then in only small numbers, it can probably be disregarded as an important transmitting agent. Although both *S. ochraceum* and *metallicum* are usually found throughout the onchocerciasis zones, *metallicum* is also widespread in all parts of the country outside of the disease zones, from the coastal region to well above 6,000 feet. Where *S. ochraceum* exists outside of the disease zones, it is found in only small numbers. From these distributional data alone, it would seem that *S. ochraceum* is probably the most important vector of onchocerciasis.

Now let us consider the frequency with which the different *Simulium* species attack man, their biting preferences, and their natural infection with *Onchocerca volvulus.* In table 9 (p. 45) it will be noticed that, of the species attacking man, only *S. metallicum, ochraceum,* and *callidum* do so to a significant degree. Since only 4 percent of the flies biting man were *callidum* in comparison to 65 percent for *metallicum* and 30 percent for *ochraceum,* it again appears that *callidum* must play only a minor role, if any, in the transmission of the disease. In comparing *metallicum* and *ochraceum* only, it would appear that *metallicum* is of much greater importance as a human biter than is *ochraceum.* It is true that *metallicum* bites man freely and that wherever it exists it far outnumbers *ochraceum.* However, if we compare the host preferences of these two species (table 10, p. 46), when both human and other animal bait are available to the flies, side by side, we find that *ochraceum* is strictly anthropophilic, while *metallicum* definitely prefers hosts other than man. In nature, both species harbor larvae of *Onchocerca* spp. (see "Animal Associations" in the section on epidemiology and "Natural Infection of Adults with *Onchocerca volvulus*" in the section on ecology). Since we still cannot distinguish the species of the developing *Onchocerca* larvae found in the flies, it is possible that natural infections may be of either human or other animal origin (see "Animal Associations" in the section on epidemiology). Comparing the two species of black flies, however, since *metallicum* is definitely more zoophilic in its host preferences, and since it will feed alternately on human and other animal hosts (see "Body Regions Preferred" in the section on ecology), it is more likely that its infections are of mixed origin. Thus *S. ochraceum,* with its marked anthropophilic habits, emerges as the more probable vector.

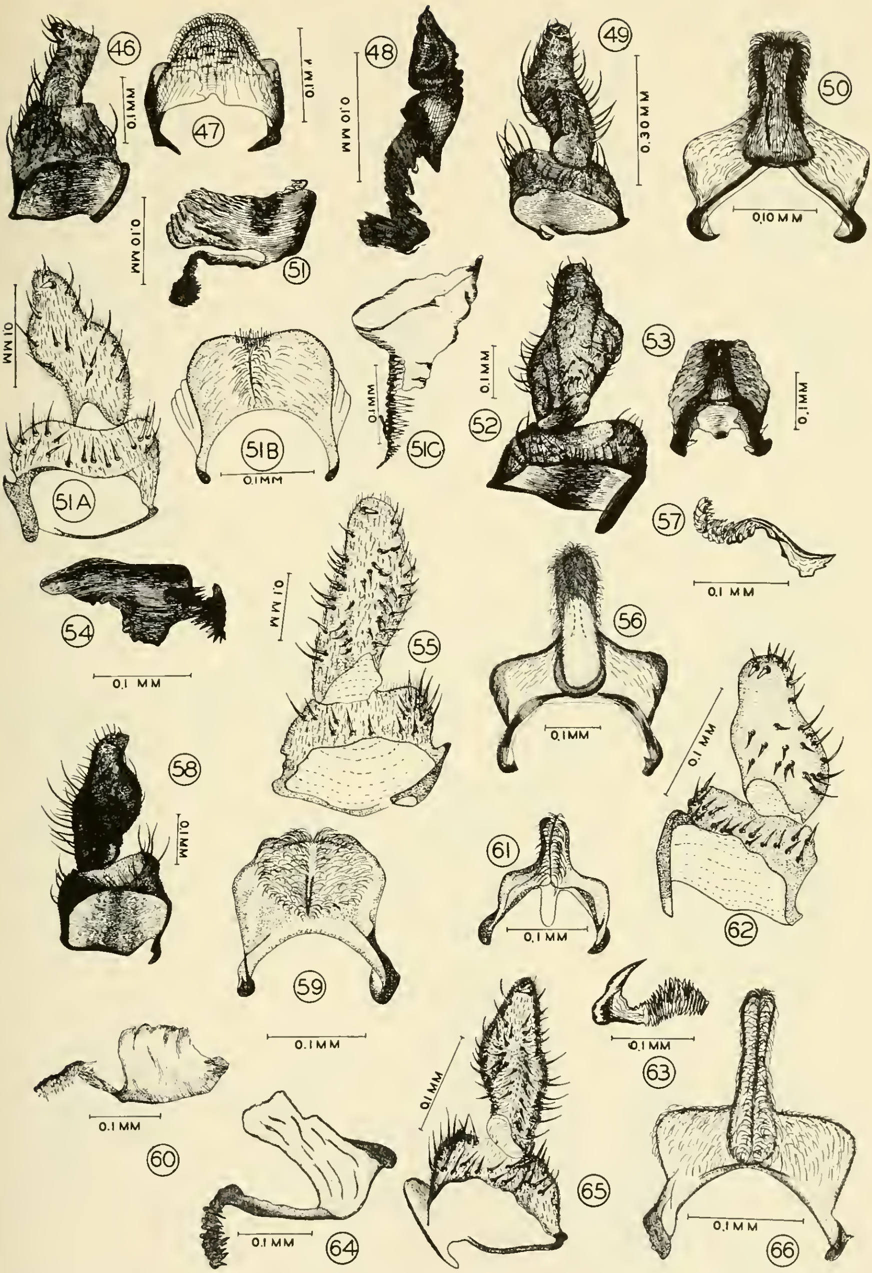
It has frequently been stated that *S. ochraceum* is a more effective transmitter of onchocerciasis to man than are *metallicum* or *callidum* because it attacks the upper regions of the body that are generally exposed, while the latter two species bite only on the lower regions where microfilariae are not found. Although it is true that *ochraceum* prefers the upper regions while *metallicum* and *callidum* usually select the lower limbs (table 12, p. 316), microfilariae are present in both regions (see "Body Regions Preferred" in the section on ecology). Also, although the preferred body part may be covered, any one of the three species of flies mentioned will bite on other less desirable areas (table 13, p. 316). However, the microfilariae in the legs concentrate in the thighs, which are generally less accessible to the flies than the upper part of the body. Thus, under normal circumstances, the species biting on the upper body regions would be more likely to ingest microfilariae with their blood meals. It appears probable, then, that *ochraceum* is the most effective transmitter on the basis of its feeding preference for these upper regions of the human body.



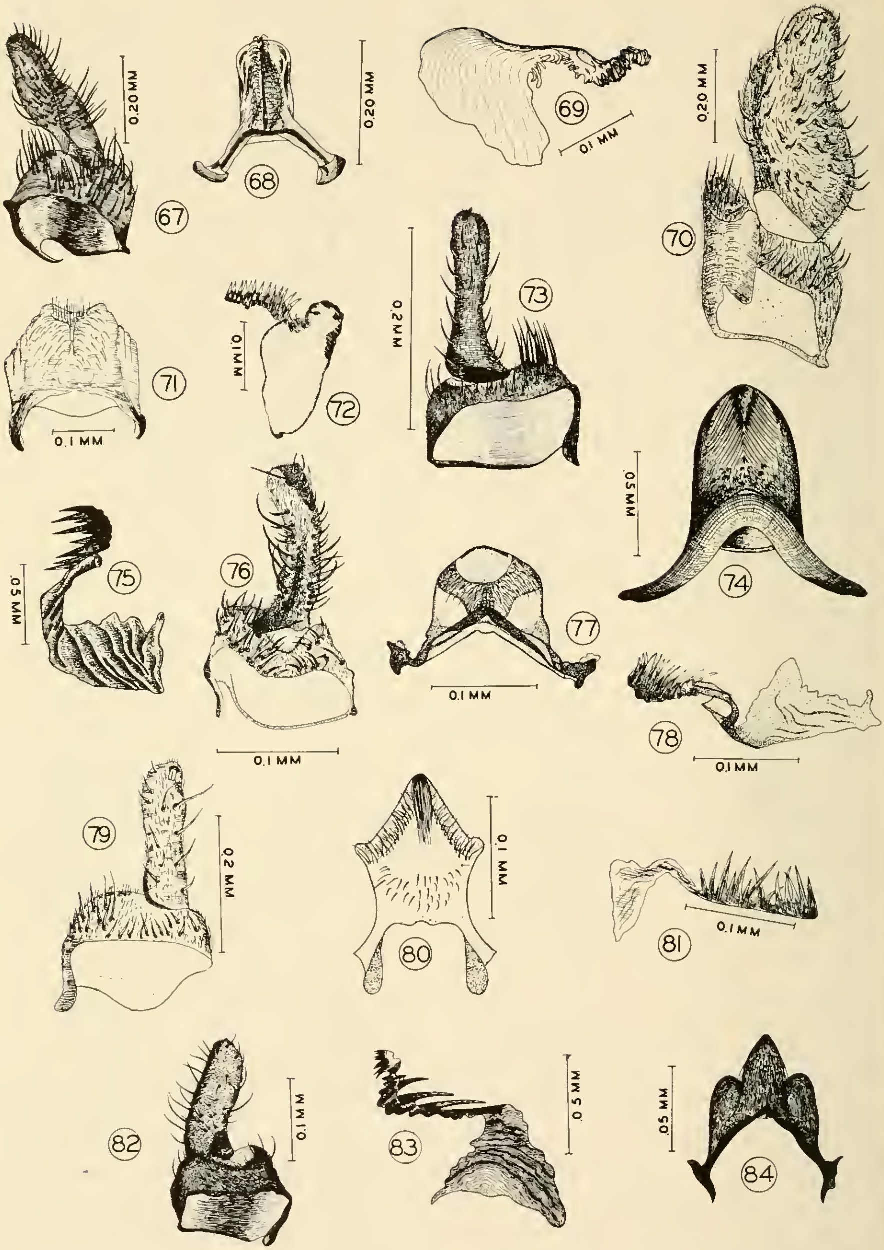
Sidepiece and clasper, adminiculum, and adminicular arm of males: 1-3, *Cnephia aguirrei;* 4-6, *Cnephia pacheco-lunai;* 7-9, *Cnephia roblesi;* 10-12, *Gigantodax aquamarensis;* 13-15, *Gigantodax wrighti;* 16-18, *Simulium (Notolepria) exiguum;* 19-21, *Simulium (Eusimulium) aureum;* 22-24, *Simulium (Byssodon) benjamini.*



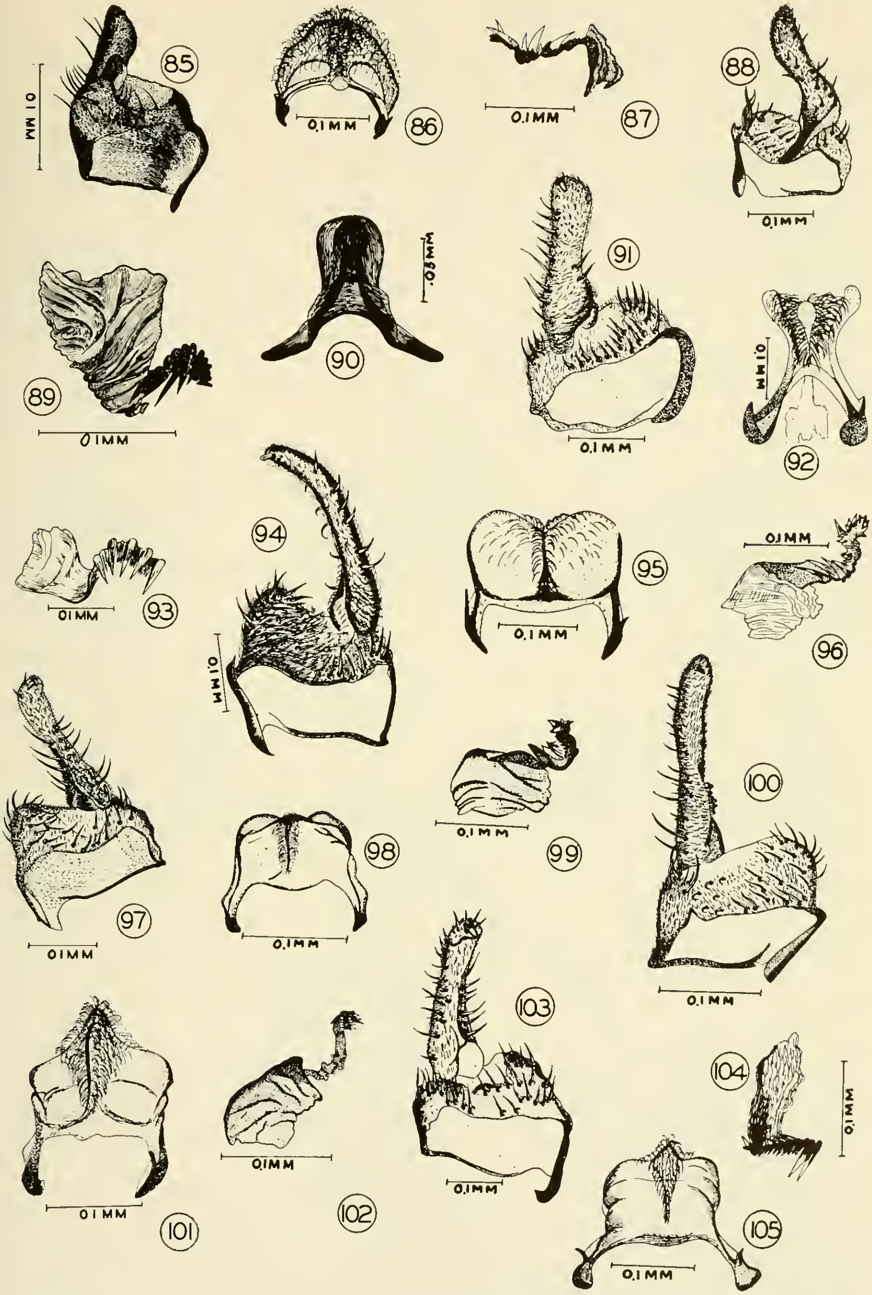
Sidepiece and clasper, adminiculum, and adminicular arm of males: 25-27, *Simulium (Lanea) callidum;* 28-30, *S. (L.) colvini;* 31-33, *S. (L.) downsi;* 34-36, *S. (L.) dugesi;* 37-39, *S. (L.) haematopotum;* 40-42, *S. (L.) samboni;* 43-45, *S. (L.) trivittatum.*



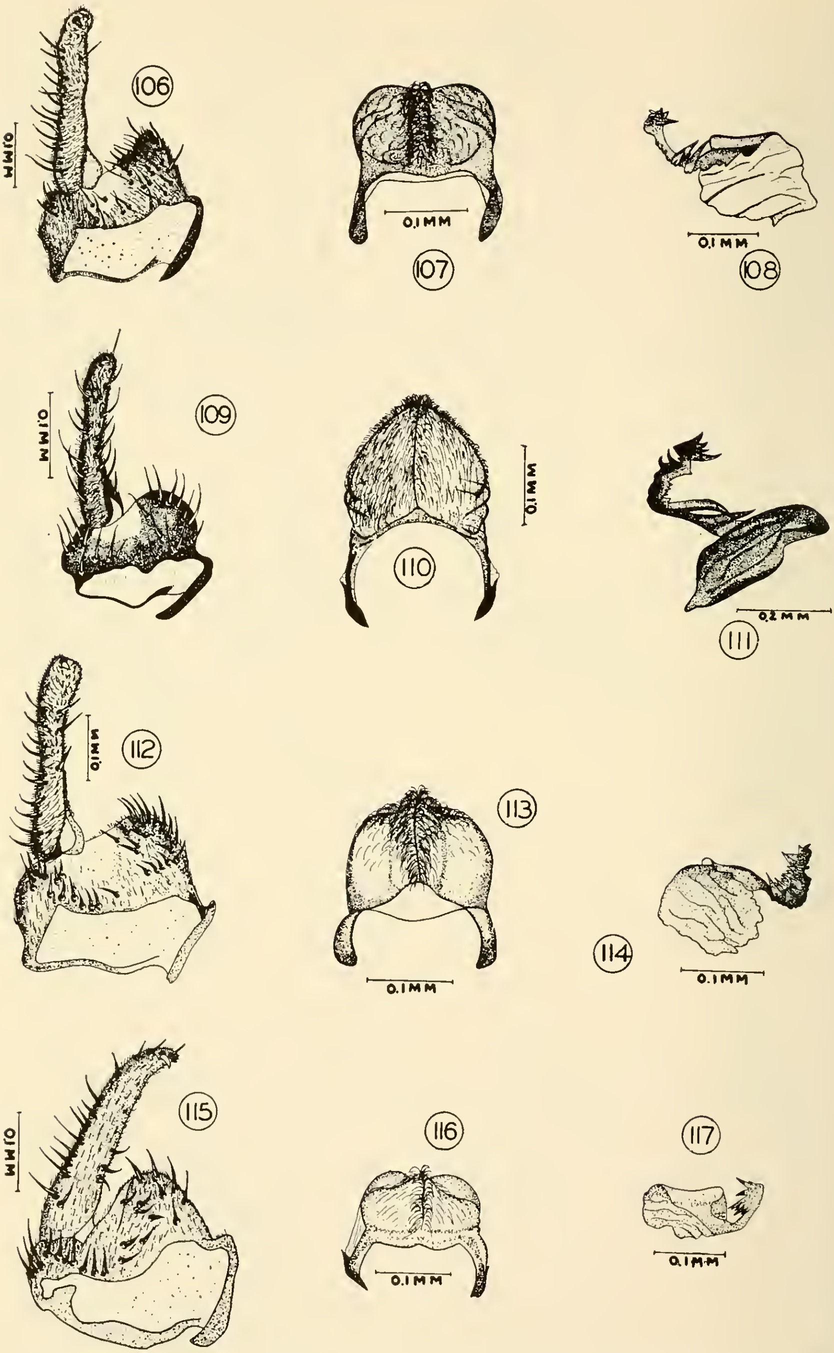
Sidepiece and clasper, adminiculum, and adminicular arm of males: 46-48, *Simulium (Lanea) veracruzanum*; 49-51, *Simulium (Dyarella) acatenangoensis*; 51A-51C, *S. (D.) ardeni*; 52-54, *S. (D.) earlei*; 55-57, *S. (D.) mathesoni*; 58-60, *S. (D.) mexicanum*; 61-63, *S. (D.) pulverulentum*; 64-66, *S. (D.) rubicundulum*.



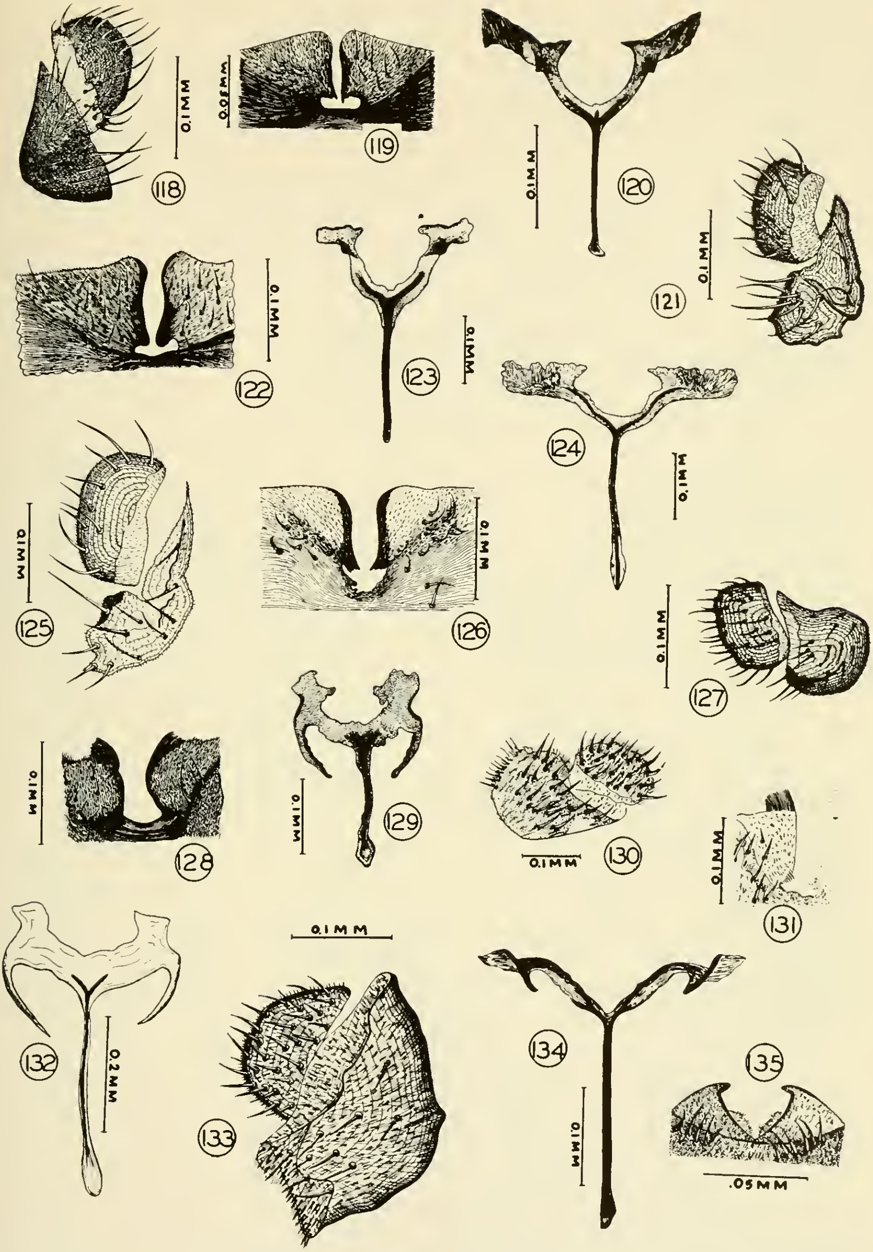
Sidepiece and clasper, adminiculum, and adminicular arm of males: 67-69, *Simulium (Dyarella) smarti;* 70-72, *S. (D.) yepocapense;* 73-75, *S. (Simulium) jacumbae;* 76-78, *S. (S.) jobbinsi;* 79-81, *S. (S.) kompi;* 82-84, *S. (S.) metallicum.*



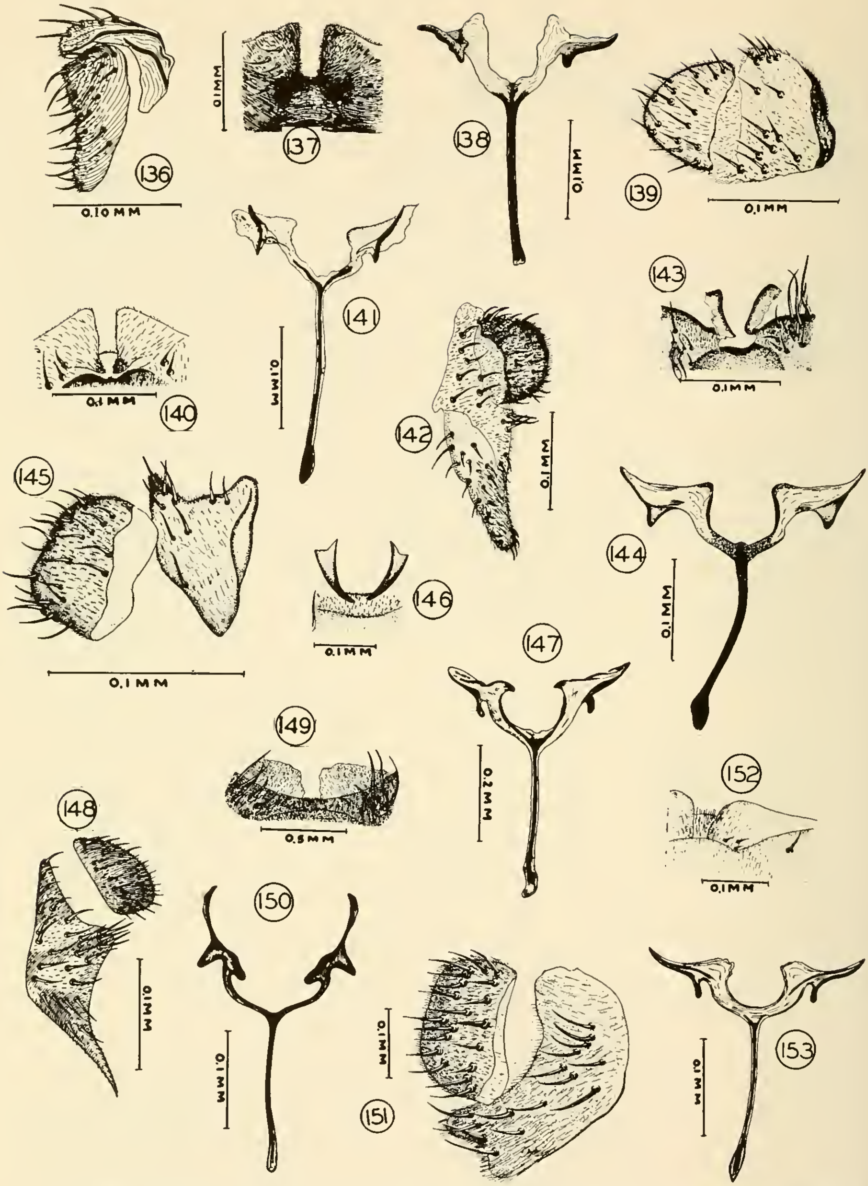
Sidepiece and clasper, adminiculum, and adminicular arm of males: 85-87, *Simulium (Simulium) ochraceum;* 88-90, *S. (S.) parrai;* 91-93, *S. (S.) tricornis;* 94-96, *S. (Hearlea) burchi;* 97-99, *S. (H.) capricornis;* 100-102, *S. (H.) carolinae;* 103-105, *S. (H.) delatorrei.*



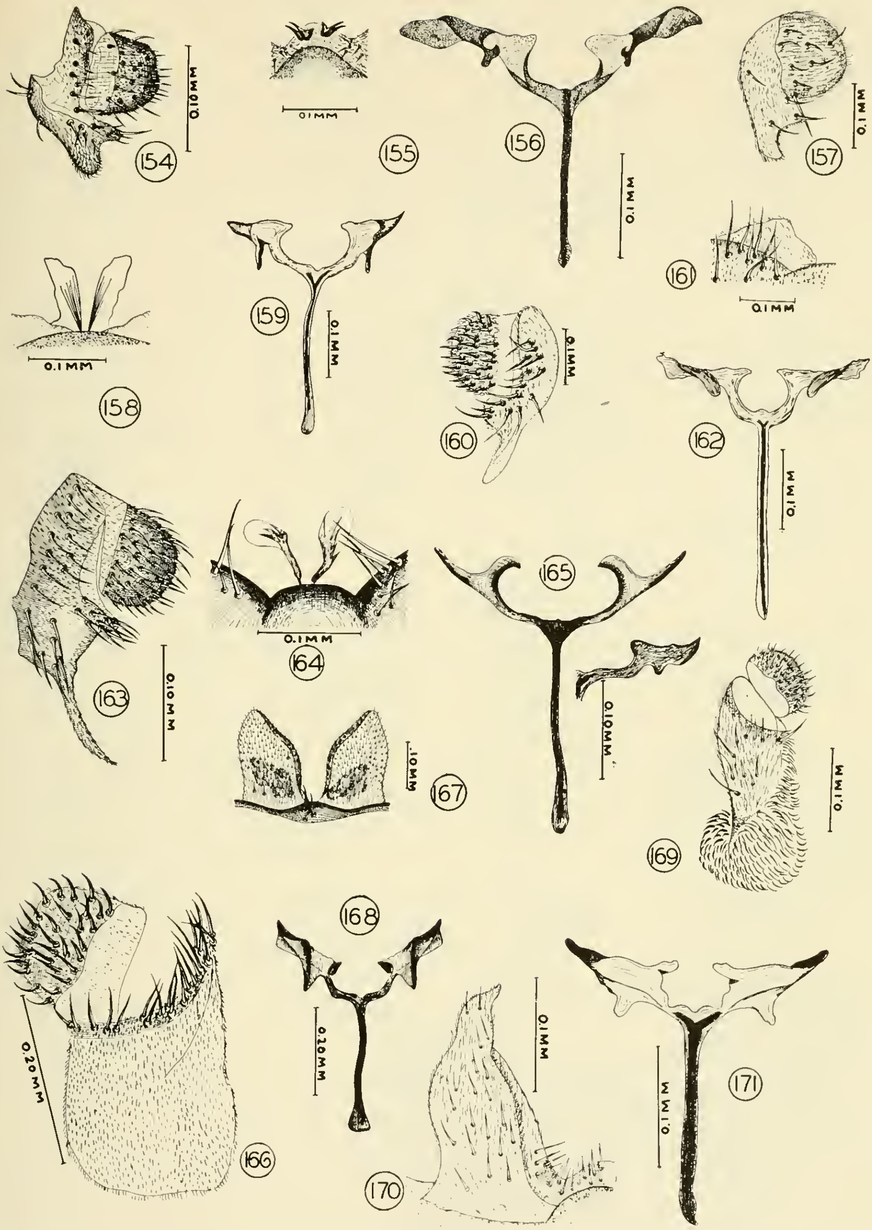
Sidepiece and clasper, adminiculum, and adminicular arm of males: 106-108, *Simulium (Hearlea) ethelae;* 109-111, *S. (H.) larvispinosum;* 112-114, *S. (H.) microbranchium;* 115-117, *S. (H.) nigricornis.*



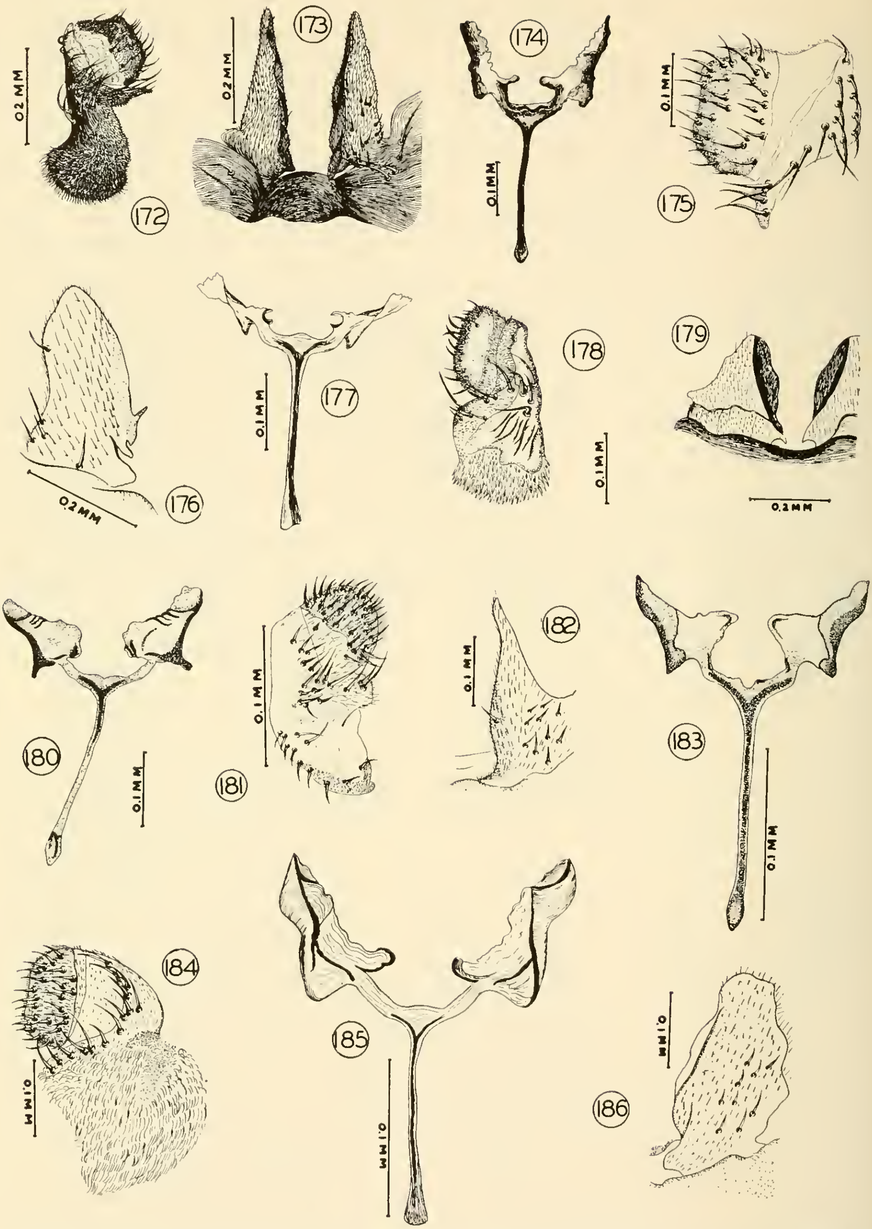
Cercus and anal lobe, genital fork, and ovipositor of females: 118-120, *Cnephia aguirrei;* 121-123, *Cnephia pacheco-lunai;* 124-126, *Cnephia roblesi;* 127-129, *Gigantodax aquamarensis;* 130-132, *Gigantodax wrighti;* 133-135, *Simulium (Notolepria) exiguum.*



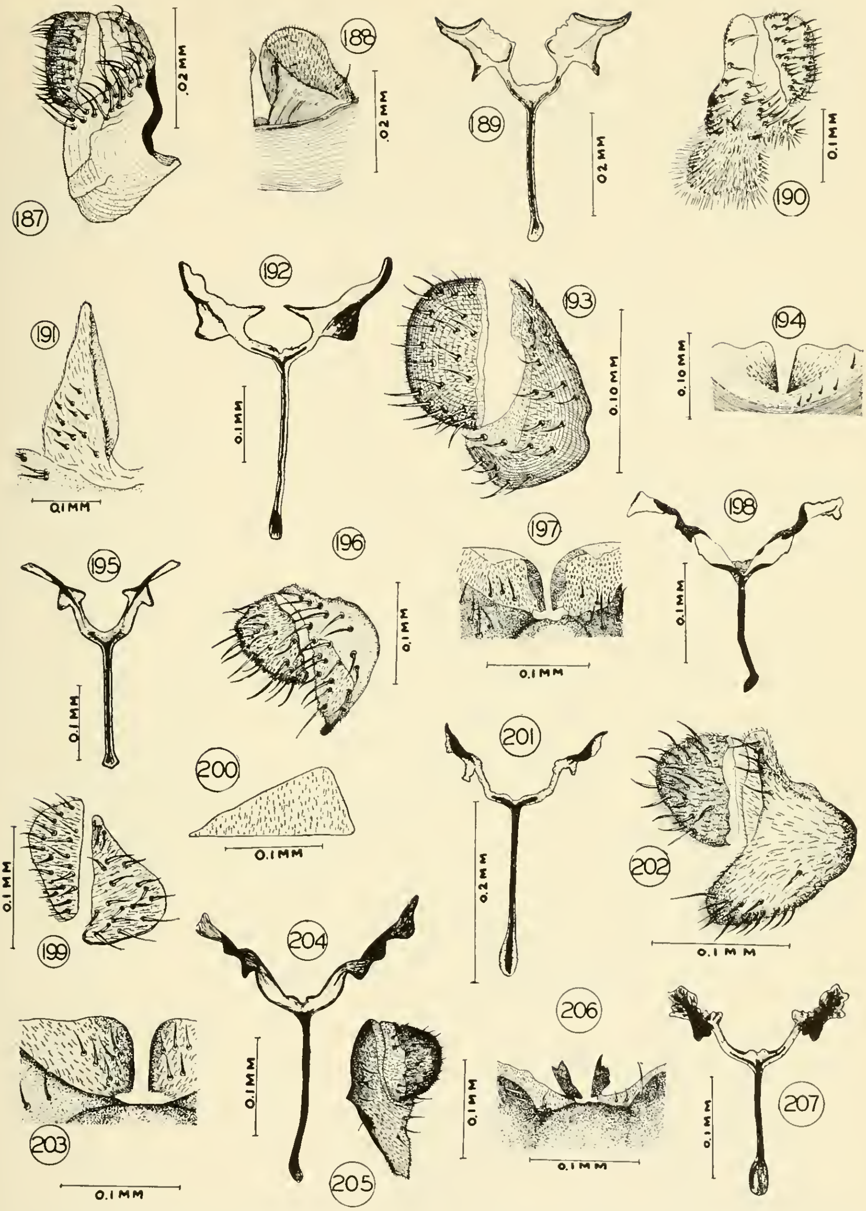
Cercus and anal lobe, genital fork, and ovipositor of females: 136-138, *Simulium (Eusimulium) aureum;* 139-141, *Simulium (Byssodon) benjamini;* 142-144, *Simulium (Lanea) callidum;* 145-147, *S. (L.) colvini;* 148-150, *S. (L.) downsi;* 151-153, *S. (L.) dugesi.*



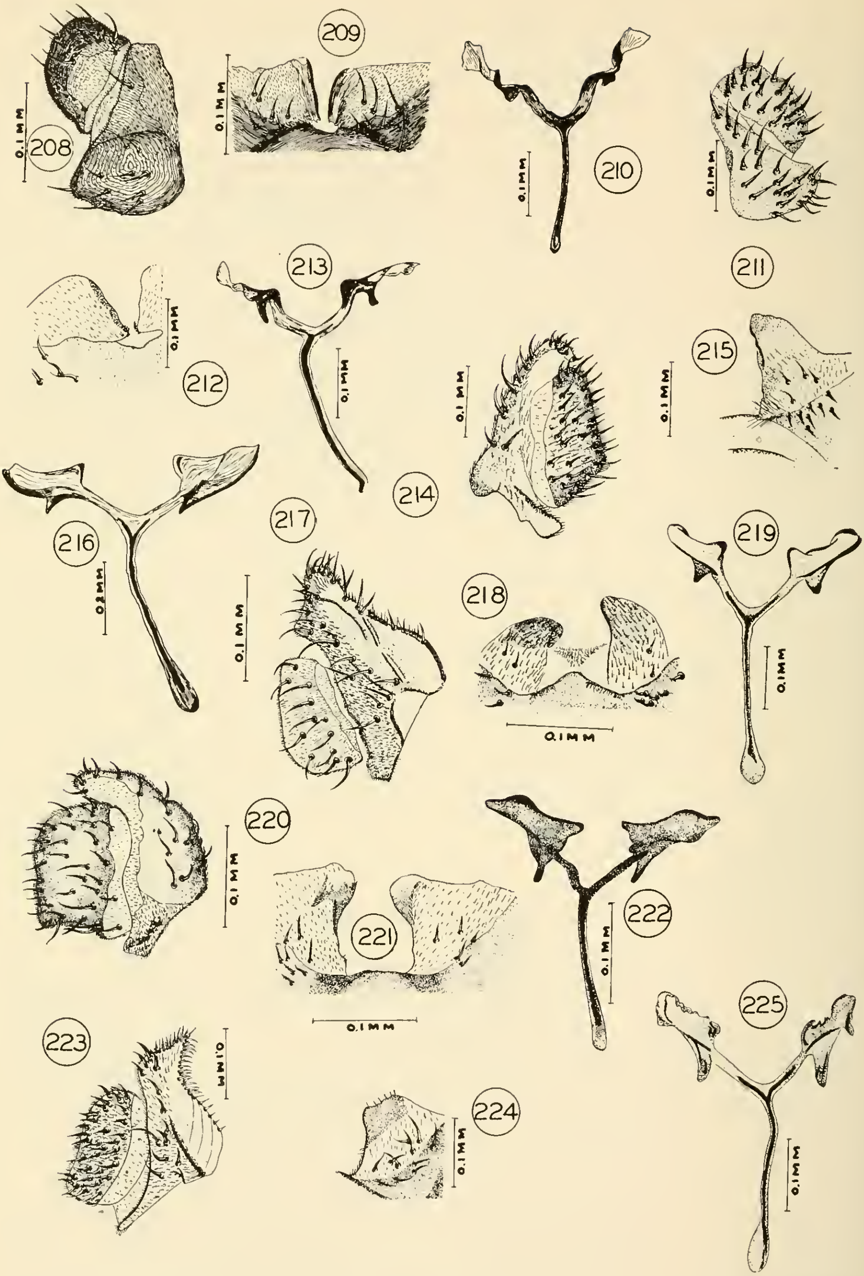
Cercus and anal lobe, genital fork, and ovipositor of females: 154-156, *Simulium (Lanea) haematopotum;* 157-159, *S. (L.) samboni;* 160-162, *S. (L.) trivittatum;* 163-165, *S. (L.) veracruzanum;* 166-168, *S. (Dyarella) acatenangoensis;* 169-171, *S. (D.) ardeni.*



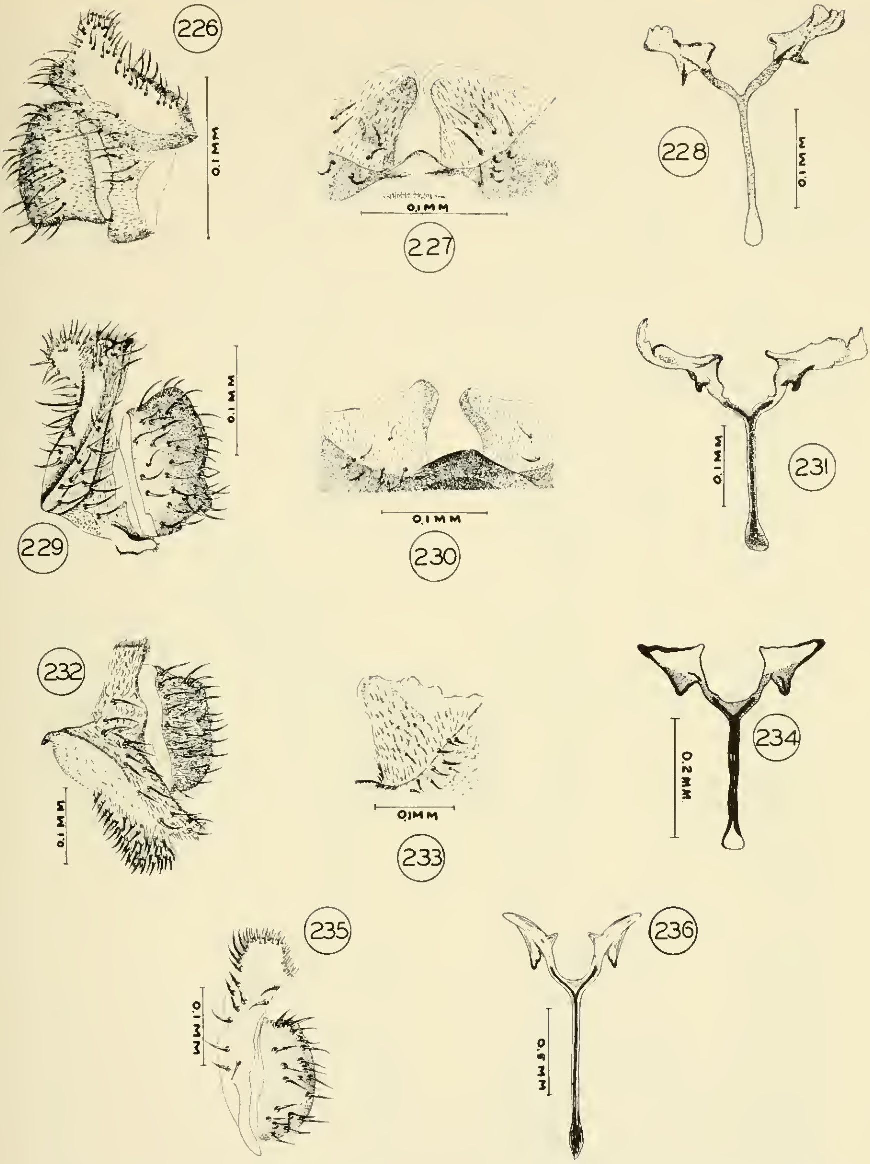
Cercus and anal lobe, genital fork, and ovipositor of females: 172-174, *Simulium (Dyarella) earlei*; 175-177, *S. (D.) mathesoni*; 178-180, *S. (D.) mexicanum*; 181-183, *S. (D.) pulverulentum*; 184-186, *S. (D.) rubicundulum*.



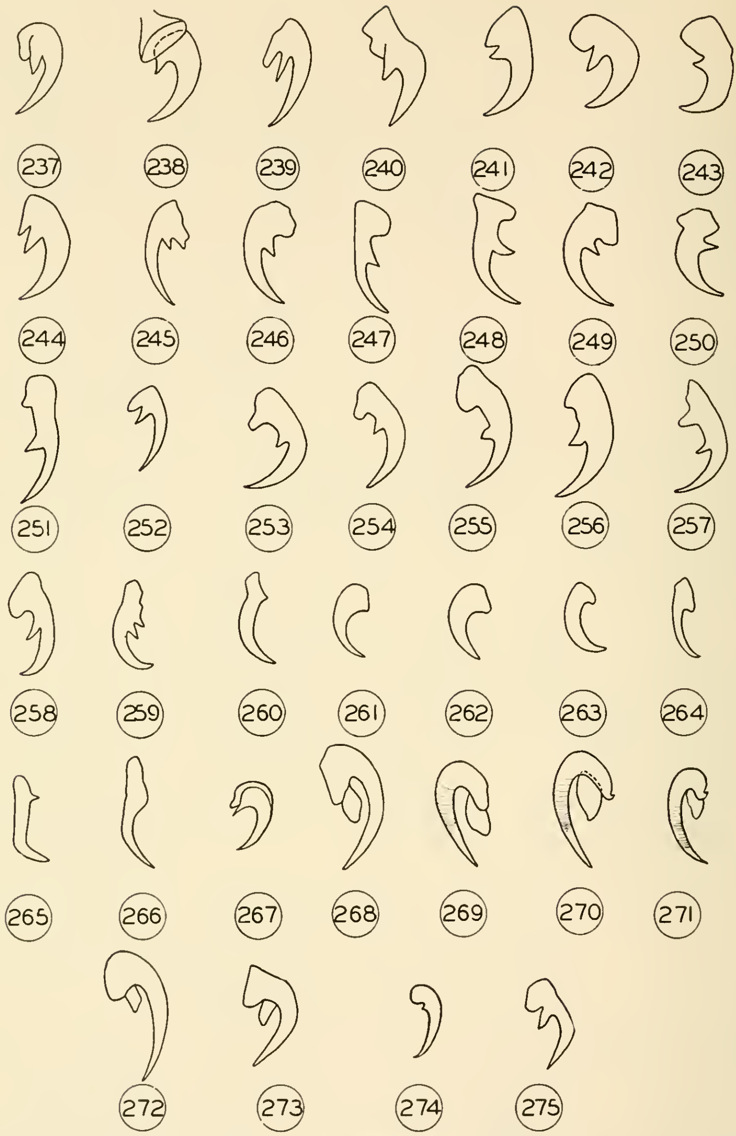
Cercus and anal lobe, genital fork, and ovipositor of females: 187-189, *Simulium (Dyarella) smarti*; 190-192, *S. (D.) yepocapense*; 193-195, *S. (Simulium) jacumbae*; 196-198, *S. (S.) jobbinsi*; 199-201, *S. (S.) kompi*; 202-204; *S. (S.) metallicum*; 205-207, *S. (S.) ochraceum*.



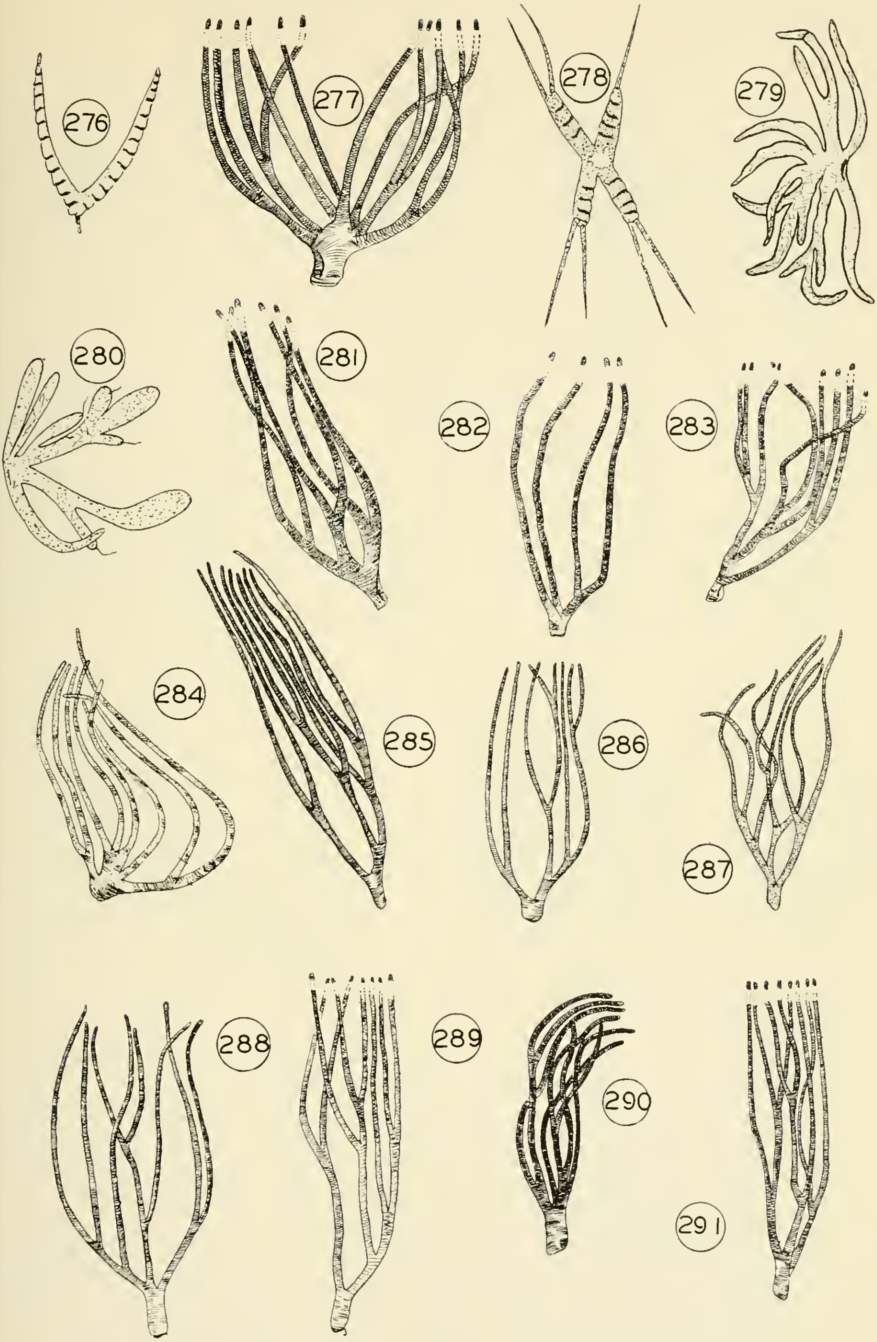
Cercus and anal lobe, genital fork, and ovipositor of females: 208-210, *Simulium (Simulium) parrai*; 211-213, *S. (S.) tricornis*; 214-216, *S. (Hearlea) burchi*; 217-219, *S. (H.) capricornis*; 220-222, *S. (H.) carolinae*; 223-225, *S. (H.) delatorrei*.



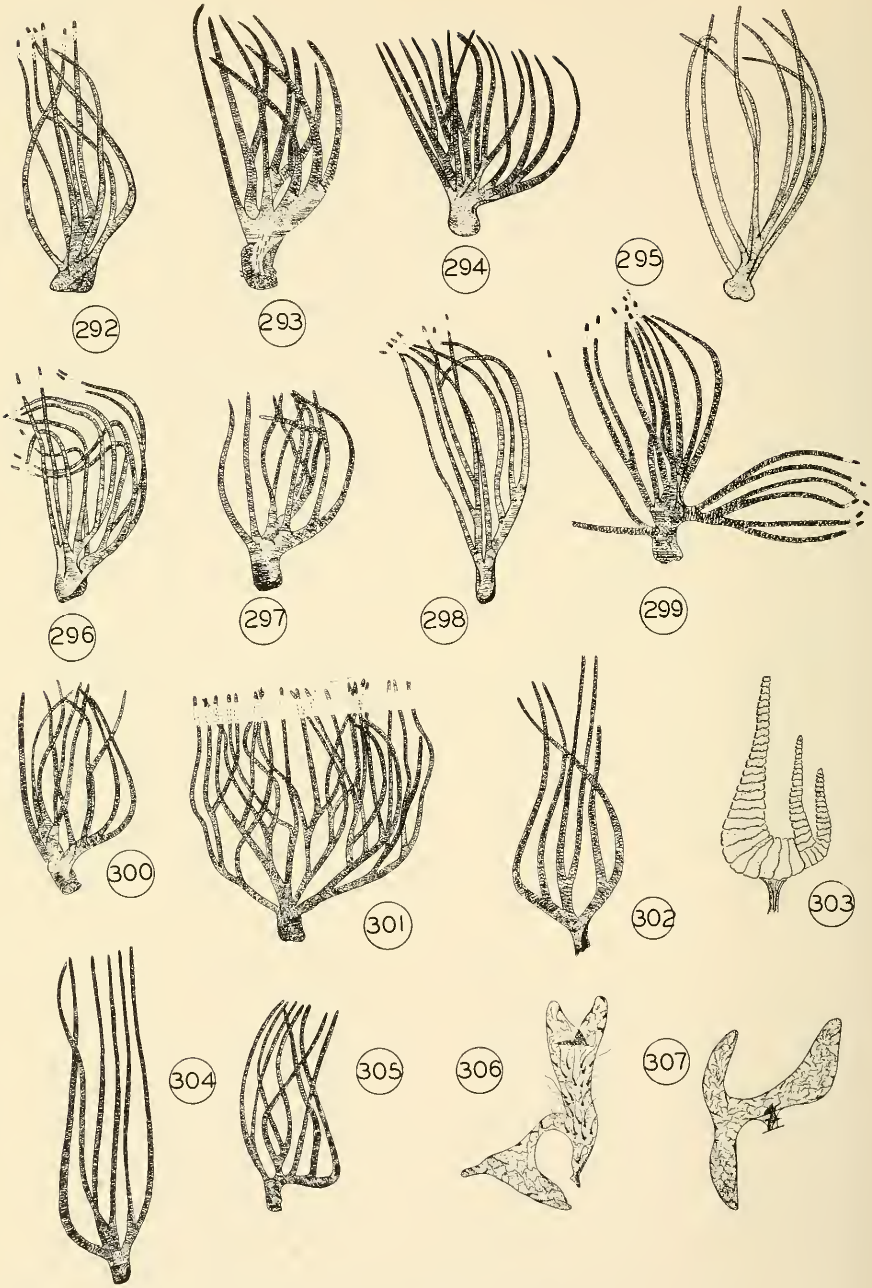
Cercus and anal lobe, genital fork, and ovipositor of females: 226-228, *Simulium (Hearlea) ethelae;* 229-231, *S. (H.) larvispinosum;* 232-234, *S. (H.) microbranchium;* 235, 236, *S. (H.) nigricornis.*



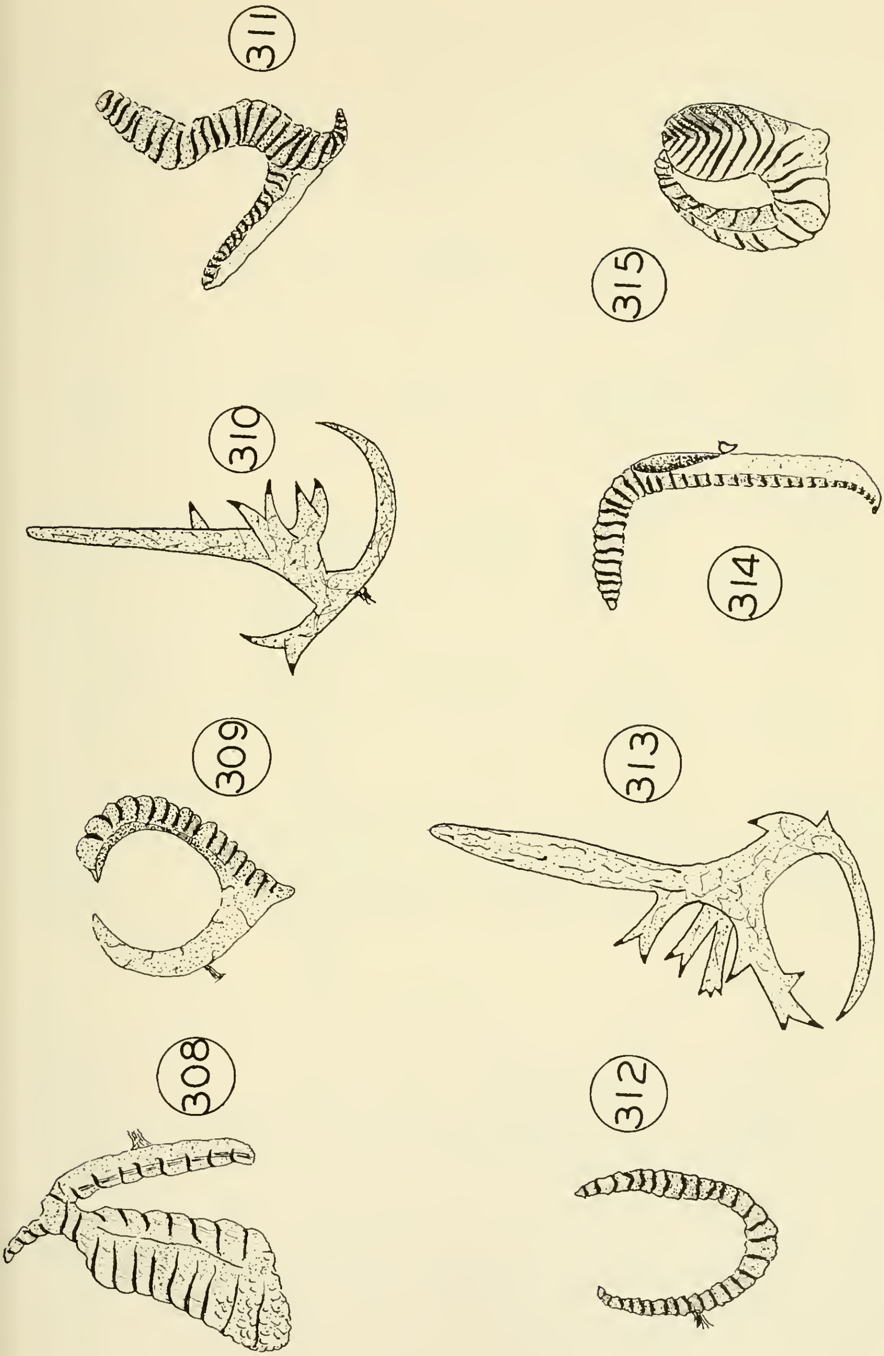
Claw of hind leg of females: 237, *Simulium (Dyarella) acatenangoensis*, 238, *S. (D.) earlei*; 239, *S. (D.) mathesoni*; 240, *S. (D.) mexicanum*; 241, *S. (D.) pulverulentum*; 242, *S. (D.) rubicundulum*; 243, *S. (D.) smarti*; 244, *S. (D.) yepocapense*; 245, *S. (Simulium) jacumbae*; 246 *S. (S.) metallicum*; 247, *S. (S.) tricornis*; 248, *S. (S.) parrai*; 249, *S. (S.) jobbinsi*; 250, *S. (S.) ochraceum*; 251, *S. (Hearlea) burchi*; 252, *S. (H.) capricornis*; 253, *S. (H.) carolinae*; 254, *S. (H.) ethelae*; 255, *S. (H.) nigricornis*; 256, *S. (H.) larvispinosum*; 257, *S. (H.) microbranchium*; 258, *S. (H.) delatorrei*; 259, *S. (Lanea) callidum*; 260, *S. (L.) downsi*; 261, *S. (L.) dugesi*; 262, *S. (L.) haematopotum*; 263, *S. (L.) veracruzanum*; 264, *S. (L.) samboni*; 265, *S. (L.) colvini*; 266, *S. (L.) trivittatum*; 267, *S. (Dyarella) ardeni*; 268, *S. (Eusimulium) aureum*; 269, *Cnephia aguirrei*; 270, *Cnephia roblesi*; 271, *Cnephia pacheco-lunai*; 272, *Gigantodax aquamarensis*; 273, *Gigantodax wrighti*; 274, *Simulium (Notolepria) exiguum*; 275, *Simulium (Byssodon) benjamini*.



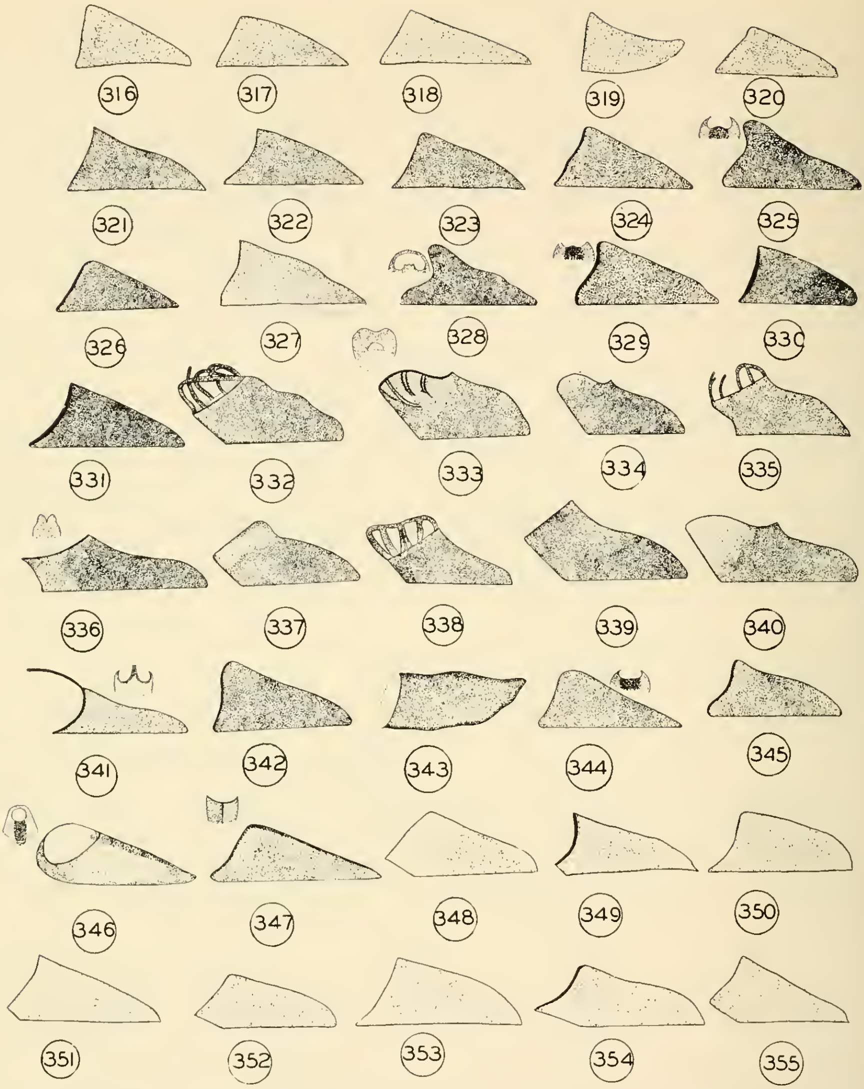
Pupal respiratory apparatus: 276, *Cnephia aguirrei;* 277, *Cnephia pacheco-lunai;* 278, *Cnephia roblesi;* 279, *Gigantodax aquamarensis;* 280, *Gigantodax wrighti;* 281, *Simulium (Notolepria) exiguum;* 282, *S. (Eusimulium) aureum;* 283, *S. (Byssodon) benjamini;* 284, *S. (Lanea) callidum;* 285, *S. (L.) colvini;* 286, *S. (L.) downsi;* 287, *S. (L.) dugesi;* 288, *S. (L.) haematopotum;* 289, *S. (L.) samboni;* 290, *S. (L.) trivittatum;* 291, *S. (L.) veracruzanum.*



Pupal respiratory apparatus: 292, *Simulium (Dyarella) acatenangoensis;* 293, *S. (D.) ardeni;* 294, *S. (D.) earlei;* 295, *S. (D.) mathesoni;* 296, *S. (D.) mexicanum;* 297, *S. (D.) pulverulentum;* 298, *S. (D.) rubicundulum;* 299, *S. (D.) smarti;* 300, *S. (D.) yepocapense;* 301, *S. (Simulium) jacumbae;* 302, *S. (S.) jobbinsi;* 303, *S. (S.) kompi;* 304, *S. (S.) metallicum;* 305, *S. (S.) ochraceum;* 306, *S. (S.) parrai;* 307, *S. (S.) tricornis.*



Pupal respiratory apparatus: 308, *Simulium* (*Hearlea*) *burchi*; 309, *S.* (*H.*) *capricornis*; 310, *S.* (*H.*) *carolinae*; 311, *S.* (*H.*) *delatorrei*; 312, *S.* (*H.*) *ethelae*; 313, *S.* (*H.*) *larvispinosum*; 314, *S.* (*H.*) *microbranchium*; 315, *S.* (*H.*) *nigricornis*.



Cocoons (in profile): 316, *Cnephia aguirrei*; 317, *Cnephia pacheco-lunai*; 318, *Cnephia roblesi*; 319, *Gigantodax aquamarensis*; 320, *Gigantodax wrighti*; 321, *Simulium (Notolepria) exiguum*; 322, *S. (Eusimulium) aureum*; 323, *S. (Byssodon) benjamini*; 324, *S. (Lanea) callidum*; 325, *S. (L.) colvini*; 326, *S. (L.) downsi*; 327, *S. (L.) dugêsi*; 328, *S. (L.) haematopotum*; 329, *S. (L.) samboni*; 330, *S. (L.) trivittatum*; 331, *S. (L.) veracruzanum*; 332, *S. (Dyarella) acatenangoensis*; 333, *S. (D.) ardeni*; 334, *S. (D.) earlei*; 335, *S. (D.) mathesoni*; 336, *S. (D.) mexicanum*; 337, *S. (D.) pulverulentum*; 338, *S. (D.) rubicundulum*; 339, *S. (D.) smarti*; 340, *S. (D.) yepocapense*; 341, *S. (Simulium) jacumbae*; 342, *S. (S.) jobbinsi*; 343, *S. (S.) kompi*; 344, *S. (S.) metallicum*; 345, *S. (S.) ochraceum*; 346, *S. (S.) parrai*; 347, *S. (S.) tricornis*; 348, *S. (Hearlea) burchi*; 349, *S. (H.) capricornis*; 350, *S. (H.) carolinae*; 351, *S. (H.) delatorrei*; 352, *S. (H.) ethelae*; 353, *S. (H.) larvispinosum*; 354, *S. (H.) microbranchium*; 355, *S. (H.) nigricornis*.

Frons-clypeus and epicranial plates of larvae: 356, *Cnephia aguirrei;* 357, *Cnephia pacheco-lunai;* 358, *Cnephia roblesi;* 359, *Gigantodax aquamarensis;* 360, *Gigantodax wrighti;* 361, *Simulium (Notolepria) exiguum;* 362, *S. (Eusimulium) aureum;* 363, *S. (Lanea) callidum;* 364, *S. (L.) colvini;* 365, *S. (L.) downsi;* 366, *S. (L.) dugesi;* 367, *S. (L.) haematopotum;* 368, *S. (L.) jacobsi;* 369, *S. (L.) samboni;* 370, *S. (L.) veracruzanum;* 371, *S. (Dyarella) acatenangoensis;* 372, *S. (D.) earlei;* 373, *S. (D.) mathesoni;* 374, *S. (D.) mexicanum;* 375, *S. (D.) pulverulentum.*

Frons-clypeus and epicranial plates of larvae: 376, *Simulium (Dyarella) rubicundulum*; 377, *S. (D.) smarti*; 378, *S. (D.) yepocapense*; 379, *S. (Simulium) jacumbae*; 380, *S. (S.) jobbinsi*; 381, *S. (S.) kompi*; 382, *S. (S.) metallicum*; 383, *S. (S.) ochraceum*; 384, *S. (S.) parrai*; 385, *S. (S.) tricornis*; 386, *S. (Hearlea) burchi*; 387, *S. (H.) capricornis*; 388, *S. (H.) carolinae*; 389, *S. (H.) delatorrei*; 390, *S. (H.) ethelae*; 391, *S. (H.) larvispinosum*; 392, *S. (H.) microbranchium*.

Occipital cleft of larvae: 393: *Cnephia aguirrei;* 394, *Cnephia pacheco-lunai;* 395, *Cnephia roblesi;* 396, *Gigantodax aquamarensis;* 397, *Gigantodax wrighti;* 398, *Simulium (Notolepria) exiguum;* 399, *S. (Eusimulium) aureum;* 400, *S. (Lanea) callidum;* 401, *S. (L.) colvini;* 402, *S. (L.) downsi;* 403, *S. (L.) dugesi;* 404, *S. (L.) haematopotum;* 405, *S. (L.) jacobsi;* 406, *S. (L.) samboni;* 407, *S. (L.) veracruzanum;* 408, *S. (Dyarella) acatenangoensis;* 409, *S. (D.) earlei;* 410; *S. (D.) mathesoni;* 411, *S. (D.) mexicanum;* 412, *S. (D.) pulverulentum;* 413, *S. (D.) rubicundulum;* 414, *S. (D.) smarti;* 415, *S. (D.) yepocapense.*

Occipital cleft of larvae: 416, *Simulium (Simulium) jacumbae;* 417, *S. (S.) jobbinsi;* 418, *S. (S.) kompi;* 419, *S. (S.) metallicum;* 420, *S. (S.) ochraceum;* 421, *S. (S.) parrai;* 422, *S. (S.) tricornis;* 423, *S. (Hearlea) burchi;* 424, *S. (H.) capricornis;* 425, *S. (H.) carolinae;* 426, *S. (H.) delatorrei;* 427, *S. (H.) ethelae;* 428, S. *(H.) larvispinosum;* 429, *S. (H.) microbranchium.*

In reviewing the biting habits and duration of blood meals (see "Feeding Time" in the section on ecology), we learned that *S. ochraceum* usually feeds on its host longer than *metallicum* or *callidum*. Also, while *metallicum* and *callidum* are "nervous" feeders, landing several times, moving around on the skin before inserting the mouthparts, and easily disturbed while feeding, *ochraceum* will land directly without hovering around the host, will pierce the skin without much initial movement, and once feeding, it will not remove its mouthparts or fly off, even when touched by the fingers. The behavior pattern and feeding time of *ochraceum* indicate that this species probably is a more efficient agent in the transmission of onchocerciasis. Its longer, uninterrupted blood meals would provide a more suitable situation for the migration of the infective stages to the mouthparts, as well as for the ingestion of large numbers of microfilariae from infected individuals.

Of all the environmental conditions, relative humidity is the one that most affects the activity and life of the adult flies. *S. ochraceum* demonstrates a definite preference for a high relative humidity in a sunny atmosphere, while *metallicum* prefers a lower relative humidity. High relative humidity with bright skies prevails in the coffee-growing regions along the Pacific slopes of the cordillera.

Referring to the breeding places of the black flies, *S. ochraceum* chooses small streams that are usually narrower than 5 feet, with a depth ranging from 1 inch to 5 inches, and with a small volume flow. These breeding places are usually covered by a dense canopy of vegetation—emergent, shrubs, low trees, and tall trees. Such *infant* and *young* streams are typical of the 3,000- to 5,000-foot altitude range in the coffee-growing regions of the Pacific slopes (see section on life history). Although *metallicum* and *callidum* will also breed in these streams, they prefer the larger watercourses, with greater volume flow, in which zoophilic species abound (see section on life history, and "Species Associations" in the section on ecology). Such streams are at least as common outside of the onchocerciasis zones as they are within it. Again, circumstances point to the greater probability of *ochraceum* being the principal vector, since its preferred habitat coincides with that of maximum onchocerciasis endemicity.

Although we are willing to accept the hypothesis that *S. ochraceum* is the principal vector of human onchocerciasis, certain puzzling questions concerning it can be raised: Why are the disease zones so much more circumscribed than the distribution of *S. ochraceum?* Why is the natural-infection rate in *ochraceum* as low as it is, even in areas where more than 50 percent of the residents are infected with onchocerciasis? Why is the natural-infection rate in *metallicum* higher than in *ochraceum?*

Let us discuss the first question, relative to the nonconformity of the distribution of *ochraceum* with that of the disease. As has already been mentioned, *ochraceum* is present primarily in regions of highest endemicity of onchocerciasis, although relatively small numbers are also in evidence outside of the known disease zones. The endemic areas can be extended by either of two means: migration of infected flies from a disease region to regions free of the disease where they can infect other individuals; or entrance of infected individuals into nonendemic regions, giving *ochraceum* the opportunity of ingesting microfilariae. In the studies of flight range and longevity of infected flies (see section on ecology), it was seen that infection with *O. volvulus* does reduce the flight capacity and life span of the flies. Thus the probability of migration of infected flies from infected to noninfected regions is greatly reduced. In the case of *ochraceum* living outside of the infected region, it is possible that certain environmental factors might reduce either their anthropophilic tendencies or their ability to support development of the *Onchocerca* larvae. Peterson (1953) found that four species of black flies in Utah would bite humans only within certain limits of its altitude range, above and below which it was not anthropophilic. Since our records of *S. ochraceum* outside of the infected regions were based primarily on collections of pupae, it cannot be ascertained to what extent emerging adults would have favored human hosts. The number of adults collected outside of the zone was too small to be of significance. Taking into consideration the low natural-infection rate in *ochraceum,* it can be seen that in a highly dispersed agricultural population there would have to be an abundance of *ochraceum* in order to adequately establish an endemic disease region.

To answer the second question, we need only to refer to the heavy mortality in the flies of this species caused by infection with *O. volvulus*. This was mentioned in the discussion of flight range and longevity of infected flies. Knowing that *S. ochraceum* undoubtedly ingests tremendous numbers of microfilariae, owing to its extended and noninterrupted blood meals, it becomes evident that a very large proportion of the infected flies must die because of that infection.

The last question has already been alluded to in "Animal Associations" in the section on epidemiology and in the earlier part of this section. Since *metallicum* bites both human and other animal hosts, and since it actually prefers hosts other than man, it is quite probable that its high natural infection is, at least in part, of equine or bovine origin. Skin biopsies of 884 local animals (mainly horses and cattle) in the Yepocapa area showed that 12 percent of the horses and cattle were infected with skin-inhabiting microfilariae superficially similar to those of human onchocerciasis (Gibson, 1951a). Since *ochraceum* is definitely anthropophilic in its feeding habits, its natural infection is more likely to be exclusively of human origin. Also, since the more extended, noninterrupted blood meals of *ochraceum* permit it to ingest numerous microfilariae, which, in turn, cause the death of large numbers of the flies, fewer infected flies of this species can be found than of *metallicum,* which feeds more nervously and for a shorter time interval.

It should be understood that the author does not believe that *S. ochraceum* is the only vector of onchocerciasis in Guatemala, but rather that it is the most efficient and important one. It is likely that *S. metallicum* is a good secondary vector and that *callidum* also transmits the disease, although to no significant degree. Probably in parts of the onchocerciasis zones where the *ochraceum* population is low but where *haematopotum, veracruzanum,* or *exiguum* are abundant, these species may be important in transmission (Gibson and Dalmat, 1952). In considering programs for the control of onchocerciasis, although prime attention should be given to the eradication of *S. ochraceum,* control of *metallicum* is also indicated. Small-scale control studies, based on our knowledge of the life history, optimum breeding conditions, and habits of the immature and adult forms, have already been conducted in the Yepocapa region. It is hoped that the Guatemalan federal health authorities, in cooperation with the local plantation owners, will continue with control activities on a large scale, using our experiences and indications as a groundwork.

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APPENDIX I

PLANTS ASSOCIATED WITH GUATEMALAN SPECIES[12]

Division Bryophyta
- Class Musci
  - Order Bryales
    - Family Leskeaceae
      - *Thuidium delicatulum* (Hedw.) Mitt.

Division Pteridophyta
- Class Filicinae
  - Order Filicales
    - Family Polypodiaceae
      - *Blechnum occidentale* L. (PL)
      - *Diplazium* sp.
      - *Dryopteris patens* (Sw.) Kuntze
      - *Pityrogramma tartarea* (Cav.) Maxon
      - *Pteris* sp.
      - *Pteris biaurita* L. (PL)
      - *Pteris podophylla* Sw.
      - *Pteris quadriaurita* Retz.
      - *Trismeria trifoliata* (L.) Diels (O)
- Class Lycopodinae
  - Order Selaginellales
    - Family Selaginellaceae
      - *Selaginella poeppingiana* (H. & G.) Baker

Division Spermatophyta
- Subdivision Angiospermae
  - Class Monocotyledoneae
    - Order Glumiflorae
      - Family Gramineae
        - *Axonopus compressus* (Sw.) Beauv. (PL)
        - *Bambusa* sp.
        - *Coix lachryma-jobi* L. (PL)
        - *Ichnanthus* sp.
        - *Ichnanthus pallens* (Sw.) Munro
        - *Lasiacis procerrima* (Hack.) Hitchc. (PL)
        - *Muhlenbergia setarioides* Fourn.
        - *Olyra latifolia* L.
        - *Oplismenus burmannii* (Retz.) Beauv.
        - *Oplismenus hirtellus* Beauv.

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[12] All identifications in this and the following list were very kindly made by Julian A. Steyermark, Curator of the Herbarium, Chicago Natural History Museum. Unless otherwise indicated, all plants listed were found within the Onchocerciasis Zone.

(O) = Plants found outside of the Onchocerciasis Zone only.

(OI) = Plants found both outside of and within the Onchocerciasis Zone.

(P), (L), (E) = Plants serving as substrata for pupae, larvae, or eggs, respectively, of *Simulium* spp.

Oplismenus rariflorus Presl (O)
Panicum laxum Sw. (PL)
Pharus latifolius L.
Family CYPERACEAE
Eleocharis sp. (O)
Kyllinga brevifolia Rottb.
Order SPATHIFLORAE
Family ARACEAE
Anthurium sp.
Araceae (OI)
Monstera sp.
Philodendron sp.
Syngonium podophyllum Schott
Xanthosoma sp.
Order FARINOSAE
Family COMMELINACEAE
Callisia multiflora (M. & G.) Standl. (PL)
Callisia repens L.
Campelia zanonia (L.) H. B. K.
Commelina erecta L.
Tradescantia commelinoides R. & S. (PL)
Tradescantia guatemalensis C. B. Clarke (PL)
Tripogandra cumanensis (Kunth) Woodson (OI) (PL)
Family PONTEDERIACEAE
Heteranthera reniformis R. & P. (PL)
Pontederia sp.
Order LILIFLORAE
Family HAEMODORACEAE
Xiphidium caeruleum Aubl.
Order SCITAMINEAE
Family ZINGIBERACEAE
Costus sp.
Renealmia aromatica (Aubl.) Griseb. (PLE)
Renealmia strobilifera Poepp. & Endl. (PLE)
Class DICOTYLEDONEAE
Order PIPERALES
Family PIPERACEAE
Piper scabrum Sw.
Piper umbellatum L.
Peperomia sp.
Order SALICALES
Family SALICACEAE
Salix chilensis Molina (O)
Order FAGALES
Family FAGACEAE
Quercus sp.
Order URTICALES
Family URTICACEAE
Pilea irrorata D. Sm.
Urera alceifolia Gaud.

Order Polygonales
  Family Polygonaceae
    Polygonum sp. (OI)
    Polygonum punctatum Ell.
    Rumex crispus L. (O)
Order Centrospermae
  Family Amaranthaceae
    Iresine celosia L.
    Iresine spiculigera Seub.
  Family Phytolaccaceae
    Petiveria alliacea L.
    Phytolacca octandra L.
  Family Caryophyllaceae
    Stellaria cuspidata Willd. (PL)
    Stellaria ovata Willd.
Order Ranales
  Family Ranunculaceae
    Ranunculus flagelliformis J. E. Smith (O)
Order Rhoeadales
  Family Cruciferae
    Nasturtium officinale R. Br. (OI)
Order Rosales
  Family Rosaceae
    Alchemilla sp. (O)
  Family Leguminosae
    Desmodium sp.
    Leguminosae (PL)
    Mucuna sp.
    Nissolia fructicosa Jacq.
Order Geraniales
  Family Malpighiaceae
    Hiraea obovata (H. B. K.) Ndzu. (PL)
  Family Euphorbiaceae
    Acalypha sp.
    Croton guatemalensis Lotsy (OI)
    Euphorbia lancifolia Schl. (PL)
    Phyllanthus lathyroides H. B. K.
Order Malvales
  Family Tiliaceae
    Triumfetta sp.
  Family Malvaceae
    Pavonia rosea Schl.
    Sida acuta Burm.
    Sida rhombifolia L.
Order Myrtiflorae
  Family Lythraceae
    Cuphea utriculosa Koehne
  Family Melastomaceae
    Centradenia sp. (PL)
    Centradenia floribunda Planch.

Heterocentron sp.
Miconia sp.
Family Onagraceae
Jussiaea suffruticosa L.
Order Umbelliflorae
Family Araliaceae
Oreopanax capitatus (Jacq.) Dcne. & Planch.
Family Umbelliferae
Hydrocotyle mexicana C. & S. (OI)
Hydrocotyle ranunculoides L. f.
Order Contortae
Family Asclepiadaceae
Asclepias curassavica L.
Order Tubiflorae
Family Convolvulaceae
Ipomoea sp. (OI) (PL)
Ipomoea tiliacea (Willd.) Choisy (PL)
Family Polemoniaceae
Cobaea lutea Don
Family Verbenaceae
Citharexylum donnell-smithii Greenm.
Priva lappulacea (L.) Pers.
Verbena littoralis H. B. K.
Family Labiatae
Hyptis sinuata Pohl (OI) (PL)
Mentha citrata Ehrh.
Family Scrophulariaceae
Mimulus glabratus H. B. K. (O)
Family Gesneriaceae
Diastema rupestre Brandeg. (PL)
Family Acanthaceae
Acanthaceae (PL)
Justicia sp.
Ruellia sp.
Order Plantaginales
Family Plantaginaceae
Plantago hirtella H. B. K.
Order Rubiales
Family Rubiaceae
Borreria laevis (Lam.) Griseb.
Order Campanulales
Family Cucurbitaceae
Cyclanthera sp.
Family Lobeliaceae
Family Compositae
Baccharis glutinosa Pers.
Bidens squarrosa H. B. K.
Calyptocarpus vialis Less. (PL)
Clibadium sp. (PL)
Compositae (PL)

Eupatorium sp.
Galinsoga ciliata (Raf.) Blake
Hidalgoa ternata L. & L.
Liabum sp.
Melanthera nivea (L.) Small
Mikania micrantha H. B. K.
Pseudelephantopus spicatus (Juss.) Rohr
Spilanthes sp. (OI)
Spilanthes americana (Mutis) Hieron.
Spilanthes ocymifolia (Lam.) A. H. Moore
Spilanthes papposa Hemsl.
Verbesina turbacensis H. B. K.
Wedelia sp.

PLANTS ASSOCIATED WITH WOODLANDS AND CULTIVATED AREAS ON FINCAS IN ONCHOCERCIASIS ZONE[13]

Division Pteridophyta
Class Filicinae
Order Filicales
Family Polypodiaceae
Dryopteris sp.
Elaphoglossum guatemalense (Kl.) Moore
Pityrogramma tartarea (Cav.) Maxon
Polypodium triseriale Uv.
Pteris altissima Poir.
Division Spermatophyta
Subdivision Angiospermae
Class Monocotyledoneae
Order Glumiflorae
Family Gramineae
Bambusa vulgaris Schrad.
Order Principes
Family Palmae
Chamaedorea sp.
Order Synanthae
Family Cyclanthaceae
Carludovica utilis (Oerst.) Benth. & Hook.
Order Apathiflorae
Family Araceae
Monstera pertusa (L.) DeVriese
Philodendron anisotomum Schott
Philodendron guatemalense Engler
Order Liliflorae
Family Musaceae
Musa sapientum L.

[13] (R) = Trees or shrubs on which adult *Simulium* were found to rest during daylight hours.
(S) = Planted in the Yepocapa region to give shade to the coffee trees.

Family Liliaceae
Yucca elephantipes Cav.
Family Amaryllidaceae
Crinum erubescens Soland.
Class Dicotyledoneae
Order Verticillatae
Family Casuarinaceae
Casuarina equisetifolia L. (R)
Order Urticales
Family Moraceae
Cecropia sp.
Ficus hemsleyana Standl. (R)
Order Proteales
Family Proteaceae
Grevillea robusta Cunn. (S)
Order Santalales
Family Loranthaceae
Struthanthus orbiculares (H. B. K.) Blume (R)
Order Ranales
Family Annonaceae
Annona Cherimola Mill.
Order Rhoedales
Family Papaveraceae
Bocconia arborea Wats.
Order Rosales
Family Leguminosae
Acacia angustissima (Mill.) Kuntze
Aeschynomene virginica (L.) B. S. P.
Calliandra sp.
Canavalia villosa Benth.
Cassia uniflora Mill.
Crotalaria longirostrata Hook. & Arn.
Erythrina mexicana Krukoff
Inga leptoloba Schlecht. (S) (R)
Inga Micheliana Harms. (S) (R)
Inga punctata Wildenow (S) (R)
Pithecolobium saman (Jacq.) Benth.
Order Geraniales
Family Meliaceae
Trichilia havanensis Jacq.
Trichilia hirta L.
Family Malpighiaceae
Bunchosia cornifolia H. B. K. (R)
Gaudichaudia albida C. & S.
Family Polygalaceae
Polygala costaricensis Chodat
Family Euphorbiaceae
Croton guatemalensis Lotsy
Euphorbia cotinifolia L.
Ricinus communis L. (R)

Order Sapindales
    Family Anacardiaceae
        Mangifera indica L. (R)
Order Malvales
    Family Elaeocarpaceae
        Sloanea ampla I. M. Johnst.
    Family Bombacaceae
        Ceiba pentandra (L.) Gaertn.
    Family Tiliaceae
        Belotia mexicana (DC.) Schum.
Order Parietales
    Family Dilleniaceae
        Saurauia oreophila Hemsl.
    Family Flacourtiaceae
        Cascaria arguta H. B. K.
        Casearia nitida (L.) Jacq.
    Family Passifloraceae
        Passiflora prolata Mast.
    Family Begoniaceae
        Begonia heracleifolia C. & S.
        Begonia peltata Otto & Dietr.
Order Myrtiflorae
    Family Lythraceae
        Cuphea aequipetala Cav.
    Family Myrtaceae
        Eugenia capuli (S. & C.) Berg.
        Psidium friedrichsthalianum (Berg.) Niedenzu
    Family Melastomaceae
        Heterocentron glandulosum Schenck
        Heterocentron macrostachyum Naud.
        Miconia sp.
Order Umbelliflorae
    Family Araliaceae
        Oreopanax xalapense (H. B. K.) Dcne. & Planch.
Order Primulales
    Family Myrsinaceae
        Parathesis serrulata (Sw.) Mez
Order Ebenales
    Family Sapotaceae
        Calocarpum mammosum Pierre (R)
        Lucuma salicifolia H. B. K. (R)
        Pouteria campechiana (H. B. K.) Behni
        Sideroxylon tempisque Pittier (R)
Order Contortae
    Family Apocynaceae
        Tonduzia longifolia (A. DC.) Woodson
Order Tubiflorae
    Family Convolvulaceae
        Ipomoea sp.

Family Verbenaceae
Lippia myriocephala S. & C.
Family Labiatae
Hyptis mutabilis (Rich.) Briq.
Salvia Mocinoi Benth.
Family Solanaceae
Physalis sp.
Solanum nudum H. B. K.
Family Scrophulariaceae
Castelleja integrifolia L. f.
Family Bignoniaceae
Tabebuia pentaphylla (L.) Hemsl. (R)
Family Acanthaceae
Jacobinia umbrosa (Benth.) Blake
Order Rubiales
Family Rubiaceae
Crusea calocephala DC.
Guettarda macrosperma D. Sm.
Psychotria sp.
Order Campanulales
Family Lobeliaceae
Lobelia laxiflora H. B. K.
Family Compositae
Ageratum corymbosum Zuccagni
Baccharis glutinosa Pers.
Baccharis trinervis (Lam.) Pers.
Cirsium subcoriaceum (Less.) Sch. Bip.
Coreopsis mutica DC.
Mikania micrantha H. B. K.
Milleria quinqueflora L.
Polymnia maculata Cav. (R)
Senecio petasioides Greenm.
Tagetes erecta L. f.
Vernonia deppeana Less.
Zexmenia frutescens (Mill.) Blake

APPENDIX II

FAUNA COLLECTED IN REGION OF SAN PEDRO YEPOCAPA [14]

Phylum Platyhelminthes
Class Turbellaria
Order Tricladida
Suborder Paludicola
Family Planariidae

[14] The annelids were determined by Marvin C. Meyer, of the U. S. Department of Agriculture; the crustaceans by Fenner A. Chace, Jr., of the U. S. National Museum; the insects by L. L. Buchanan, H. W. Capps, A. B. Gurney, and R. I. Sailer, all of the U. S. Department of Agriculture, and O. L. Cartwright and C. T. Greene, of the U. S. National Museum; the goriids by Benja-

Phylum ANNELIDA
  Class HIRUDINEA
    Order GNATHOBDELLAE
      Family HIRUDIDAE
        Diestecoma Vaillant
        probably *Diestecoma magna* Moore
Phylum ARTHROPODA
  Class CRUSTACEA
    Order DECAPODA
      Family POTOMONIDAE
        Pseudothelphusa similis Rathbun
  Class INSECTA
    Order ORTHOPTERA
      Family BLATTIDAE
        Epilampra sp.
    Order MEGALOPTERA
      Family SIALIDAE
        Corydalus sp.[a]
    Order EPHEMEROPTERA
      Family BAETIDAE
        Genus and species ?
      Family HEPTAGENIIDAE
        Genus and species ?
    Order ODONATA
      Family AESCHNIDAE
        Ophiogomphus sp. or *Erpetogomphus* sp.
        Epiaeschna sp. (near)
      Family LIBELLULIDAE
        Libellula sp.[a]
        Sympetrum sp. (or near)
      Family AGRIONIDAE
        Hetaerina sp.[a]
        Agrion sp.
      Family COENAGRIONIDAE
        Genus and species ?
    Order PLECOPTERA
      Family PERLIDAE
        Neoperla sp. (or near)
    Order HEMIPTERA
      Family BELOSTOMATIDAE
        Abedus ovatus Stal [a]
        Letherocerus delpontei De Carlo
      Family NAUCORIDAE
        Cryphocricus macrocephalus Mont.

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min Schwartz, of the U. S. Department of Agriculture; the amphibians and reptiles by L. C. Stuart, Institute of Human Biology, University of Michigan; the birds by Ernst Mayr, of the American Museum of Natural History. I wish to express my deep appreciation to these experts who have made the faunistic study possible.

[a] Predaceous on black-fly larvae or adults.

Family Veliidae
Ragovelia insularis Champion
Ragovelia distmeta Champion
Family Gerridae
Tenagogonus sp.
Gerris sp.
Family Pentatomidae (Cydninae)
Cyrtomenus vestigiatus Distant
Order Trichoptera
Family Hydropsychidae
Smicridea sp. (or near)[a]
Hydropsyche sp. (or near)
Order Coleoptera
Family Dytiscidae
Agabus sp. (or near)
Family Hydrophilidae
Tropisternus sp.
Family Ptilodactylidae
Anchytarsus sp.
Family Psephenidae
Psephenus sp.
Order Hymenoptera
Family Sphecidae
Oxybelus sp.[a]
probably *Oxybelus pyrurus* (Rohwer)
Order Diptera
Family Tipulidae
Holorusa rubiginosa Loew
Tipula sp.
Family Chironomidae
Genus and species ?
Family Stratiomyidae
Geosargus sp.
Phylum Aschelminthes
Class Gordiacea
Order Gordioidea
Family Chordodidae
Chordodes sp.
Pseudochordodes sp.
Parachordodes sp.
Phylum Chordata
Subphylum Vertebrata
Class Pisces
Family Cyprinodontidae
Profundulus[a]
probably *Profundulus punctatus* Günther
Class Amphibia
Order Gymnophiona
Family Caeciliidae
Gymnopis mexicana mexicana (Duméril and Bibron)
Dermophis mexicanus mexicanus Peters

Order Caudata
- Family Plethodontidae
  - *Magnadigita engelhardti* (Schmidt)
  - *Magnadigita morio* (Cope)
  - *Oedipina ignis* Stuart

Order Salientia
- Family Bufonidae
  - *Bufo bocourti* Brocchi
  - *Bufo canaliferus* Cope
- Family Leptodactylidae
  - *Eleutherodactylus rhodopis* (s.l.) (Cope)
  - *Eleutherodactylus rugulosus* (s.l.) (Cope)
- Family Hylidae
  - *Plectrohyla matudai* Hartweg
- Family Ranidae
  - *Rana macroglossa* Brocchi

Class Reptilia
- Suborder Sauria
  - Family Iguanidae
    - *Anolis crassulus crassulus* Cope
    - *Anolis dollfusianus* Bocourt
    - *Anolis petersi* Bocourt
    - *Basiliscus vittatus* Wiegmann
    - *Corythophanes percarinatus* Duméril
    - *Iguana iguana rhinolopha* Wiegmann
    - *Sceloporus acanthinus* Bocourt
  - Family Scincidae
    - *Scincella assata assata* (Cope)
  - Family Teiidae
    - *Ameiva undulata parva* Barbour and Noble
  - Family Anguidae
    - *Barisia moreleti fulva* Bocourt
- Suborder Serpentes
  - Family Boidae
    - *Constrictor constrictor imperator* (Daudin)
  - Family Colubridae
    - *Adelphicos quadrivirgatus sargi* (Fischer)
    - *Coniophanes fissidens punctigularis* Cope
    - *Dryadophis dorsalis* (Bocourt)
    - *Dryadolphis melanolomus stuarti* Smith
    - *Drymarchon corais unicolor* Smith
    - *Drymobius chloroticus* (Cope)
    - *Drymobius margaritiferus occidentalis* Bocourt
    - *Elephe triaspis* (Cope)
    - *Geophis nasalis* (Cope)
    - *Leptodeira annulata polysticta* Günther
    - *Ninia diademata labiosa* (Bocourt)
    - *Ninia sebae sebae* (Duméril, Bibron, and Duméril)
    - *Oxybelis aeneus aeneus* (Wagler)
    - *Pituophis deppei lineaticollis* (Cope)
    - *Pliocercus elapoides diastemus* (Bocourt)

Scaphiodontophis albonuchalis Taylor and Smith
Sibon sibon (Linnaeus)
Thalerophis mexicanus mexicanus (Duméril, Bibron, and Duméril)
Tropidodipsas sartori annulatus (Peters)
Xenodon mexicanus Smith
Lampropeltis doliata oligozona (Bocourt)
Imantodes cenchoa lencomelas Cope

Family Elapidae
Micrurus nigrocinctus zunilensis Schmidt

Family Crotalidae
Bothrops nummifer affinis Bocourt
Bothrops atrox asper (Garman)
Bothrops bicolor Bocourt
Bothrops godmani (Günther)

Class Aves

Order Coraciiformes

Family Momotidae
Momotus lessonii lessonii Lesson

Order Caprimulgiformes

Family Caprimulgidae
Caprimulgus vociferus vociferus Wilson

Order Apodiformes

Family Trochilidae
Campylapterus rufus Lesson
Campylapterus hemileucurus Lesson
Amazilis candida pacifica (Griscom)[a]
Amazilis rutila rutila (De Lattre)
Amazilis beryelina devillei (Bourcier and Mulsant)

Order Coccyzes

Family Cuculidae
Geococcyx velox (A. Wagner)

Order Scansores

Family Ramphastidae
Aulacorhynchus prasinus stenorhabdus Dickey and Van Rossem

Order Piciformes

Family Picidae
Centurus aurifrons santacruzi (Bonaparte)
Balanosphyra formicivora lineata Dickey and Van Rossem

Order Passeriformes

Family Cotingidae
Tityra semifasciata personata (Jardine and Selby)

Family Tyrannidae
Myiodynastes luteiventris luteiventris Sclater[a]
Onychorhynchus mexicanus mexicanus (Sclater)[a]
Myiarchus crinitus (L.)

Family Hirundinidae
Stelgidopteryx ruficollis ridgwayi Nelson

Family Corvidae
Cissilopha melanocyanea melanocyanea (Hartlaub)[a]

Family Turdidae

Turdus assimilis leucauchen Sclater

Family Thraupidae

Chlorophonia occipitalis occipitalis (Du Bus)

Tanagra musica elegantissima (Bonaparte)

Thraupis episcapus diacona (Lesson)

Piranga ludoviciana (Wilson)

Family Coerebidae

Cyanerpes cyaneus carneipes (Sclater)

Family Parulidae

Vermivora peregrina (Wilson)[a]

Basileuterus culicivorus culicivorus (Lichtenstein)[a]

Family Vireonidae

Vireo solitarius solitarius (Wilson)[a]

Vireo olivaceus flavoviridis (Cassin)

Family Icteridae

Icterus galbula (Linnaeus)

Family Bombycillidae

Bombycilla cedrorum Vieillot

APPENDIX III

TABLE 31.—*Ecological factors*

(Optimum conditions for *S. ochraceum*, *S. metallicum*, and *S. callidum*)

Species	Stream characteristics: Altitude (feet)	Width (feet)	Depth (inches)	Temperature (° C.)	pH	Current (inches/second)	Substratum
ochraceum	3,000–5,000	1–5	1–5	18–20	7.1–7.5	1–10	Leaves and stems
metallicum	2,000–5,000	1–8	<12	17–20	6.6–8.0	1–20	Leaves; stones
callidum	900–6,000	1–15	1–12	17–20	6.6–8.0	1–30	Leaves; debris; stones

TABLE 32.—*Synoptic life-history chart of the three principal anthropophilic species of simuliids of Guatemala*

Species	Eggs: No. per group Substratum	Eggs: Hours of oviposition	Eggs: Days to hatching	Larvae: Duration larval stages (days)	Pupae: Duration pupal stages (days)	Adults: Time of mating	Adults: Longevity (days)	Adults: Flight range (miles)	Adults: Height above ground flies biting (feet)	Adults: Host preference	Adults: Regional preference on humans
S. ochraceum	1–4 leaves	12 m.- 2 p.m.	3–10	7–15	4–6	soon after emerging	27	6.3	112 (0–60)*	man	upper torso
S. metallicum	150–500 leaves	5 p.m.- 6 p.m.	3–20	6–20	4–10	"	85	9.7	112 (0–112)*	horses, mules, cattle	lower torso
S. callidum	singly rocks	4:30 p.m.- 5:30 p.m.	3–8	8–25	3–6	"	20	3	112 (0–112)*	horses, mules, cattle	lower torso

* Generally preferred range.

E*ulium (H.) ethelae* was found associated

	S. (S.) parrai	S. (D.) pulverulentum	S. (D.) rubicundulum	Cnephia roblesi	S. (L.) samboni	S. (D.) smarti	S. (S.) tricornis	S. (L.) veracruzanum	Gigantodax wrighti	S. (D.) yepocapense	S. (L.) trivittatum
S. (D) acate	14	1	32	..	..	22	5	29	5	4	..
Gigantodax	..	..	..	..	..	..	..	..	..	..	..
S. (D.) arde	..	..	..	..	..	..	..	..	..	..	1
S. (E.) aure	3	..	10	2	..	4	8	19	13	..	..
Cnephia agu	2	..	3	..	..	2	2	3	..	2	..
S. (H.) burc	..	..	..	..	..	..	1	1	..	..	..
S. (B.) benj	..	..	..	..	1	..	..	..	..	..	..
S. (L.) calli	23	24	140	..	..	61	9	63	6	21	..
S. (H.) capr	18	1	39	..	..	26	10	33	7	6	..
S. (H.) carc	4	..	11	..	..	7	4	7	2	..	..
S. (L.) colvi	..	1	..	..	..	..	..	..	..	..	..
S. (L.) dow	12	35	106	..	2	36	5	44	2	17	..
S. (H.) dela	4	..	13	1	..	9	7	17	8	2	..
S. (H.) ethe	3	..	6	..	..	3	7	7	4	..	..
S. (D.) earl	..	8	11	..	..	..	..	1	..	..	..
S. (N.) exig	1	27	32	..	1	8	1	11	..	5	..
S. (L.) hacr	..	11	3	..	1	..	..	2	..	..	..
S. (S.) jobb	18	4	50	1	..	29	5	31	8	8	..
S. (S.) jacu	10	3	26	..	..	14	7	21	6	3	..
S. (S.) kom	1	..	1	..	..	1	1	1	1	..	..
S. (H.) larv	6	..	8	..	..	7	2	8	2	1	..
S. (D.) mex	16	20	101	..	..	41	4	34	2	23	..
S. (S.) metc	22	37	141	..	2	55	8	63	7	23	..
S. (D.) mat	2	1	7	..	..	4	1	5	1	1	..
S. (H.) mic	1	..	3	..	..	1	3	6	2	..	..
S. (H.) nigr	4	..	4	..	..	4	2	4	2	..	..
S. (S.) ochr	14	8	62	..	1	29	5	28	3	8	..
Cnephia pac	1	..	1	2	..	1	2	1	2	1	..
S. (S.) parr	..	..	23	..	..	..	3	16	4	3	..
S. (D.) pulv	..	..	25	..	2	3	..	6	..	4	..
S. (D.) rubi	23	25	..	..	..	59	9	55	8	24	..
Cnephia rob	..	..	..	..	..	..	2	..	1	..	..
S. (L.) sam	..	..	..	..	..	..	..	..	..	..	..
S. (D.) sma	16	3	59	..	..	..	5	28	5	9	..
S. (S.) tric	3	..	9	2	..	5	..	15	6	1	..
S. (L.) vera	16	6	55	..	..	28	15	..	8	8	..
Gigantodax	4	..	8	1	..	5	6	8	..	..	..
S. (D.) yep	3	4	24	..	..	9	1	8	..	..	..
S. (L.) triv	..	..	..	..	..	..	..	..	..	..	..

Table 33.—*Representation of associated species groups found in streams*

Expressed as the total number of collections in which the species in the left column is found associated in the same stream with the species listed across the top. (Thus, *Simulium* (*H.*) *ethelae* was found associated with *S.* (*D.*) *acatenangoensis* three times, with *S.* (*E.*) *aureum* five times, etc. . . .)

	S. (D.) acatenangoensis	*Gigantodax aquamarensis*	*S. (D.) ardeni*	*S. (E.) aureum*	*Cnephia aguirrei*	*S. (H.) burchi*	*S. (B.) benjamini*	*S. (L.) callidum*	*S. (H.) capricornis*	*S. (H.) carolinae*	*S. (L.) colvini*	*S. (L.) dowsi*	*S. (H.) delatorrei*	*S. (H.) ethelae*	*S. (D.) earlei*	*S. (N.) exiguum*	*S. (L.) haematopotum*	*S. (S.) jobbinsi*	*S. (S.) jacumbae*	*S. (S.) kompi*	*S. (H.) larvispinosum*	*S. (D.) mexicanum*	*S. (S.) metallicum*	*S. (D.) mathesoni*	*S. (H.) microbranchium*	*S. (H.) nigricornis*	*S. (S.) ochraceum*	*Cnephia pacheco-lunai*	*S. (S.) parrai*	*S. (D.) pulverulentum*	*S. (D.) rubicundulum*	*Cnephia roblesi*	*S. (L.) samboni*	*S. (D.) smarti*	*S. (S.) tricornis*	*S. (L.) veracruzanum*	*Gigantodax wrighti*	*S. (D.) yepocapense*	*S. (L.) trivittatum*
S. (D) acatenangoensis	..	..	..	6	3	..	..	30	23	4	..	18	9	3	..	5	..	19	15	1	8	17	30	4	..	4	16	1	14	1	32	..	..	22	5	29	5	4	..
Gigantodax aquamarensis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S. (D.) ardeni	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
S. (E.) aureum	6	..	..	..	..	..	..	5	7	3	..	5	10	5	..	1	..	9	5	1	1	4	6	1	2	3	3	2	3	..	10	2	..	4	8	19	13	..	..
Cnephia aguirrei	3	..	..	..	..	..	..	3	3	..	..	2	..	..	..	..	..	1	2	..	1	2	3	..	..	..	2	1	2	..	3	..	..	2	2	3	..	2	..
S. (H.) burchi	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	1	1	..	..	..
S. (B.) benjamini	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..
S. (L.) callidum	30	..	..	5	3	1	..	..	41	8	..	135	10	5	6	36	2	59	26	1	8	102	184	4	4	4	75	1	23	24	140	..	..	61	9	63	6	21	..
S. (H.) capricornis	23	..	..	7	3	..	..	41	..	9	..	21	11	8	1	3	..	28	15	1	8	24	38	3	3	4	21	1	18	1	39	..	..	26	10	33	7	6	..
S. (H.) carolinae	4	..	..	3	..	..	..	8	9	..	..	3	6	7	..	2	..	4	3	..	5	2	8	2	2	1	4	..	4	..	11	..	..	7	4	7	2	..	..
S. (L.) colvini	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..
S. (L.) dowsi	18	..	..	5	2	..	1	135	21	3	1	..	4	2	7	52	2	34	18	..	4	89	155	3	2	2	47	1	12	35	106	..	2	36	5	44	2	17	..
S. (H.) delatorrei	9	..	..	10	..	..	..	10	11	6	..	4	..	6	..	2	..	7	7	1	2	3	9	1	4	2	4	1	4	..	13	1	..	9	7	17	8	2	..
S. (H.) ethelae	3	..	..	5	..	..	..	5	8	7	..	2	6	..	..	1	..	4	5	1	2	2	5	..	3	2	1	..	3	..	6	..	..	3	7	7	4	..	..
S. (D.) earlei	..	..	..	..	..	..	..	6	1	..	..	7	..	..	..	6	1	..	..	..	..	2	8	1	..	..	..	..	..	8	11	..	..	..	..	1	..	..	..
S. (N.) exiguum	5	..	..	1	..	..	..	36	3	2	..	52	2	2	6	..	2	5	5	..	1	28	43	1	..	1	8	..	1	27	32	..	1	8	1	11	..	5	..
S. (L.) haematopotum	..	..	..	..	..	..	..	2	..	..	..	2	..	..	1	2	..	..	..	..	..	..	4	..	..	..	1	..	..	11	3	..	1	..	..	2	..	..	..
S. (S.) jobbinsi	19	..	..	9	1	..	..	59	28	4	..	34	7	4	..	5	..	..	13	1	5	38	59	3	2	3	39	2	18	4	50	1	..	29	5	31	8	8	..
S. (S.) jacumbae	15	..	..	5	2	..	..	26	15	3	..	18	7	5	..	5	..	13	..	1	4	18	31	..	1	4	11	..	10	3	26	..	..	14	7	21	6	3	..
S. (S.) kompi	1	..	..	1	..	..	..	1	1	..	..	..	1	1	..	..	..	1	1	..	..	1	1	..	..	1	..	..	1	..	1	..	..	1	1	1	1	..	..
S. (H.) larvispinosum	8	..	..	1	1	..	..	8	8	5	..	4	2	2	..	1	..	5	4	..	..	4	8	2	..	2	6	1	6	..	8	..	..	7	2	8	2	1	..
S. (D.) mexicanum	17	..	..	4	2	..	..	102	24	2	..	89	3	2	2	28	..	38	18	1	4	..	105	1	..	3	44	1	16	20	101	..	..	41	4	34	2	23	..
S. (S.) metallicum	30	..	..	6	3	..	1	184	38	8	1	155	..	5	8	43	4	59	31	1	8	105	..	5	2	4	77	1	22	37	141	..	2	55	8	63	7	23	..
S. (D.) mathesoni	4	..	..	1	..	..	..	4	3	2	..	3	1	..	1	1	..	3	..	..	2	1	5	..	1	..	4	..	2	1	7	..	..	4	1	5	1	1	..
S. (H.) microbranchium	..	..	..	2	..	1	..	4	3	2	..	2	4	3	..	..	..	2	1	..	..	..	2	1	..	..	1	..	1	..	3	..	..	1	3	6	2	..	..
S. (H.) nigricornis	4	..	..	3	..	..	..	4	4	1	..	2	2	2	..	1	..	3	4	1	2	3	4	..	..	..	2	..	4	..	4	..	..	4	2	4	2	..	..
S. (S.) ochraceum	16	..	..	3	2	1	1	75	21	4	..	47	4	1	..	8	1	39	11	..	6	44	77	4	1	2	..	1	14	8	62	..	1	29	5	28	3	8	..
Cnephia pacheco-lunai	1	..	..	2	1	..	..	1	1	..	..	1	1	..	..	..	..	2	..	..	1	1	1	..	..	..	1	..	1	..	1	2	..	1	2	1	2	1	..
S. (S.) parrai	14	..	..	3	2	..	..	23	18	4	..	12	4	3	..	1	..	18	10	1	6	16	22	2	1	4	14	1	..	..	23	..	..	..	3	16	4	3	..
S. (D.) pulverulentum	1	..	..	..	..	..	..	24	1	..	1	35	..	..	8	27	11	4	3	..	..	20	37	1	..	..	7	..	..	..	25	..	2	3	..	6	..	4	..
S. (D.) rubicundulum	32	..	..	10	3	..	..	140	39	11	..	106	13	6	11	32	3	50	26	1	8	101	141	7	3	4	62	1	23	25	..	..	..	59	9	55	8	24	..
Cnephia roblesi	..	..	..	2	..	..	..	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	2	..	1	..	..
S. (L.) samboni	..	..	..	..	..	..	1	..	..	..	..	2	..	..	..	1	1	..	..	..	..	..	2	..	..	..	1	2	..	..	..	..	..	..	..	..	..	..	..
S. (D.) smarti	22	..	..	4	2	..	..	61	26	7	..	36	9	3	..	8	..	29	14	1	7	41	55	4	1	4	29	1	16	3	59	..	..	..	5	28	5	9	..
S. (S.) tricornis	5	..	..	8	2	1	..	9	10	4	..	5	7	7	..	1	..	5	7	1	2	4	8	1	3	2	5	2	3	..	9	2	..	5	..	15	6	1	..
S. (L.) veracruzanum	29	..	..	19	3	1	..	63	33	7	..	44	17	7	1	2	2	31	21	1	8	34	63	5	6	4	28	1	16	6	55	..	..	28	15	..	8	8	..
Gigantodax wrighti	5	..	..	13	..	..	..	6	7	2	..	2	8	4	..	..	..	8	6	1	2	2	7	1	2	2	3	2	4	..	8	1	..	5	6	8	..	..	..
S. (D.) yepocapense	4	..	..	..	2	..	..	21	6	..	..	17	2	..	..	5	..	8	3	..	1	23	23	1	..	..	8	1	3	4	24	..	..	9	1	8	..	..	..
S. (L.) trivittatum	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

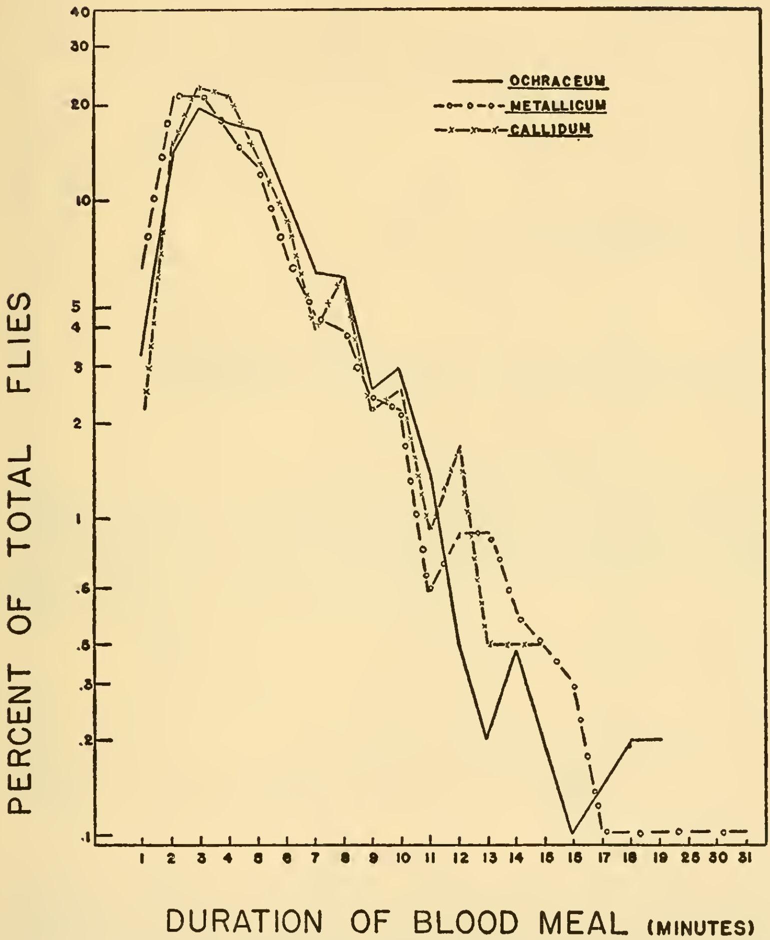

FIG. 14.—Feeding time (in minutes) of the three principal anthropophilic species of Simuliidae. (Prepared on 3-cycle semilogarithmic paper.) Observations were made on the feeding time of 1,012 *S. ochraceum*, 803 *metallicum*, and 232 *callidum*.

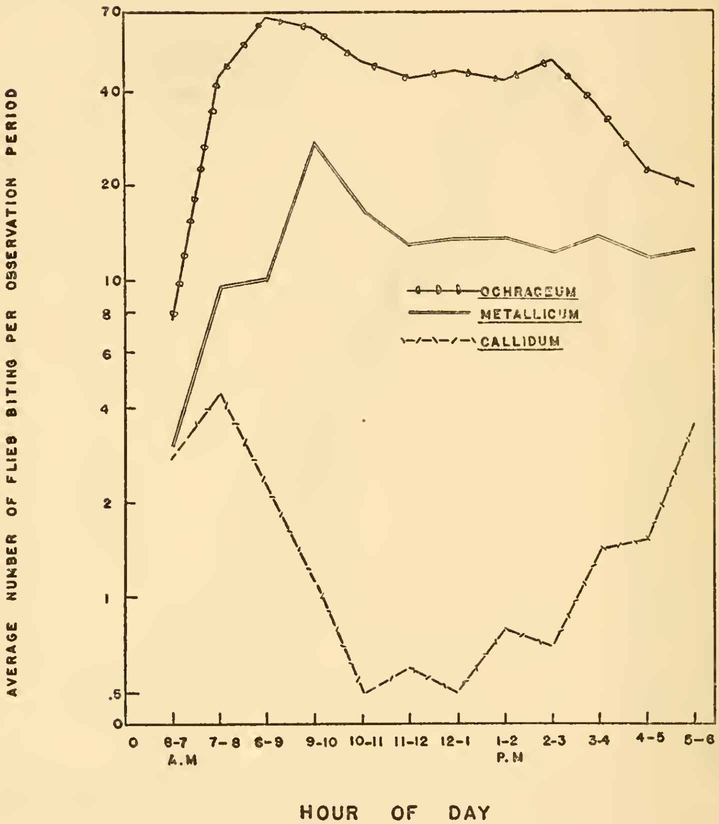

FIG. 15.—Relation of time of day to biting activity of the three principal anthropophilic species of Simuliidae. (Prepared on 3-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 95 days from 6:30 a.m. until 5:30 p.m. Flies biting on regions exposed to sun or to shade have been grouped together.

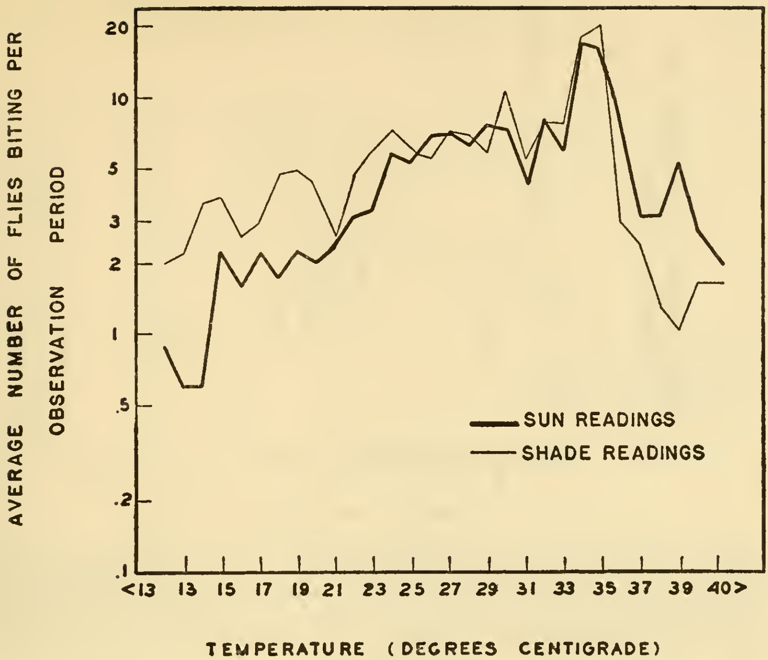

Fig. 16.—Effect of air temperature on biting activity of *Simulium (S.) ochraceum*. (Prepared on 4-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 95 days from 6:30 a.m. until 5:30 p.m. The air temperature was recorded every 10 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was exposed to either the sun or shade.

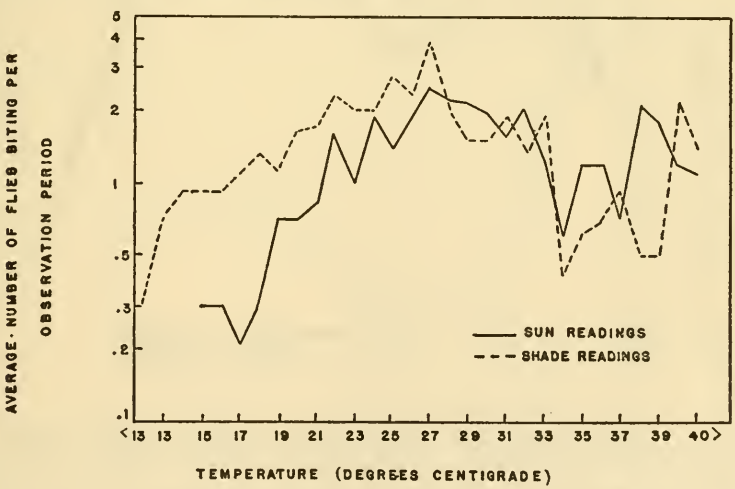

Fig. 17.—Effect of air temperature on biting activity of *Simulium (S.) metallicum*. (Prepared on 4-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 95 days from 6:30 a.m. until 5:30 p.m. The air temperature was recorded every 10 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was exposed to either the sun or shade.

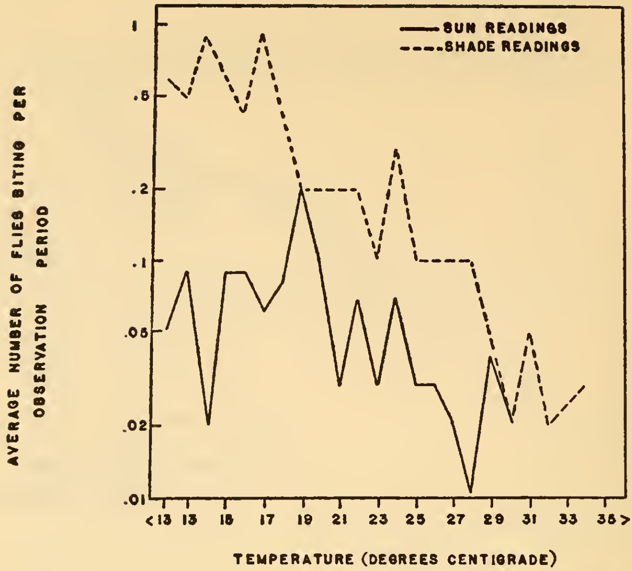

FIG. 18.—Effect of air temperature on biting activity of *Simulium* (*L.*) *callidum*. (Prepared on 4-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 95 days from 6:30 a.m. until 5:30 p.m. The air temperature was recorded every 10 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was exposed to either the sun or shade.

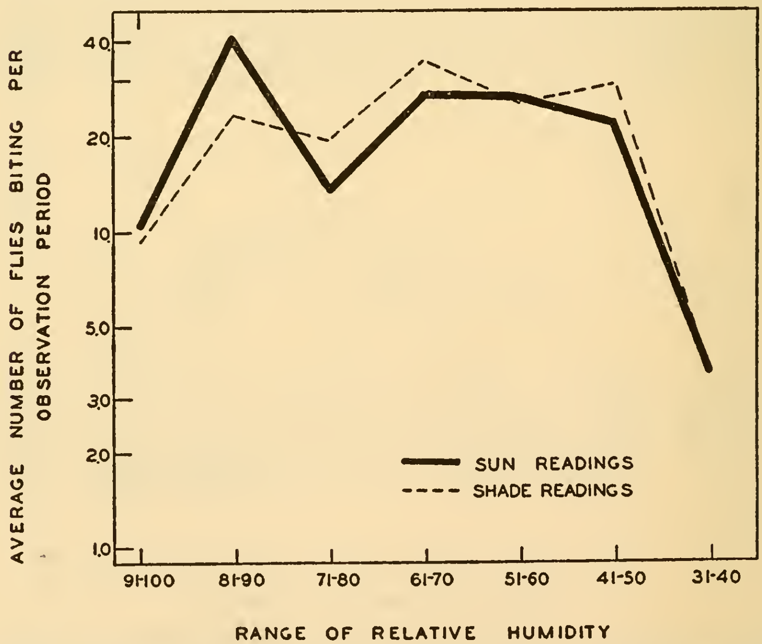

FIG. 19.—Effect of relative humidity on biting activity of *Simulium* (*S.*) *ochraceum*. (Prepared on 3-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 69 days from 6:30 a.m. until 5:30 p.m. Relative humidity was recorded every 30 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was either shaded or exposed to the sun.

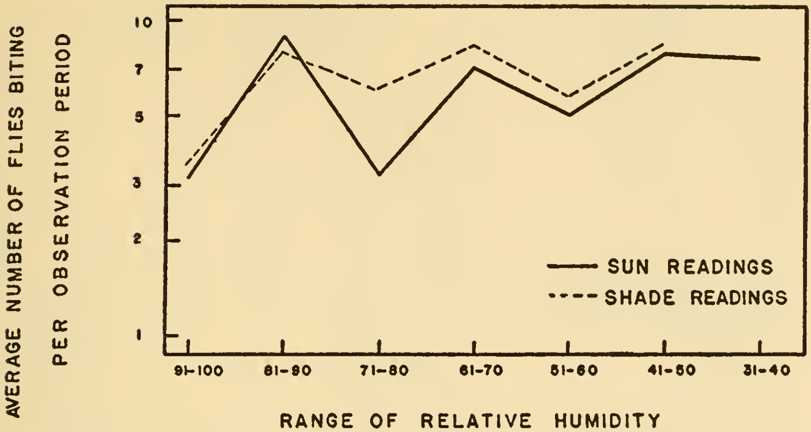

FIG. 20.—Effect of relative humidity on biting activity of *Simulium (S.) metallicum.* (Prepared on 3-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 69 days from 6:30 a.m. until 5:30 p.m. Relative humidity was recorded every 30 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was either shaded or exposed to the sun.

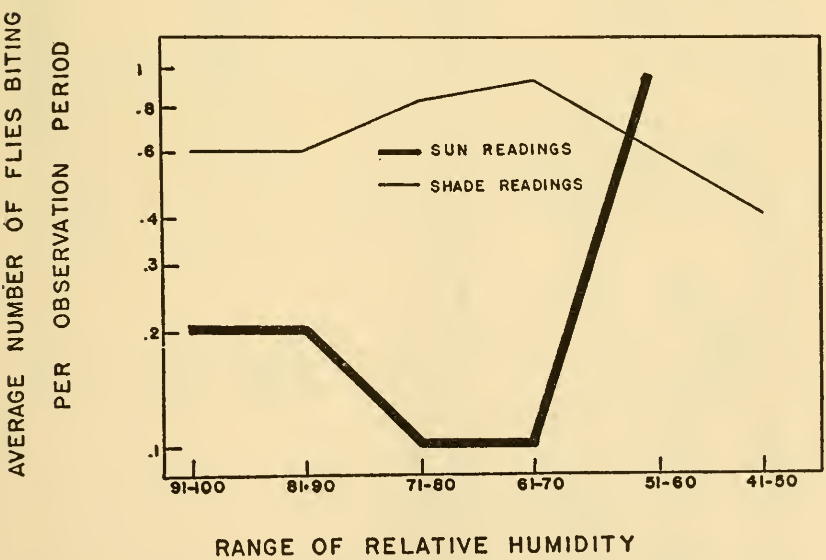

FIG. 21.—Effect of relative humidity on biting activity of *Simulium* (*L.*) *callidum.* (Prepared on 3-cycle semilogarithmic paper.) The flies were collected while feeding on human subjects who were exposed to bites on 69 days from 6:30 a.m. until 5:30 p.m. Relative humidity was recorded every 30 minutes. Sun or shade readings indicate that the flies were biting on a part of the body that was either shaded or exposed to the sun.

TABLE 34.—*Summary of feeding and resting habits of three species of Guatemalan Simuliidae that attack man*

Species	Feeding time (minutes)		Preferred region of body	Activity prior to feeding	Altitude biting (feet)		Resting places
	Mean	Range			Highest	Preferred	
S. (*L.*) *veracruzanum*	4.9	1–19	lower limbs and back	starts feeding immediately upon landing	41	up to 16	leaves and branches of trees and shrubs
S. (*L.*) *haematopotum*	3.7	1– 9	lower limbs	"	36	ground	"
S. (*N.*) *exiguum*	4.5	1–15	lower limbs	"	36	ground	"

TABLE 35.—*Species of Simuliidae attacking various animals, and their feeding preferences for different parts of the body*

Preference for body parts expressed as a percentage of the total number of flies collected of the particular species

Species	Total number flies collected	Part of body attacked (percent)												
		Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Belly	Hind-legs	Groin	Udder	Anal region (including external genitalia)
HORSES														
acatenangoensis	2	...	...	...	...	...	...	...	...	100.0	...	...	...	...
callidum	177	1.2	1.6	1.7	20.3	...	...	7.9	...	60.5	0.6	...	6.2	...
downsi	32	...	...	...	91.0	...	...	...	...	...	9.0	...	...	...
exiguum	13	...	15.0	...	...	...	...	...	...	77.0	...	...	8.0	...
metallicum	913	0.8	1.4	1.2	7.6	0.1	...	5.4	...	71.7	1.1	0.3	10.1	0.3

(*Continued*)

TABLE 35.—*Species of Simuliidae attacking various animals*—Continued

Species	Total number flies collected	Part of body attacked (percent) Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Belly	Hind-legs	Groin	Udder	Anal region (including external genitalia)
HORSES—Continued														
mexicanum	632	1.6	1.6	0.5	23.4	...	...	0.9	...	62.2	0.5	...	8.5	0.8
ochraceum	108	...	0.9	...	10.2	...	4.6	23.2	...	53.7	2.8	0.9	...	3.7
pulverulentum	6	...	...	...	67.0	...	...	...	...	33.0	...	...	...	...
rubicundulum	215	...	1.4	0.9	10.2	...	...	3.3	...	60.9	1.9	...	21.4	...
smarti	3	...	...	...	67.0	...	...	33.0	...	...	...	...	...	...
veracruzanum	9	...	...	...	...	...	...	...	...	89.0	...	...	11.0	...
MULES														
callidum	105	...	7.6	1.0	31.4	...	...	13.3	...	43.7	1.0	...	...	2.0
downsi	19	...	...	...	84.2	...	...	...	...	10.5	...	...	...	5.3
exiguum	4	...	25.0	...	25.0	...	...	...	...	50.0	...	...	...	...
metallicum	565	...	13.1	3.5	8.7	...	0.8	17.4	0.2	50.8	3.2	...	0.4	1.9
mexicanum	187	...	4.3	27.3	...	...	...	4.8	...	61.5	1.6	...	0.5	...
ochraceum	69	...	...	...	34.8	...	...	26.1	...	39.1	...	...	...	...
pulverulentum	3	...	...	...	33.3	...	...	...	...	66.7	...	...	...	...
rubicundulum	53	...	13.2	...	24.5	...	...	1.9	...	56.6	...	...	...	3.8
smarti	3	...	...	...	33.3	...	...	...	...	66.7	...	...	...	...
veracruzanum	3	...	...	...	66.7	...	...	...	...	33.3	...	...	...	...

(*Continued*)

TABLE 35.—*Species of Simuliidae attacking various animals*—Continued

Species	Total number flies collected	Part of body attacked (percent)												
		Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Belly	Hind-legs	Groin	Udder	Anal region (including external genitalia)
					DONKEYS									
metallicum	20	...	...	...	...	...	...	65.0	...	20.0	15.0	...	...	...
mexicanum	3	...	...	...	...	...	...	100.0	...	...	...	...	...	...
ochraceum	2	...	...	...	...	...	...	100.0	...	...	...	...	...	...
					CATTLE									
callidum	180	...	2.8	...	4.4	...	1.7	4.4	1.7	47.2	1.7	...	36.1	...
downsi	36	...	...	...	50.0	...	2.8	2.8	...	25.0	2.8	...	16.6	...
exiguum	5	...	20.0	20.0	...	...	...	...	...	20.0	...	...	40.0	...
metallicum	897	0.1	4.3	1.3	5.0	...	0.2	5.8	0.1	41.8	3.4	...	37.4	0.6
mexicanum	119	1.7	1.7	...	22.7	...	...	10.9	...	47.9	...	...	15.1	...
ochraceum	136	...	6.7	...	6.7	...	...	5.1	...	41.9	8.8	...	27.9	2.9
pulverulentum	3	...	...	...	...	...	...	...	...	66.7	...	...	33.3	...
rubicundulum	73	...	1.4	...	17.8	...	...	5.5	...	13.7	39.7	...	20.5	1.4
smarti	6	...	...	...	16.7	...	...	...	...	83.3	...	...	...	...
					SHEEP									
callidum	7	...	28.6	...	14.3	...	...	...	...	14.3	...	42.8	...	...
downsi	1	...	...	...	100.0	...	...	...	...	...	...	...	...	...

(*Continued*)

TABLE 35.—*Species of Simuliidae attacking various animals*—Continued

Species	Total number flies collected	Part of body attacked (percent)												
		Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Belly	Hind-legs	Groin	Udder	Anal region (including external genitalia)
SHEEP—Continued														
exiguum	1	...	...	...	100.0	...	...	...	...	...	...	...	...	...
metallicum	42	...	38.1	19.0	4.8	...	...	...	...	28.5	...	...	7.1	2.5
mexicanum	4	...	25.0	...	25.0	...	...	...	...	50.0	...	...	...	...
ochraceum	20	...	55.0	15.0	15.0	...	...	...	...	...	10.0	...	5.0	...
GOATS														
callidum	9	...	33.3	...	11.1	...	...	...	...	...	...	...	55.6	...
downsi	1	...	...	100.0	...	...	...	...	...	...	...	...	...	...
metallicum	55	...	36.4	5.5	...	...	...	5.5	...	...	...	...	38.2	14.4
mexicanum	1	...	...	...	...	...	...	...	...	...	...	...	100.0	...
ochraceum	17	...	11.8	...	11.8	...	...	...	...	...	...	...	70.5	5.9
rubicundulum	1	...	...	...	...	...	...	...	...	...	...	...	100.0	...
smarti	1	...	...	...	100.0	...	...	...	...	...	...	...	...	...
DEER (*Odocoileus thomasi* Merriam)														
metallicum	14	...	...	...	14.3	...	...	...	...	...	57.1	28.6	...	...

(*Continued*)

TABLE 35.—*Species of Simuliidae attacking various animals*—Continued

PIGS

Species	Total number flies collected	Part of body attacked (percent): Head	Snout	Ears	Neck	Fore-legs	Chest	Ribs	Belly	Hind-legs	Groin	Udder	Anal region (including external genitalia)
callidum	32	...	12.5	12.5	...	...	6.3	21.8	43.8	3.1	...	...	...
downsi	8	...	...	50.0	...	...	...	...	50.0	...	...	...	...
metallicum	144	...	9.1	17.3	...	3.5	2.1	19.4	47.2	1.4	...	...	...
mexicanum	2	...	50.0	50.0	...	...	...	...	...	...	...	...	...
ochraceum	69	...	15.9	5.8	...	7.3	...	8.7	62.3	...	...	...	...

DOGS

Species	Total number flies collected	Part of body attacked (percent): Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Abdomen	Hind-legs	Groin	Mammaries	Anal region (including external genitalia)
callidum	20	...	45.0	10.0	20.0	...	...	15.0	...	5.0	5.0	...	...	...
downsi	2	...	...	...	100.0	...	...	...	...	...	...	...	...	...
exiguum	72	...	3.0	20.0	1.0	...	6.0	3.0	...	15.0	24.0	...	...	28.0
haematopotum	164	...	...	...	...	...	...	...	1.0	32.0	24.0	...	...	43.0
metallicum	406	...	62.8	23.9	2.3	...	...	0.2	0.2	9.7	...	...	...	0.9

(Continued)

Table 35.—*Species of Simuliidae attacking various animals*—Continued

Species	Total number flies collected	Part of body attacked (percent)												
		Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Abdomen	Hind-legs	Groin	Mammaries	Anal region (including external genitalia)
					DOGS—Continued									
mexicanum	11	...	...	...	...	...	...	...	...	...	...	...	...	100.0
ochraceum	49	4.0	26.5	40.8	12.2	...	...	...	2.1	10.2	2.1	...	...	2.1
rubicundulum	2	...	...	...	...	...	...	...	...	...	...	...	...	100.0
smarti	1	...	...	...	...	...	...	...	...	...	...	...	...	100.0
veracruzanum	12	...	...	...	...	...	...	...	...	58.0	25.0	...	...	17.0
					GRAY FOX (*Urocyon guatemalae* Miller)									
metallicum	8	...	37.5	...	12.5	...	...	...	...	50.0	...	...	...	...
ochraceum	6	...	66.7	...	...	...	...	...	...	33.3	...	...	...	...
					DOMESTIC CATS									
callidum	6	...	16.7	66.6	...	...	...	...	...	...	...	...	...	16.7
downsi	3	...	...	...	...	...	...	...	...	100.0	...	...	...	...
exiguum	1	...	...	100.0	...	...	...	...	...	...	...	...	...	...
metallicum	26	7.7	15.4	42.3	23.1	...	...	...	...	7.7	...	...	...	3.8
ochraceum	27	...	44.5	37.0	14.8	...	3.7	...	...	...	...	...	...	...

(Continued)

TABLE 35.—*Species of Simuliidae attacking various animals*—Continued

Species	Total number flies collected	Part of body attacked (percent)												
		Head	Muzzle	Nose	Ears	Neck	Fore-legs	Chest	Ribs	Abdo-men	Hind-legs	Groin	Mam-maries	Anal region (includ-ing ex-ternal geni-talia)
OCELOTS (*Felis pardalis pardalis* Linnaeus)														
metallicum	2	...	...	50.0	50.0	...	...	...	...	...	...	...	...	...
TAYRA (*Tayra barbara senet* Thomas)														
callidum	1	...	...	...	100	...	...	...	...	...	...	...	...	...
metallicum	8	...	37.5	...	...	...	...	...	...	...	12.5 (toes) 50.0	...	...	...
ochraceum	8	...	12.5	...	...	...	...	...	...	...	62.5	12.5	...	12.5

(*Continued*)

TABLE 35.—*Species of Simuliidae attacking various animals*—Concluded

Species	Total number flies collected	Part of body attacked (percent)							
		Head	Comb	Wattle	Neck	Ear	Breast	Legs	Cloacal region
				CHICKENS					
callidum	5	80	...	...	...	...	...	...	20.0
downsi	1	100.0	...	...	...	...	...	...	...
exiguum	2	100.0	...	...	...	...	...	...	...
metallicum	193	72.5	18.2	...	...	0.5	3.1	5.2	0.5
mexicanum	1	100.0	...	...	...	...	...	...	...
ochraceum	23	47.8	43.5	8.7	...	...	...	...	...
				TURKEYS					
callidum	11	81.8	...	...	18.2	...	...	...	...
downsi	4	50.0	...	...	...	...	...	50.0	...
metallicum	129	93.8	3.1	...	3.1	...	...	...	...
ochraceum	44	81.8	4.6	...	13.6	...	...	...	...
				DUCKS					
callidum	2	50.0	...	...	...	...	...	50.0	...
downsi	1	100.0	...	...	...	...	...	...	...
metallicum	37	70.3	...	...	...	...	21.6	8.1	...
ochraceum	3	100.0	...	...	...	...	...	...	...
				PIGEONS					
ochraceum	2	...	...	...	...	...	...	100.0	...

TABLE 36.—*Distribution of Simuliidae according to altitude*

Expressed as number of collections in which each species was found in the different altitude zones. The average number of flies per collection is given in parentheses

Species	Total number of specimens	Altitude zone: Coastal-1,000	1,000-2,000	2,000-3,000	3,000-4,000	4,000-5,000	5,000-6,000	6,000-7,000	7,000-8,000	8,000-9,000	>9,000
		Total number collections in each zone									
		54	309	878	1,658	2,358	761	252	61	26	38
aquamarensis	542	.....	.....	.....	.....	.....	1(227.0)	5(31.6)	1(157.0)	.....	.....
aureum	597	.....	.....	2(12.0)	2(3.5)	.....	5(5.8)	3(2.0)	13(13.4)	5(8.6)	11(28.6)
acatenangoensis	7,121	.....	.....	1(1.0)	23(20.9)	90(35.4)	115(23.3)	32(23.8)	2(10.0)	.....	.....
aguirrei	553	.....	.....	.....	1(9.0)	3(3.3)	16(33.4)	.....	.....	.....	.....
burchi	65	.....	.....	.....	.....	.....	.....	1(53.0)	1(9.0)	1(3.0)	.....
callidum	7,300	6(1.7)	40(10.3)	137(4.2)	316(5.8)	406(8.4)	102(9.5)	10(4.6)	2(9.5)	3(8.3)	.....
capricornis	2,974	.....	1(39.0)	.....	22(8.0)	62(24.3)	65(15.5)	21(12.0)	1(5.0)	.....	1(1.0)
carolinae	461	.....	3(1.7)	.....	.....	.....	9(21.4)	12(21.9)	.....	.....	.....
downsi	13,121	8(21.0)	62(14.9)	231(15.4)	268(20.7)	242(11.2)	21(9.6)	1(1.0)	.....	2(10.0)	.....
delatorrei	151	.....	.....	1(2.0)	.....	.....	7(4.4)	20(3.9)	8(4.1)	.....	3(2.3)
ethelae	131	.....	.....	.....	.....	.....	4(8.5)	7(13.9)	.....	.....	.....
earlei	824	3(26.7)	4(45.5)	4(25.3)	1(25.0)	4(109.0)	.....	.....	.....	.....	.....
exiguum	1,057	8(12.6)	33(5.6)	43(6.2)	11(12.3)	5(57.4)	4(20.5)	.....	.....	.....	.....
haematopotum	299	4(7.3)	1(7.0)	1(8.9)	.....	2(13.0)	3(49.0)	.....	1(1.0)	.....	.....
jobbinsi	831	.....	9(7.6)	5(2.8)	32(2.5)	87(3.5)	32(8.9)	6(9.3)	.....	1(4.0)	3(7.0)
jacumbae	362	.....	.....	2(14.0)	5(3.2)	27(7.7)	18(4.7)	8(3.1)	.....	.....	1(1.0)
kompi	2	.....	.....	.....	.....	.....	.....	2(2.0)	.....	.....	.....
larvispinosum	44	.....	.....	.....	3(7.0)	2(3.0)	2(3.0)	1(11.0)	.....	.....	.....

(*Continued*)

TABLE 36.—*Distribution of Simuliidae according to altitude*—Concluded

Species	Total number of specimens	Altitude zone: Coastal-1,000	1,000-2,000	2,000-3,000	3,000-4,000	4,000-5,000	5,000-6,000	6,000-7,000	7,000-8,000	8,000-9,000	>9,000
		Total number collections in each zone									
		54	309	878	1,658	2,358	761	252	61	26	38
mexicanum	10,580	1(1.0)	23(6.4)	94(13.4)	264(23.3)	146(20.1)	9(5.9)	2(15.0)	1(1.0)	1(1.0)	.....
metallicum	13,694	7(1.7)	62(8.5)	234(10.8)	304(8.0)	639(10.9)	107(8.8)	24(11.8)	.....	1(6.0)	1(2.0)
mathesoni	13	.....	.....	.....	1(1.0)	.....	2(5.5)	.....	1(1.0)	.....	.....
microbranchium	81	.....	.....	.....	.....	.....	5(1.6)	3(18.7)	2(8.5)	.....	.....
nigricornis	3	.....	.....	.....	.....	2(1.0)	1(1.0)	.....	.....	.....	.....
ochraceum	593	.....	2(4.0)	14(1.5)	47(4.4)	83(3.9)	8(3.9)	.....	.....	1(4.0)	.....
pacheco-lunai	88	.....	.....	1(2.0)	.....	2(2.5)	.....	.....	.....	3(23.7)	1(10.0)
parrai	818	.....	.....	1(2.0)	10(2.5)	38(3.2)	61(11.0)	1(1.0)	.....	.....	.....
pulverulentum	2,890	15(27.1)	21(42.6)	25(29.2)	39(11.8)	12(8.0)	4(3.5)	1(143.5)	2(1.0)	.....	.....
rubicundulum	10,565	2(4.5)	29(8.9)	58(5.7)	202(9.5)	329(20.8)	65(15.8)	12(10.7)	4(7.0)	.....	1(1.0)
roblesi	54	.....	.....	.....	.....	.....	.....	.....	.....	3(7.3)	1(32.0)
samboni	183	.....	4(45.0)	2(1.5)	.....	.....	.....	.....	.....	.....	.....
smarti	1,078	.....	4(1.8)	6(2.5)	39(5.7)	57(9.7)	14(17.7)	2(16.0)	.....	.....	.....
tricornis	168	.....	.....	.....	1(1.0)	.....	1(1.0)	16(7.3)	4(6.0)	4(4.5)	2(4.5)
veracruzanum	6,319	.....	5(1.3)	5(1.6)	8(12.0)	106(16.6)	75(43.6)	32(18.5)	17(29.9)	2(8.5)	1(4.0)
wrighti	1,203	.....	2(7.0)	2(6.0)	.....	.....	.....	31(23.0)	3(5.3)	2(53.5)	13(26.4)
yepocapense	925	.....	4(1.3)	8(1.1)	58(14.2)	13(6.4)	4(1.0)	.....	.....	.....	.....

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(Boldface figures indicate principal references)