

JOURNAL OF AGRICULTURAL RESEARCH

VOL. XXVI WASHINGTON, D. C., NOVEMBER 17, 1923

No. 7

BIOLOGICAL NOTES ON THE TERMITES OF THE CANAL ZONE AND ADJOINING PARTS OF THE REPUBLIC OF PANAMA¹

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INTRODUCTION

The Isthmus of Panama, especially that part of it which now forms the Canal Zone, has been at various times in the past, and is now, one of the great highways of the New World's commerce. Here it is that the Americas and the Old World meet. Despite this fact, little or nothing is known about the majority of the insects that occur there and affect the white man's ability to continue his conquest of the Tropics.

In any new region invaded by the white man, his activities sooner or later result in the overturning of the so-called "balance in nature," which is followed by a readjustment. In the Canal Zone the American régime has begun the agricultural development of the region, which in turn has led to a similar development in the adjoining parts of Panama. Thus decided changes have been wrought. Large areas have been denuded of their original tropical vegetation and have been replaced by cities or towns, by extensive pasture lands, or by agricultural projects of various kinds. Likewise, by the impounding of the waters of the Chagres River to form Gatun Lake and to make the Panama Canal possible, over one-fourth of the total area of the Canal Zone was inundated, killing outright all the vegetation growing on it.

Such procedure has unquestionably brought about radical changes in the fauna of the region, and the insects living there have died out or become scarce; or they have gone to whatever jungles or other untouched areas were left; or they have adapted themselves to the new order of things, increased in numbers, and become insects of economic importance. It is this last course that the termites, "white ants," or, as they are called in Central America, "comejenes," have largely followed. Several species have become important pests of buildings, while other species are, or promise to be, enemies of growing crops. The hardest kinds of woods are riddled by termites (see Pl. 7).

The United States Government in recent years has spent no less than \$10,000 in repairing damage caused by termites to the woodwork of the Hotel Tivoli at Ancon, C. Z. The woodwork of this hotel is infested by several species of termites.

¹ Accepted for publication Aug. 11, 1923.

² Resigned November 3, 1919. The arrangement of the authors' names is purely alphabetical and denotes neither seniority nor precedence.

Although there are several references in literature to the termites that occur in Panama, in only two cases has definite work dealing with these species been done. Dudley and Beaumont (6, 7, 8),³ have contributed three papers on the biology and habits of several of the species found in the Canal Zone and in near-by parts of the Republic of Panama. Banks (1) has recently published a taxonomic paper on the species of the same general region based on material collected by Motschulsky, Dudley, Beaumont, Jennings, Busck, and the Hassler Expedition.

It is the purpose of this article to bring together all that is known about the habits and habitats, the biology, and the economic importance of the 21 species of termites that have been recorded from this region. Four of these were new and their habits hitherto unknown.⁴ This paper is based largely on the material collected by Mr. Dietz and notes that were made by him at the time the material was collected. Doctor Snyder⁵ (21) has identified and described the material and both authors have helped to interpret the field notes. Their work has been supplemented by material for identification and notes from various sources that have been sent to Doctor Snyder from time to time.⁶ Credit for such notes and material is given in the text.

All of the material collected was given an accession number in the field and all notes were taken under the same number. The notes and observations recorded were based on collected specimens, and, in the case of the photographs of the nests, these were accompanied by specimens taken from the nest and numbered with the same number that was given to the negative. That this is an important procedure is shown in the case of the work done by Dudley and Beaumont. The classification of the termites in their day had not reached the plane on which it is to-day, and Banks (1), in working over their material, found that, instead of one species, they had at least two or more in the genera *Nasutitermes* and *Amitermes*. Therefore, although the present writers suppose that the common species in the genus "*Eutermes*" Fritz Müller (l. s.) with which Dudley and Beaumont worked and which they later designated as "*Eutermes*" (*Termes*) *morio* Latreille was most probably *Nasutitermes cornigera* Motschulsky, unfortunately they can not be certain of the fact, nor does any means remain to-day by which the question can be definitely settled. The identity of other termites described by Dudley and Beaumont is also in doubt.

Twenty-one species of termites have been recorded from the Canal Zone and adjacent regions in Panama and specimens are in hand of all these species. Fifteen of these species occur on the Pacific slope and 10 of them on the Atlantic slope, but of these 10 only 8 are from both slopes. Hardly any collecting, however, has been done on the Atlantic slope. In Table I these termites are given in their proper systematic position and their present known distribution in the Canal Zone and near-by parts of Panama is shown. The difference in the distribution may be at least partly due to the 33½ per cent greater rainfall on the Atlantic slope than on the Pacific. Dr. David Fairchild (9) states that the rainfall at Chagres on the Atlantic slope is nearly double that on the heights of Balboa on the Pacific side.

³ Reference is made by number (italic) to "Literature cited," pp. 301-302.

⁴ This article was written in May, 1921. Since then other species of termites have been found in Panama, descriptions of some of which have been published.

⁵ SNYDER, THOMAS ELLIOTT. DESCRIPTIONS OF NEW SPECIES AND HITHERTO UNKNOWN CASTES OF TERMITES FROM AMERICA AND HAWAII. *In* Proc. U. S. Nat. Mus., v. 64, not yet published.

⁶ Special mention should be made of the assistance generously given Mr. Dietz by James Zetek, formerly entomologist of the Canal Zone. Ignacio Molino assisted in collecting specimens. Since Mr. Dietz left Panama, Messrs. Zetek and Molino have continued to cooperate.

TABLE I.—Distribution of the termites of Panama

Species.	Locality.	Atlantic slope.	Pacific slope.	Both slopes.
Family Kalotermitidae:				
<i>Kalotermes marginipennis</i> Latreille.	Gamboa, Canal Zone . . . . .	×	.....	} ×
	Taboga Island, Republic of Panama.	.....	×
<i>Neotermes holmgreni</i> Banks.	Paraiso, Canal Zone . . . . .	.....	×	} ×
	Tabernilla, Canal Zone . . . . .	×	.....
	Taboga Island, Republic of Panama.	.....	×
	Trinidad River, Republic of Panama.	×	.....
<i>Cryptotermes brevicollis</i> Banks.	(?) . . . . .	.....	.....
<i>Cryptotermes dudleyi</i> Banks.	(?) . . . . .	.....	.....
<i>Cryptotermes longicollis</i> Banks.	(?) . . . . .	.....	.....
<i>Cryptotermes thompsonae</i> Snyder.	Ancon, Canal Zone . . . . .	.....	×
Family Termitidae:				
<i>Coptotermes niger</i> Snyder.	Ancon, Canal Zone . . . . .	.....	×	} ×
	Bohio, Canal Zone . . . . .	×	.....
	Frijoles, Canal Zone . . . . .	×	.....
	Gamboa, Canal Zone . . . . .	×	.....
	Gold Hill, Canal Zone	^a	×	
	Juan Mina, Canal Zone . . . . .	×	.....
	Panama City, Republic of Panama.	.....	×
		^a	.....
<i>Amitermes medius</i> Banks.	Las Sabanas (Panama City), Republic of Panama.	.....	×
	Taboga Island, Republic of Panama.	.....	×
<i>Amitermes beaumonti</i> Banks.	Juan Mina, Canal Zone . . . . .	×	.....
	Trinidad River, Republic of Panama.	×	.....
<i>Cornitermes acignathus</i> Silvestri.	Cabima, Republic of Panama.	.....	×
<i>Armitermes armigera</i> Motschulsky.	Paraiso, Canal Zone . . . . .	.....	×
<i>Nasutitermes cornigera</i> Motschulsky.	Ancon, Canal Zone . . . . .	.....	×	} ×
	Balboa, Canal Zone . . . . .	.....	×
	Bracho, Canal Zone . . . . .	×	.....
	Chagres River . . . . .	×	.....
	Colon, Republic of Panama.	×	.....
	Gamboa, Canal Zone . . . . .	×	.....
	Gatun Lake, Canal Zone . . . . .	×	.....
	Juan Mina, Canal Zone . . . . .	×	.....
Las Cascadas, Canal Zone . . . . .	×	.....	

^a Divide (Pacific slope).

TABLE I.—Distribution of the termites of Panama—Continued

Species.	Locality.	Atlantic slope.	Pacific slope.	Both slopes.
Family Termitidae—Con.				
<i>Nasutitermes cornigera</i> Motschulsky.	Las Sabanas, Republic of Panama.	×	}
	Pacora, Republic of Panama.	.....	×
	Panama City, Republic of Panama.	.....	×
	Summit, Canal Zone.....	^a	×	
	Trinidad River, Republic of Panama.	×	.....
<i>Nasutitermes pilifrons</i> Holmgren.	Cabima, Republic of Panama.	×	}
	Paraiso, Canal Zone.....	.....	×
	Trinidad River, Republic of Panama.	×	.....
<i>Nasutitermes ephratae</i> Holmgren.	Ancon, Canal Zone.....	×	}
	Cabima, Republic of Panama.	.....	×
	Frijoles, Canal Zone.....	×	.....
	Las Cascadas, Canal Zone..	×	.....
<i>Nasutitermes guayanae</i> Holmg. var. <i>columbicus</i> Holmgren.	Frijoles, Canal Zone.....	×	}
	Las Cascadas, Canal Zone..	×	.....
	Las Sabanas, Republic of Panama.	.....	×
<i>Anoplotermes gracilis</i> Snyder.	Ancon, Canal Zone.....	×
	Las Sabanas, Republic of Panama.	×
	Panama City, Republic of Panama.	×
<i>Eutermes debilis</i> Heer.	(?).....
<i>Eutermes exiguus</i> Hagen.	Las Sabanas, Republic of Panama.	×
<i>Mirotermes hispaniolae</i> Banks.	(?).....
<i>Leucotermes tenuis</i> Hagen.	Ancon, Canal Zone.....	×	}
	Cabima, Republic of Panama.	.....	×
	Frijoles, Canal Zone.....	×	.....
	Panama City, Republic of Panama.	.....	×
<i>Leucotermes convexinotatus</i> Snyder.	Colon, Republic of Panama..	×	}
	Las Sabanas, Republic of Panama.	.....	×
	Matias Hernandez, Republic of Panama.	.....	×
	Obispo.....	×	.....
	Panama City, Republic of Panama.	.....	×
	Summit, Canal Zone.....	.....	×

* Divide (Pacific slope).

FAMILY KALOTERMITIDAE

Certain members of the family Kalotermitidae, such as species of *Kalotermes* and *Cryptotermes*, are very destructive to the interior woodwork of buildings and to furniture. They differ from other termites in that they attack dry wood—if any wood in a region where the relative humidity never goes below 70 per cent can become dry—and do not need a constant resource of moisture in order to continue their work. Hence all that is necessary for the beginning of an infestation is a crevice in woodwork or furniture where a fertilized female can secrete herself. Dudley and Beaumont (6, 7, 8), taking advantage of this fact, used white ash blocks of dry wood shown in Plate 6, A, for making observations on *Kalotermes marginipennis* Latreille.

Six species of termites in this family occur in Panama. Much trouble is experienced in obtaining forms for specific determination, since the owners of valuable infested furniture are usually adverse to tearing it apart in order to obtain the soldier caste. It is therefore necessary to watch for emergence of winged forms.

Usually the furniture or woodwork is infested with species of this family before their presence is even suspected. In their work these insects, although they come very near to the surface of the wood, do not break through except at a very few places and then usually at an edge or corner of the wood. The holes that are made are only large enough to allow for the casting out of the characteristically sculptured or impressed pellets. The presence of these insects is often indicated by the small piles of pellets beneath infested wood. Likewise, through the sculpturing of the surface of these pellets, which is due to the impression imparted to them in the lower portion of the alimentary tract of the insects, it is possible to identify the genus of the insects excreting them (Pl. 8, B, C).

The following six species of this family have been recorded from the Canal Zone and Panama: *Kalotermes marginipennis*, *Neotermes holmgreni*, *Cryptotermes brevicollis*, *C. dudleyi*, *C. longicollis*, and *C. thompsonae*.

Dudley and Beaumont (6, 7, 8) first called attention to the destructiveness of termites of this family in Panama and stated that a first-class coach belonging to the Panama Railroad became so badly riddled by *Kalotermes marginipennis* as to be absolutely worthless. Beaumont also found the nymphs and soldiers of *Cryptotermes longicollis* working in a window sill in Panama.

KALOTERMES MARGINIPENNIS

This destructive termite occurs in both Central and North America. It not only injures the woodwork of buildings and other structures but attacks timber as well. The specimens from Panama differ somewhat from those in Texas but are apparently of the same species.

SWARMING¹

August Busck collected winged adults of *Kalotermes marginipennis* Latreille at trap lights on June 9, 10, and 13, 1911, at Taboga Island, Republic of Panama. At Gamboa, Canal Zone, on May 14, 1919, winged adults were obtained by Mr. Dietz.

¹ This so-called swarming is the colonizing flight of the sexual adults.

NEOTERMES HOLMGRENI

The winged adults of *Neotermes holmgreni* were collected by August Busck on May 7 and June 13, 1911, at Trinidad River, Republic of Panama. Mr. Busck also has specimens from Taboga Island collected on the last-mentioned date. The other stages of this species have not as yet been collected nor is its economic status in Panama known.

CRYPTOTERMES THOMPSONAE

Winged adults of *Cryptotermes thompsonae* were collected in Mr. Dietz's room at Ancon, Canal Zone, on May 7, 9, 11, and 16, 1919. On these days not more than six specimens were seen at any time. The emergence took place in the late afternoon, never earlier than 4 o'clock, and always following a rain either earlier the same afternoon or during the preceding night.

On June 21, 1921, J. Zetek and I. Molino collected nymphs, soldiers and deálated adults, both males and females, of *Cryptotermes thompsonae* from the dry oak baseboard of a revolving bookcase in a room in the Health Laboratory at Ancon, Canal Zone. These termites were first noted through the characteristic frass on the floor. The board was removed and on its upper surface it was found that in places only the thin coat of varnish remained, the wood being all destroyed. There were several large areas, longitudinal, i. e., parallel in a general way to the grain, and, opening into these, small round burrows. (Pl. 8, A.) Soldiers were very few. When the galleries were opened up the soldiers did not assume a vicious attitude; they merely held their mandibles open. Nymphs of the sexual forms were very much more abundant. Five deálated adults were also present, both sexes being included.

The time of the swarming of *Cryptotermes brevicollis*, *C. longicollis*, and *C. dudleyi* is not known.

Just why the termites of the family Kalotermitidae (at least the species upon which we have data) should swarm in this region during the early part of the rainy season (in May and June) is not known, for they attack dry wood (or at least comparatively dry wood for a region like the Isthmus of Panama), and, as has been pointed out above, they are not dependent on a source of moisture in order to continue their work. Probably, however, moisture in wood creates a condition favorable for beginning excavations.

In the case of species of the family Termitidae Banks, some species of which build conspicuous "nests" or termitaria, the absolute necessity for swarming at this time will be pointed out later.

There are records of injury to timber by other species of the family Kalotermitidae the specific identity of which it has been impossible to establish.

In June, 1914, the Western Electric Co. of New York sent nymphs of a species in the family Kalotermitidae to the Bureau of Entomology, United States Department of Agriculture, for identification. These were taken from a bookcase in the National Palace in Panama City.

On November 11, 1918, Mr. Dietz collected nymphs of a species of the family Kalotermitidae which were tunnelling a bureau drawer in the Hotel Tivoli at Ancon, Canal Zone. This drawer was made of oak veneered with mahogany and both kinds of wood were badly riddled by the insects.

At Quarry Heights, Canal Zone, on April 16, 1919, a species of *Cryptotermes* was found tunnelling a piano which had been brought to Panama by the French when they attempted to dig a canal across the Isthmus. This instrument was made of ebony (?) and one side of it was so badly damaged that it was a mere shell and in many places could have been easily broken through with a slight pressure of the fingers. It was possible to collect only pellets of excrement of this termite.

FAMILY TERMITIDAE

Fifteen species, or the great majority of the recorded termites of Panama, belong to the family Termitidae. These are *Coptotermes niger*, *Cornitermes acignathus*, *Armitermes armigera*, *Mirotermes hispaniolae*, *Leucotermes tenuis*, *L. convexinotatus*, *Eutermes debilis*, *E. exiguus*, *Amitermes beaumonti*, *A. medius*, *Nasutitermes cornigera*, *N. ephratae*, *N. guayanae* var. *columbicus*, *N. pilifrons*, and *Anoplotermes gracilis*. Some of these termites, namely, *C. acignathus*, *A. armigera*, *M. hispaniolae*, and *N. pilifrons*, were not collected during 1918 and 1919 and little seems to be known about their habits, habitats, and potential economic importance.

Considerable information regarding the other species, with the exception of *Amitermes beaumonti*, has been obtained and is of interest either because of the actual or potential economic importance of the particular species or because of its habits, nests, or abundance.

Much of the damage to the woodwork of furniture, buildings, and other structures, such as railroad rolling stock, which has occurred at Panama has been caused by species in the family Termitidae. However, in the family Kalotermitidae species of *Cryptotermes* are undoubtedly injurious.

COPTOTERMES NIGER

Members of the genus *Coptotermes* are regarded as among the most destructive termites to timber. In Hawaii, the species *C. intrudens* Oshima (17) was thought by Dr. R. C. L. Perkins to have been introduced from the Philippines in army cots stored on one of the docks at Honolulu for a period some years ago⁸ and does an enormous annual damage to buildings (18). *C. marabitanus* Hagen is a common species in South America. In Australia, *C. lacteus* Froggatt (11, 12, 13, 14) is the commonest destructive termite in the vicinity of Sydney, New South Wales, and is especially injurious to the woodwork of buildings.

Although *Coptotermes niger* was collected by both Dudley and Beaumont, there are no published records regarding its economic status in Panama. Mr. Dietz collected this species at both Ancon and Gamboa, Canal Zone, but in neither instance was it considered of economic importance. Nevertheless, it is a species that will bear close watching in the future.

At Gold Hill, in 1916, workers of this termite perforated the lead sheathing of an underground cable, as also the tarred parcelling (Pl. 6, B). Specimens of workers and soldiers were received from the Central and South American Telegraph Co. of New York.

At Ancon on April 15, 1919, workers were found tunnelling a live "copaiferous" tree. The greater part of the nest was through the

⁸ Statement in letter of D. T. Fullaway to T. E. Snyder, dated December 29, 1919.

heartwood of the tree with portions of it coming to the surface at various places where areas had apparently died following some external injuries. In such cases the tunnels were brought through the somewhat hardened gum of the tree, which seemed to have been mixed with earth and wood particles excreted by the workers. The outer surface of the entire area was also covered with the same material.

The rainy season of the year 1919 in the Canal Zone began on April 14 and the following day when the nest was found the median line of every tunnel that touched and paralleled the surface was open. In these openings the soldiers had assembled with their mandibles and antennæ directed outward and projecting slightly above the surface. When Mr. Dietz passed his finger or a camel's-hair brush lightly over these openings, the soldiers fairly jumped at them and quickly and viciously took hold, simultaneously secreting a large globule of a milky white, somewhat viscous fluid. All soldiers that were in the least irritated, although they were not touched, secreted this fluid synchronously with the rest. The source of the fluid is a large frontal gland in the head that opens between the jaws. The purpose of the fluid is a protective one and Dudley and Beaumont have called attention to the fact that it will put an insect enemy of the termites *hors de combat*. An account of the use of such a fluid against ants invading the nest of termites is given under the discussion of *Nasutitermes cornigera*. On the fingers or hands the fluid seems to have no effect, and if it has any distinctive odor this is obscured by the pungent odor characteristic of all termites.

Dr. M. Oshima (17), expert zoologist, Government of Formosa, Japan, has called attention to the fact that this fluid, secreted by a Formosan species of *Coptotermes*, is able to disintegrate *lime* mortar; the soldier of *C. formosanus* Shiraki attacks the mortar by dissolving the lime with acidulous secretions. No experiments have been made to determine the properties of the fluid in the case of the species on the Isthmus of Panama, i. e., *C. niger*.

Once attached to an object, so tenaciously do the soldiers of this species cling that, even if their bodies are torn off, the jaws will not release their hold.

Why the tunnels of this particular nest were open was not definitely determined. Some writers have called attention to similar action on the part of other species at swarming time, the purpose of the soldiers lining the openings of the tunnels being to prevent insect enemies, particularly ants, from raiding the nest. Restricted diggings into parts of this nest, however, failed to disclose any winged forms, and although it was watched daily for more than two weeks, no winged forms were found emerging. At the end of that time all the tunnels were again closed.

The second collection of this species was made at Gamboa on May 14, 1919, following a typical tropical downpour of rain, during the close of which a heavy swarming of *Nasutitermes cornigera* took place. The nest of the *Coptotermes* in this case was in an old post which was badly riddled. On top of the post, and in several crevices leading down into it, dead and injured dealkated adults of *N. cornigera* were found. Apparently these had tried to invade the post to establish new nests and had been killed by the *Coptotermes* soldiers which were on guard just beneath the surface. These soldiers were very nervous and immediately began secreting considerable quantities of the milky white fluid when their nest was disturbed during the collection of specimens.

On June 16, 1921, Messrs. Zetek and Molino collected soldiers of *Coptotermes niger* from a small hole in an avocado tree trunk at Frijoles, Canal Zone. The wood inside the trunk was honeycombed by these termites. Only soldiers were obtained, although the hole was well explored.

In another tree on the same day workers and soldiers of this termite were found at Frijoles, Canal Zone. The base of the tree was rotted and honeycombed. A soldier of *Leucotermes tenuis* was present in the wood.

At the same locality, on the same day, still another colony was found in a hole at the base of an avocado tree. The hole was filled in with an earthlike mass as hard as talc stone, riddled and inhabited by the termites so that it looked very much like a "nest." (Cavities in trees, poles, etc., are often filled in by termites with a mixture of excreta and earth.) There were also tunnels in the rotted wood.

Coptotermes niger seems to be fond of the gum of "copaiferous trees," and tunnels the tarred parcelling of telephone cables which under ordinary conditions one would suspect of being repellent. In this connection it might be said that the swabbing of building timbers and railroad ties with tar, as is now done in the Canal Zone, has no value in preventing injury by termites and, if the tar coating is of any great thickness, it is even a harmful practice.

The copal tree of tropical Africa is *Trachylobium mossambicense*. From this tree exudes the gum copal in which so many winged fossil termites are found.

SWARMING

Coptotermes niger swarms from April till June.

On April 19, 1919, *Coptotermes niger* swarmed simultaneously with *Nasutitermes cornigera* on the Pacific side of the Canal Zone, between 3 p. m. and dusk following a 12-hour rain. The combined swarm was very large.

On June 18 a much lesser swarming took place, winged adults being collected at Ancon at dusk, following a heavy rain that fell on the preceding day and another rain in the morning of the same day.

That swarming is decidedly influenced by rainfall is shown by the swarming at Juan Mina on the Atlantic side of the divide on May 14, 1919. At noon a very heavy rain began to fall, over an inch falling between that time and 3 p. m. At 2.30 p. m., although it was still raining hard, Mr. Dietz's attention was attracted to the actions of a large number of birds that had collected on the dead trees bordering the Chagres River and repeatedly flew forth from their perches to catch insects. When the rain subsided enough to permit investigation, it was found that the air was full of the large dusky adults of *Coptotermes niger* and *Nasutitermes cornigera* and that not only swallows, but chickens, ants, and spiders were catching these clumsy winged termites. The swarming continued during a drizzling rain throughout the return trip down the Chagres River until about 3.30 p. m., and when a point about a mile above Gamboa was reached, no more adults were seen.

On June 4 James Zetek collected winged adults of this termite at Ancon. The rains had just about begun and it was notable that when the rains were heavy there was no swarming of termites. On June 4 the first long drizzle occurred and at dusk there was a very extensive swarming of termites which lasted about two hours. For a distance of

nearly 3 miles along the streets of Ancon these "Palomitas de San Juan" were everywhere flying aimlessly yet persistently through the air.

On June 28, 1921, Mr. Zetek collected winged adults of *Coptotermes niger* in flight at his home in Panama City. He states:

There was a heavy downpour at about 11.30 a. m. which lasted till about 2 p. m., with light drizzle after that till about 3 p. m. Thereafter it was very humid and dusky, and the sun hidden by clouds. At exactly 5.30 p. m. on our front porch we saw the first winged termites and then they came in large numbers, flying about aimlessly yet intent upon flying, for as they touched the floor they at once got up again or fluttered around hastily. If a hood was put over them so as to produce darkness, they became very quiet, either entirely still or else walked slowly. We had to adopt this method in order to get good specimens quickly for otherwise it was very difficult to catch them. I was unable to find where they came from. They flew as high as the second story of the house. The flight ended by gradual diminution at about 8 p. m., having made our dinner hasty and nasty. When they alighted on light clothing or on a white face they danced about rapidly, causing much irritation both to skin and temperament. If they alighted on dark clothes or on the skin of a negro they were more quiet and did not move about rapidly. They cause much nervousness in those visited by them, the people becoming very irritable. I am sure the hasty eating, which in unscreened houses necessarily results, reflects on the general health of the victim. Only one species appeared to be involved.

LEUCOTERMES TENUIS

Two new species of *Leucotermes* have been included under the specific name *tenuis*, one of which, *convexinotatus*, occurs in Panama.⁹ *Leucotermes tenuis* is a widely distributed termite and has been found in South America, Central America, and the West Indies. *L. convexinotatus* occurs in Panama and in the West Indies.⁹

Leucotermes tenuis was taken in Panama by Beaumont and *L. convexinotatus* by the Hassler Expedition. The latter is probably the more common species. Both species are found on the Atlantic as well as the Pacific slope. These two termites have apparently the same habits; they attack timber and living vegetation and are found in the outer parts of mound nests of *Amitermes medius*. Both *L. tenuis* and *L. convexinotatus* are of considerable interest from an economic point of view and of great importance in the Canal Zone and Panama, where they do considerable damage both to timber and to living vegetation. These termites have been found in a wide variety of habitats, and are common and destructive species.

Leucotermes tenuis well illustrates what may happen when tropical termites, even though they seem unimportant in their native home, are introduced into a new region where conditions are favorable to their establishment. This has also been shown in the case of *Coptotermes intrudens* Oshima, the history of the introduction of which into Hawaii is not so clear as is that of the introduction of *L. tenuis* into the isolated island of St. Helena. Froggatt (10, 11, and 14) has given the account of this. In the year 1840 a West Indian slaver was captured by the British warships in the vicinity of St. Helena and towed into the port of Jamestown, where it was allowed to rot. In due season the winged adults of the termites (*L. tenuis*), with which its wooden hull had become infested in the West Indies, swarmed and flew into the town. Conditions being favorable to its development, the species soon established itself in the wooden roofs and other parts of the buildings, necessitating the removal

⁹ SNYDER, Thomas E. OP. CIT. Unpublished.

of the infested parts in a short time. It was later estimated that damage amounting to 60,000 pounds sterling to the buildings there had been done by this termite, 30,000 pounds being the amount of damage in Jamestown alone.

The fact that these termites not only tunnel the woodwork of buildings but also attack and tunnel living plants in the field makes the species of great potential economic importance in the Canal Zone and Panama, especially since the agricultural development of the region is now taking place.

Leucotermes tenuis is often closely associated with a species of *Nasutitermes* in the woodwork of infested buildings in Panama or even as an apparent inquiline in the tunnels of species of *Nasutitermes*, one such case of this having been found. The instance was brought to the attention of Mr. Dietz by Mr. Zetek, who collected a few soldiers of *L. tenuis* from tunnels of *Nasutitermes cornigera* on coffins infested by that species, which were stored at Ancon Hospital.

Soldiers and workers of *Leucotermes tenuis* were sent to the Bureau of Entomology for identification along with parts of earthlike tunnels from a termite tunnel extending from the baseboard up into a plastered wall to a picture molding in the National Palace, Panama City, R. P., on January 1, 1914, by the Western Electric Co. of New York. This is the first instance brought to the writers' attention of the construction of earthlike shelter tubes by this termite.

Leucotermes tenuis was found tunnelling a living eggplant at Frijoles, Canal Zone, on October 23, 1918.

On May 13, 1919, a nest of this species was found beneath the bark of a rotting log on a vacant lot in Panama City and soldiers and workers as well as the winged adults, ready to swarm, were taken. There was nothing unusual about this nest, which seemed to be a rather small one consisting of not more than several thousand (?) individuals. No earthlike shelter tubes or secreted runways such as are built by members of the genus *Nasutitermes* were found, the galleries of *Leucotermes tenuis* being tunnelled through the wood. Several species of ants were also found inhabiting the same log in close proximity to the termites and apparently at peace with them or oblivious of their presence. When the log was broken open, however, the ants raided the termite nest, carrying off large numbers of all stages in spite of the resistance of the soldiers, well-armed but too few in numbers to protect their opened nest. The queen of the nest was not found.

On April 28, 1921, J. Zetek and I. Molino collected soldiers of *Leucotermes tenuis* in a rotted piece of log at an avocado plantation at Frijoles, Canal Zone. These were associated with the workers, soldiers, nymphs, and winged adults (which were ready to fly) of the termite *Nasutitermes guayanae*, var. *columbicus*.

Messrs. Zetek and Molino found a soldier of this termite in the wood at the base of an avocado tree at Frijoles, Canal Zone, on June 16, 1921. In this case *Leucotermes tenuis* was associated with *Coptotermes niger*, workers and soldiers. The base of the tree was rotted and honeycombed.

SWARMING

The swarming of *Leucotermes tenuis* takes place during the early part of the rainy season. Winged adults were caught flying at Cabima on May 19, 1911, by August Busck. Winged adults were collected on May

15, 1919, beneath the bark in an old log at Panama City, Republic of Panama, by Dietz and Zetek.

LEUCOTERMES CONVEXINOTATUS

The other species, *Leucotermes convexinotatus*, was first found tunnelling the woodwork of buildings in Colon by engineers of the Western Electric Co. in 1914.

At Colon, Republic of Panama, this termite was taken from tunnels in sweet potatoes on October 25, 1918, the injury to this host superficially resembling that of the sweet-potato weevil, *Cylas formicarius* Fabricius. Banana stumps were found riddled by it at Matias Hernandez, Republic of Panama, on October 29, 1918. In the Las Sabanas region of Panama *convexinotatus* has been found living as an inquiline or "social parasite" (?) (22) in the outer parts of all the large nests of *Amitermes medius* that were opened.

On February 11, 1920, Mr. Zetek found specimens of workers and soldiers of *Leucotermes convexinotatus* at Panama City infesting young avocado trees received from Cuba and planted the day after receipt. Injury was first noted a month or so after planting. It was thought that the termites came with the ball of dirt which was around the plants, since nests were found in it. Species of *Leucotermes* (*L. convexinotatus* and *L. cardini* Snyder) occur in Cuba, but the specimens were not necessarily imported, since these termites are injurious species in Panama.

L. convexinotatus was found by Zetek on February 11, 1921, at El Retiro, Rio Abaja section, Las Sabanas, near Panama City, mining sugar cane.

On May 4, 1921, Messrs. Zetek and Molino opened a mound nest of *Amitermes medius* at Las Sabanas, the galleries of which were crowded with winged forms of *Leucotermes convexinotatus*. Soldiers and workers of *L. convexinotatus* were also present and seemed to dominate the upper and middle portions of this nest of *Amitermes*. Apparently either species of *Leucotermes* lives peacefully with *Amitermes* until human beings disturb the nest, upon which the two species engage in combat.

On May 13, 1921, Messrs. Zetek and Molino found workers and soldiers of *L. convexinotatus* in the roots of a dying young citrus tree at the Summit, Canal Zone, plantation. The termites were very abundant in the field and dead wood lay about freely.

SWARMING

Leucotermes convexinotatus apparently swarms during the same season as does *L. tenuis*. Immature winged adults were collected at Colon, Republic of Panama, on April 11, 1914, in the woodwork of the cable office.

On May 4, 1921, winged adults were found in an *Amitermes* nest at Las Sabanas, as described above. These adults were mature and ready to swarm. On May 3 and 4, 1921, Mr. Zetek collected winged adults of this species swarming at Panama City in the dining room of a dwelling house. These were abundant and were flying with adults of *Anoplotermes gracilis*.

Winged termites of *L. convexinotatus* were collected in Mr. Zetek's dining room in Panama City, around a 60-watt electric light, at about

7 p. m. on May 24, 1921. They were very abundant. It was raining slightly about this time. A light breeze made with a fan quickly dispersed them.

EUTERMES DEBILIS

This species is one of potential economic importance and of scientific interest because of its habits and history. Heer's type is a fossilized form in gum copal in the Zurich Museum. Unfortunately neither the age nor the origin of this copal is given, though it is unquestionably of tropical American origin. It is probable, since it has been found in copal, that the species is an old one. Hagen (15) also examined another specimen in copal (from the Königsberg Museum, Cabinet No. 559) in the same piece of which was a winged specimen of the Antillean species *Cryptotermes brevis* Walker.

Von Moritz collected *Eutermes debilis* in Porto Rico and Burmeister obtained it in Brazil. Hagen described the soldier from specimens from Panama. Hence it is evident that *E. debilis* is widely distributed in the American Tropics.

The exact localities in which this termite has been found in Panama are not known. A first-form queen in the Beaumont collection from Panama measures 24 mm. in length.

EUTERMES EXIGUUS

On May 11, 1921, at Las Sabanas, Messrs. Zetek and Molino found winged adults, soldiers, and workers of *Eutermes exiguus* in a mound nest of *Amitermes medius*; workers of *Anoplotermes* also occurred in this nest.

AMITERMES BEAUMONTI

No nests of *Amitermes beaumonti* were seen by Mr. Dietz. Soldiers of this species were found in the Beaumont collection and the species was named in his honor. It may be that the large mound nests to which Dudley and Beaumont (8) refer under the name of *Termes columnar* are those either of this species or a species of *Anoplotermes*. These nests were 5 feet in diameter and nearly 4 feet high. No termite nests approaching this size have been found in the Canal Zone or Panama by either Mr. Dietz or Mr. Zetek, who has traveled extensively throughout the entire region.

SWARMING

What appear to be the winged adults of this species were taken by August Busck at Trinidad River, Panama, on May 5, 1911, and by Dietz and Zetek at Juan Mina, May 14, 1919. The adults collected by Dietz and Zetek occurred sparingly among the enormous swarms of the larger, black, but otherwise superficially similar adults of *Nasutitermes corniger*.

AMITERMES MEDIUS

This species is of interest because it is a close relative of *Amitermes meridionalis* Froggatt which builds the curiously oriented "meridional" or "magnetic" nests in Australia recently discussed by Mjöberg (16) and because it also builds a very conspicuous nest. These nests or termitaria are hard, more or less hemispherical, reddish or brownish earth mounds

(Pl. 4) of varying size, the larger ones often $2\frac{1}{2}$ feet in diameter and 2 feet in height. They are usually built around and over low shrubbery, logs, or stumps, or in some instances around the bases of fence posts. On the flat, treeless pasture lands of the Sabanas region a few miles from Panama City, these nests are a common sight and remind one of the first account of mound-building termites, written by Smeathman (20), in which he pictures a wild bull surveying the surrounding country from the top of the nest of an African termite.

These nests are built from particles of earth which, having passed through the alimentary tract of the workers, are cemented together. The enveloping walls are constructed of surface soil, not of soil mined from below. Because of their shape and texture these nests are almost impervious to water; some that were examined after a heavy shower showed that only the outer wall had been penetrated by the rain. Because of their shape and internal structure (Pl. 4, B; Pl. 5) these nests are so solid that one can jump up and down on them without making the least impression, and when one attempts to open them with a machete it glances off as it would if one were trying to chop a stone in half.

Froggatt (13) records that the earthlike material from the nests of certain mound-building species in Ceylon is so fine that it is used by the native jewellers to polish gems. Several writers state that the material from similar nests is employed by the natives in parts of Africa for the floors of their huts and "J. M. C." (2) says that in Australia these termite mounds are used in making tennis courts. There is little question that the earth-material nests of *Amitermes medius* would make as good courts as cement. In no instance, however, have the natives of Panama been found using these mound nests.

From all records available this species seems to be confined to the Pacific side of the Canal Zone and to the Republic of Panama. In all the nests that have been opened no queens have been found; they are probably in the deeper underground parts. Considering the size of the nests, the number of inhabitants seems much smaller than in the case of species of the genus *Nasutitermes*.

On the afternoon of May 4, 1921, Messrs. Zetek and Molino broke open a nest in the vicinity of Las Sabanas (near Panama City). This mound nest was about 2 feet high and quite hard, a geological pick being required to open it. The galleries were filled to overcrowding with winged forms. The winged adults were always congregated in the galleries and cells lined with white (Pl. 5, B). This white lining is found in nests of *Leucotermes tenuis*, according to Silvestri (19, p. 112). In the upper and middle parts of this nest the lighter colored form with narrow wings (*convexinotatus*) predominated. In the whole nest this was the prevailing form. At the base of the nest were obtained smaller numbers of the adult with darker and wider wings (*Amitermes medius*). The soldiers tightly grasped the forceps extended to them.

Soldiers of *Leucotermes convexinotatus* were also present in the galleries of this mound nest. Soldiers of *Amitermes medius* and *L. convexinotatus* were found with mandibles locked about each other.

SWARMING

May 4, 1921, at Las Sabanas, was cloudy, and a light rain fell all the time during which the nest was being examined. The winged adults began to emerge at 3 p. m. As the nest was broken up winged adults flew out in clouds.

On May 11, 1921, Messrs. Zetek and Molino opened up a nest of *Amitermes medius* at Las Sabanas, Panama City. Winged adults as well as workers and soldiers of this species occurred in this nest and also workers and soldiers of *Leucotermes convexinotatus*. The small white forms (possibly workers or the young of *L. convexinotatus*) were in cells lined with a whitish, granular substance. The winged forms were abundant and flew about as soon as the nest was opened. These nests were very hard.

Another nest of the same kind was found containing winged adults, workers, and soldiers of *Amitermes medius*. The ant (*Pseudomyrma* sp.)¹⁰ in this material was found inside of the termite nest and quite certainly was not accidentally introduced there while the nest was being dug open.

Still another nest with the same general data was found. The thick-set forms (workers of *Amitermes medius*) were very slow in gait.

As has been mentioned before, *Leucotermes tenuis* or *L. convexinotatus* has been found living as a "social parasite" (?) in the outer parts of all the larger nests of *Amitermes medius* that have been opened.

In a large nest on Taboga Island, Republic of Panama, on June 23, 1919, two individuals of a new species of solpugid spider were found. These have been described as *Ammotrecha tabogana* by R. V. Chamberlin (3). Solpugids show a predilection for preying upon termites and there is no doubt that this is the significance of the association in this case.

No covered, earthlike runways built by *Amitermes medius* have been discovered. Species of the genus *Nasutitermes* commonly construct such runways or shelter sheds, on tree trunks, etc. In this respect *A. medius* apparently differs from the species of the genus *Nasutitermes*.

Drummond (5) has advanced the theory that in parts of Africa the termites, especially the ground-inhabiting forms, take the place of earthworms in the "economy of nature." In Panama, however, this theory does not hold, since earthworms are found there.

At the present time *Amitermes medius* is not of economic importance, but it may become so if the lands on which it occurs are ever planted in crops.

NASUTITERMES CORNIGERA

Nasutitermes cornigera is one of the commonest termites of the Canal Zone and adjoining parts of the Republic of Panama. The conspicuous "nigger-head" nests on fence posts, trees, and especially on the large dead trees on Gatun Lake, attract the attention of visitors to these regions and it is about these nests that Collins (4, p. 207) has made the following remarks under the heading of "Things not true":

The Sloth pointed out to the tourist as a black thing hanging from a tree is really an ants' nest. The sloth does hang from a tree, but not alongside the railroad tracks or highways.

A typical termitarium of this species consists of a main nest on the tree. From this numerous runways extend which traverse the trunks of trees, posts, or the sides of buildings, terminating in the ground. These carton tree nests are often called "nigger heads" because of their shape. These nests may be a considerable distance, as much as several hundred feet, away from the main nest, and are often connected with other carton nests by the characteristic runways. These "nigger-head" nests

¹⁰ Determined by W. M. Mann, Bureau of Entomology, United States Department of Agriculture, who states that its presence was probably accidental.

and runways are shown in Plates 1 and 2. The nests are generally more or less ovoid in shape, the largest one found being $1\frac{1}{2}$ feet long by 1 foot in diameter.

The nest and runways are made of a sort of papier-mâché consisting of finely digested wood, earth, and other substances that have passed through the alimentary tracts of the workers and are cemented into position as they are excreted. The nests and runways are quite tough and are practically waterproof. When either is broken the characteristic brown-headed, long-nosed nasuti (soldiers) and the lighter colored workers rush forth to repair the damage. The carton nests, however, are not always built, nor does the species always reach its feeding grounds by means of external runways, for in Panama City this species has been found tunnelling the heartwood of trees.

Nasutitermes cornigera and *N. ephratae* are of the greatest economic importance in this region, for they do not confine their attacks to trees, posts, and stumps out of doors, but are especially destructive to furniture and the woodwork of buildings. Access to a building is gained from a parent out-of-door nest by means of the runways built up over walls or up the supports on which the building rests; in fact, there are few wooden houses or buildings in the Canal Zone that do not show traces of such tunnels. Once in the building, carton nests such as are shown in Plate 3, A, B, are constructed between the walls or on the joists and studdings.

There are records of this species working in wood at the Washington Hotel, Colon, Republic of Panama, in tunnels on a storehouse at Gamboa, Canal Zone, and in a newel post at the Hotel Tivoli, Ancon, Canal Zone. At Ancon Hospital, *N. cornigera* tunnelled coffins made of poplar wood and veneered with oak, stored under the building; 7 out of 19 coffins were infested, 3 being badly damaged.

N. cornigera has also been found at Balboa, Canal Zone, tunnelling pieces of dead tree limbs on which orchids were growing. This indicates a method by which the species might be distributed in the absence of strict plant quarantine regulations; in fact, *Nasutitermes morio* Latr. has been intercepted coming into the United States from Trinidad in just such a manner, by inspectors of the Federal Horticultural Board at New York City.

On July 12, 1920, Zetek and Molino collected workers and nasuti of *Nasutitermes cornigera* in covered runways on cacao trees at the Las Cascades Cacao Plantation, Canal Zone. There was hardly a cacao tree on the plantation which did not have runways of these termites on the trunk. The manager stated that chickens eat the termites and that he expected to use them as controls. An ant, *Azteca* sp.,¹¹ was present with the termites.

On January 31, 1920, Mr. Zetek found workers and nasuti of *Nasutitermes cornigera* on another cacao plantation at Las Cascades. In this lot were a large number of young reproductive types which might have been of the second form, with short wing pads and slight grayish pigment on the wing pads and other parts of the body. The eyes were pinkish. If of this type, it is believed this is the first record of the occurrence of second-form, reproductive individuals in the genus *Nasutitermes*. An ant, *Dolichoderus (Inonacis) bispinosus* Oliv.¹¹ was present with the termites.

¹¹ Determined by W. M. Mann of the Bureau of Entomology.

Two large, black, ovoidal nests of *Nasutitermes cornigera* were found on tree trunks at Las Sabanas, Panama City, on May 4, 1921, by Messrs. Zetek and Molino. Workers, nasuti, and young nymphs, but no winged forms, were in the nests. The white individuals (workers or nymphs?) exuded a white gummy fluid. First-form queens were found in six tree nests on "soursop" trees (*Annona muricata*), at Juan Mina, Canal Zone, on February 18 to 19, 1921; these queens were enlarged, egg-laying, reproductive forms.

There were 17 queens in one nest on a tree. The termite burrows are about one-half to 1 inch broad and about three-eighths to one-half inch thick. The nest was about 2 feet high and 1 foot in diameter. All termites collected on "soursop" trees were of this sort.

The members of the genus *Nasutitermes*, and *N. cornigera* in particular, are known as "duck ants" by the West Indian negroes. These negroes and the natives of the region often open the carton nests and feed the inhabitants to chickens and ducks, which seem to relish them in spite of the characteristic pungent termite odor. So pronounced is this odor in all the species that have been collected in this region that it will remain on one's hands several days in spite of numerous washings with soap and water or with ethyl alcohol.

All of the typical "nigger-head" nests that have been examined on both the Atlantic and Pacific sides of the Canal Zone and Panama have been those of this species. A nest about 18 inches wide was dissected at Las Sabanas on May 4, 1921, by Zetek and Molino. The nest was on a tree and was black in color, as is usual in the case of this termite. Soldiers and workers were present, but no winged adults were in the nest at this time of the year.

In one case at Bracho, Canal Zone, on July 10, 1918, 15 queens were obtained from a large ovoid nest $1\frac{1}{2}$ feet long and 1 foot in diameter at its widest part. In this nest 2 queens were usually found in each "queen chamber," although Dudley and Beaumont record having taken 10 queens from a "queen chamber" of what may have been this species. The queens were all rather small, measuring less than 30 mm. (Pl. 3, C) and were all first-form or "true" queens, i. e., developed from deãlated fertilized females.

Most of the queens of this and other species of *Nasutitermes* that have been obtained are of this type. In two other, though somewhat smaller nests, at the same place and on the same day, 3 and 4 queens were obtained, respectively.

SWARMING

The swarming of this species takes place from April till June, the earliest record having been that by Jennings on April 8, 1910, at Las Cascadas, Canal Zone. August Busck collected winged adults at Trinidad River on May 5, 1911. On the Pacific side of the Canal Zone and Panama, the main swarming of *N. cornigera* took place between 3 p. m., and dusk on April 19, 1919, following a 12-hour rain; at the same time and place *Coptotermes niger* swarmed. The large, black, winged adults of these two termites are superficially very difficult to separate and were naturally confused in the field, being given the same numbers when found swarming together.

On May 14, 1919, winged adults were observed at Gamboa at 5 p. m., 45 minutes after the last specimens of this termite and *Coptotermes niger* had been noted swarming over the Chagres River. When the swarm

did appear at Gamboa the rain had ceased and the winged adults came in ever-increasing numbers from the woods north of the town and drifted out over the Canal, where large numbers perished. This flight was still in progress when observations were discontinued at 6 p. m. Since there was no rain at the time on the Pacific side of the Divide, no termites were found swarming at Ancon or Panama City.

In a region like the Canal Zone and the adjoining parts of the Republic of Panama, where there is such a decided difference, even within short distances, not only in the quantity of rainfall, but also in the time during which it falls, one place being deluged and another remaining dry, it is apparent that there will be a considerable range in the time that swarming takes place even in the same species, for it seems that accumulated rainfall is a factor in determining the time that this event occurs. Species like those of *Nasutitermes*, *Amiterms*, and *Anoploterms*, whose main nests are built in the ground and which require moisture in order to continue their work, must swarm early in the rainy season in order to establish themselves thoroughly, for during the dry season, from the last part of December to the first or middle of April, practically no rain falls over a considerable part of the region and the ground becomes hard, dry, and cracked for several feet down.

The fact that such large numbers of "true" queens have been found in the same carton nest leads to the conclusion that in this species winged individuals are more or less gregarious even after fertilization.

Because of the number of queens that occur, the nests of this species are crowded with workers and soldiers and this seems to be an advantage in keeping out intruders such as the ants in case the nest or runways are damaged. On July 19, 1919, in the Las Sabanas region of Panama the carton nest shown in Plate 2, A, was cut open with a machete to obtain queens. The outer parts of the stump on which this nest was found were inhabited by the termites and the inner parts of it by carpenter ants, *Camponotus abdominalis* Fab., subspecies *stercorarius* Forel.¹² The ants and termites, as has been repeatedly observed, were living in apparent peace, either unaware of the existence of each other or in a state of "armed neutrality." In opening the termite nest with a machete the stump was also split and the termite hordes poured forth only to meet the throngs of furious ants. Each apparently blamed the other for the catastrophe that befell its nest. The ants rushed at the termites with open jaws, closing them and crushing as many as half a dozen at a time. But the taste of termite blood was not pleasant and the ants soon let them fall. The worker termites grasped their enemies by the legs and antennæ while the nasuti with their "beaks" borne aloft and secreting the white, milky fluid from the tips thereof, rushed at the invaders as if to pierce them through. Their favorite point of attack was the abdomen, especially the pedicel of the ants, and here as many as four nasuti were found attached to a single invader by the fluid they had secreted, while half a dozen workers were clinging to its legs and antennæ. Though this fluid seems to have no effect on the skin of man, it apparently paralyzed the ants and numbers of them were seen to curl up, lose their hold on the stump, and fall to the ground helpless. If an ant did succeed in freeing itself from one lot of termites it was soon covered with another and it seemed unable to do anything when these got on its back or on its abdomen. The ants soon became discouraged,

¹² Determined by W. M. Mann of the Bureau of Entomology.

for although they killed hundreds of nasuti and worker termites, they were unable to reduce the numbers that swarmed forth to meet them and so in the course of 20 minutes the fight was over, the ants withdrawing, leaving the termites the victors. These marched up and down the stump and over the ground at its base in never-ending streams, apparently at a loss as to how to repair their completely ruined nest.

NASUTITERMES EPHRATAE

Nasutitermes ephratae, like the preceding species, is of considerable economic importance. At the Hotel Tivoli at Ancon, Canal Zone, its tunnelling in the wood necessitated the removal of over 8,000 square feet of oak flooring. These floors were laid on spruce and yellow pine joists, which, in the presence of the oak, remained free from attack. Out of several hundred joists examined one of oak was found and it was badly riddled.

N. ephratae was also found tunnelling through trunks and their contents and through boots and shoes where these had been left standing undisturbed for a long time. It showed a predilection for the outer surfaces of the last mentioned articles.

Carton nests such as those shown in Plate 3, A, B, were occasionally found on the joists beneath the floors and in one instance a large nest 3 feet high, 2 feet wide, and 6 inches deep was found between the wooden walls of a bathroom. This nest resembled superficially the comb in an old box beehive.

These termites need a source of moisture in order to continue their work, and in buildings of the Canal Zone and Panama they usually find it in the bathrooms, where some parts of the floors are always moist, owing to the general prevalence of shower baths. It is in the vicinity of the bathrooms that these termites are found in the greatest number and the damage is worst. When they gain entrance to a building and become established they do not need access to the ground for a source of water supply, and the removal of the runways leading from the building to the ground does not cause the species to die out.¹³

No out-of-door nests of *Nasutitermes ephratae* had been found until 1921, all the "nigger-head" nests examined being those of *N. cornigera*. In texture and general internal structure the nests and runways of *N. ephratae* are inseparable from those of *N. cornigera*. On February 19, 1921, however, Molino and Zetek found a small nest of *N. ephratae* on a mango tree in an avocado plantation at Frijoles, Canal Zone. This was the only nest seen. Only one large egg-laying queen was present.

SWARMING

In the Tivoli no winged adults were taken in 1919, although careful watch was kept for them from April until the end of July. On May 20, 1911, at Cabima, Panama, Busck took the winged adults at trap lights.

A queen in the Beaumont collection measures 27 mm. in length and 5 mm. in width; the queen is of the first form.

¹³ On January 19, 1920, Mr. Zetek collected specimens of workers and nasuti of *Nasutitermes ephratae* injuring a filing case in a building at Ancon, Canal Zone.

NASUTITERMES GUAYANAE VAR. COLUMBICUS

Only one nest of *Nasutitermes guayanae* var. *columbicus* has been found. This was discovered in the Sabanas region, Republic of Panama, on July 19, 1919 (Pl. 2, B). In general the nests are built like those of *N. cornigera*. In texture and internal structure they are inseparable from those of the two preceding species, although in shape they are decidedly different, as is shown in Plate 2, the carton nest being nothing more than a covering of the object to which it is attached and formed of numerous confluent and piled up runways. There is, in other words, no regular exterior separate nest.

On January 31, 1920, Mr. Zetek found specimens of workers and soldiers of *Nasutitermes guayanae* var. *columbicus* on a cacao plantation at Las Cascadas, Canal Zone.

On April 28, 1921, Zetek and Molino collected workers, soldiers, nymphs, and winged adults of *Nasutitermes guayanae* var. *columbicus* in a rotten log on an avocado plantation at Frijoles, Canal Zone. These specimens were collected from tunnels and a semidefinite "nest" on a piece of branch at the base of an avocado tree. There was no well-formed nest and it appeared as if the termites entered from the soil. This semidefinite nest was in a hollow of the branch, about 1 foot long by about 6 inches wide. There were about five tunnels in the branch. The branch was well rotted but still firm. With these were found soldiers of *Leucotermes tenuis*.

On June 16, 1921, Messrs. Zetek and Molino collected workers and nasuti of *Nasutitermes guayanae* var. *columbicus* from covered tunnels on the trunk of an avocado tree at Frijoles, Canal Zone. These tunnels were very close to the hole from which soldiers of *Coptotermes niger* were collected. No nest was present and the tunnels did not communicate with the hole so far as could be determined.

There is no doubt that this species may become as serious a pest as the two preceding ones, for, like them, it not merely builds runways over the surface of the wood but tunnels it as well. In this instance it was apparent that the fence post on which the carton nest occurred was not only being tunnelled from below the ground upward, but also downward from beneath the tin capping with which it was covered.

SWARMING

Winged forms of this species ready for flight were taken at Frijoles, Canal Zone, on April 28, 1921, in a log.

On June 16, 1921, Zetek and Molino collected at Frijoles, Canal Zone, winged adults of *Nasutitermes guayanae* var. *columbicus* with workers and nasuti from a piece of rotten avocado limb on the ground at the base of a tree. The wood was well riddled and there were some covered tunnels on the outside which communicated with the ground. No nest was found. The winged adults were very abundant, being packed in small pockets; when these were opened they began to fly about at once. This was at about 10.30 a. m.

OTHER SPECIES OF NASUTITERMES

One other species of *Nasutitermes* is recorded from Panama, namely, *N. pilifrons* Holmgren. The specimens were all collected by Busck in 1911 and the determinations were made from winged adults.

The adults of *N. pilifrons* were taken at Trinidad River, Republic of Panama, on May 2; at Cabima, Republic of Panama, on May 20; and at Paraiso, Canal Zone, on April 24.

Dudley and Beaumont (8) refer to one of the largest nests of "Milesnasitermes" (a genus without a species, to include soldiers with beaks, i. e., "soldier-nosed-termes") yet found upon the Isthmus. It was in a storehouse, and was 10 feet in height, 2½ feet at its greatest width, and 1½ feet at its greatest depth; its estimated weight was 300 pounds. The wood of the building was badly injured, while galleries ran from this to other buildings. One gallery ran to a chapel and the organ was destroyed.

It would be exceedingly interesting to learn what termite constructed this large nest. Quite possibly it was a species of *Armitermes*, since this invalid genus "Milesnasitermes" could include species in at least three genera, i. e., *Nasutitermes* Banks, *Constrictotermes* Holmgren, and *Armitermes* Wasmann.

ANOPLOTERMES GRACILIS

Anoplotermes gracilis is a small Central American species of the interesting and peculiar genus *Anoplotermes* and lacks the soldier caste, as in all species of this genus. No nests of it were found.

Certain species of *Anoplotermes* construct tall, cylindrical, earthlike mounds in tropical regions. Possibly *A. gracilis* is the termite referred to by Dudley and Beaumont (8) as *Termes columnar*, which constructed a nest more than 5 feet in diameter at the base and nearly 4 feet in height at Ceroyal Station of the Panama Railroad.¹⁴ These nests have been discovered only on the Pacific slope.

Anoplotermes fumosus Hagen, of Mexico and Texas, however, does not construct earthlike mounds, at least not in Texas, but lives underground and apparently is a "social parasite," (22), being found only with other species of termites and never in separate colonies.

In some species of the genus *Anoplotermes* the exceptionally long jaws of the winged adult are significant, in view of the absence of the soldier caste. This is especially true in the species *A. fumosus*, which is probably a social parasite and lives in the colonies of other species of termites.

Anoplotermes gracilis will probably not prove to be a termite of great economic importance in the Canal Zone. If it constructs large mound nests, they have not as yet been found, and it is probable that this termite lives underground like its North American relative, *A. fumosus*.

On May 11, 1921, at Las Sabanas, Zetek and Molino found workers of *Anoplotermes* sp. in a nest of *Amitermes medius*. They were not very abundant and were congregated thickly in small, white-lined pockets. Possibly the workers are of this species, which is only known from winged adults. Winged adults, soldiers, and workers of *Eutermes exiguus* also occurred in this nest.

SWARMING

The winged adults of this species were collected around lights in houses in Panama City and Ancon, Canal Zone, on April 19, 1919, the former collection being made by Molino and the latter by Dietz. The time of collection was between 6 and 7.30 p. m. in both cases. It will be noted

¹⁴ Probably Corozal and nests of *Amitermes medius*.

that this swarming was simultaneous with that of *Nasutitermes cornigera* on the Pacific side of the Canal Zone and followed a heavy 12-hour rain six days after the beginning of the rainy season in this region. The significance of this early swarming in the case of species building all or parts of their nest in the ground is discussed under *Nasutitermes cornigera*. Earlier on the same afternoon (April 19) a large number of winged adults of *A. gracilis* were taken from the outer wall of a wasp's nest cut down from a royal palm tree in front of the Ancon Dispensary. The nest was inhabited by *Polybia occidentalis* Olivier.¹⁵

On May 3 and 4, 1921, Mr. Zetek collected winged adults of *Anoplotermes gracilis* as they flew into a dining room in Panama City. Mr. Zetek stated that these winged adults are termed "Palomitas de San Juan" by the natives; however, any flying termites which are dark in color are thus termed apparently since both *Nasutitermes cornigera* and *Coptotermes niger* have been so designated. These winged termites are a great nuisance, particularly in dwelling houses. In the Las Sabanas region it is necessary to leave the summer homes for the city because of the immense hordes of these insects, which not only prevent one from eating but also are a disturbance at night.

The winged adults emerge usually toward dusk, as a rule after the first one or two heavy rains of the rainy season. If the afternoon is cloudy, and especially if there is a light drizzle, they emerge as early as 2.30 p. m. They also fly about in the early morning hours.

Unfortunately these observations were based on two species of termites, since the winged adults of *A. gracilis* were in a minority. Most of the flying termites were winged adults of *Leucotermes convexinotatus*.

CONTROL

Different remedies and preventives must be instituted in case of damage by the two groups of termites—namely, those that are subterranean in habit, and those nonsubterranean, living in wood. Nearly all cases of damage to buildings by subterranean termites are due to careless or faulty construction.

SUBTERRANEAN TERMITES

The remedy for and prevention of subterranean termites of the family Termitidae are practically the same—namely, complete insulation or isolation of all untreated wood from the ground. Since subterranean termites always require access to damp earth, when the source of moisture is shut off the insects will not be able to extend their galleries further and will perish. If such termites already in the wood are shut off from the source of supply of moisture in the ground, they will soon perish, since they can not live without moisture. It is not necessary to do anything more, since the insects will die when the infested timbers are disconnected from the earth, and, furthermore, such infested timbers need not be removed or replaced unless seriously weakened structurally.

Where stone, brick, or concrete foundations are not used, all timbers in contact with the ground should be impregnated with coal-tar creosote.

Injury to living vegetation by wood-boring subterranean termites can be prevented by clean cultivation and proper horticultural management.

¹⁵ Determined by S. A. Rohwer, of the Bureau of Entomology, Washington, D. C. Since there were no termite runways on the tree (in fact, no workers have been discovered as yet in Panama, nor has this termite been found building runways such as are built by the members of the genus *Nasutitermes*), no reason for the association of the termite adults and wasps could be ascertained.

Injury is more common in the new soil of recently cleared woodland containing old decaying stumps, wood, or much leaf mold. It is not desirable to use animal manure where damage by termites is serious.

In the case of species of termites of this family which are not wood-boring but which are subterranean in habit and injure vegetation and build mounds in fields which it is desired to cultivate, their galleries should be fumigated with sulphur or arsenic or a combination of the two. There are several effective machines on the market which generate fumes of these poisons in a brazier and force them into the termite galleries by means of a pump. Another method is to fumigate by termitocid cartridges which generate volatile arsenical combinations that enter the galleries under great pressure. Termites can also be controlled by placing poisoned bait in their burrows or nests or by poisoning the soil with poisonous solutions or salts.

Much injury to living vegetation by either class of subterranean termites can be prevented by clean cultivation.

NONSUBTERRANEAN TERMITES

Termites that do not live in the earth—namely, such species as *Kalotermes*, *Neotermes*, and *Cryptotermes*, can not be combatted as can the subterranean species by shutting them off from their supply of moisture in the soil. They infest even dry wood directly through crevices, cracks, or decayed places and require little moisture. Of course their breeding places in decayed wood should be destroyed. Where these species are abundant, windows and doors in buildings should be screened, especially during the period of swarming or flight. In unscreened buildings the lights should be put out during the swarm. Since species in these genera swarm at night and are attracted to lights in large numbers, the winged adults can be caught by placing under the lights large shallow receptacles full of oil or water.

The unprotected woodwork of buildings should be impregnated with chemical wood preservatives. If a coating of the brown creosote or carbolineum is not suitable in the case of interior woodwork impregnation of the wood with a 6 per cent solution of zinc chlorid or a 1 per cent solution of bichlorid of mercury is recommended. A 2 per cent solution of sodium fluorid is effective, as is also impregnation with chlorinated naphthalene. The best method of treatment when using the soluble wood preservatives is by the "open tank."

Possibly the chlorinated naphthalene is the best treatment for furniture. Wood must be impregnated before it is made up into furniture if it is to be effectively protected; no known solution applied externally is satisfactory.

Much of the damage caused by white ants to furniture and interior woodwork in the Tropics is due to the improper construction of buildings. All wood in contact with the ground should be thoroughly impregnated with coal-tar creosote.

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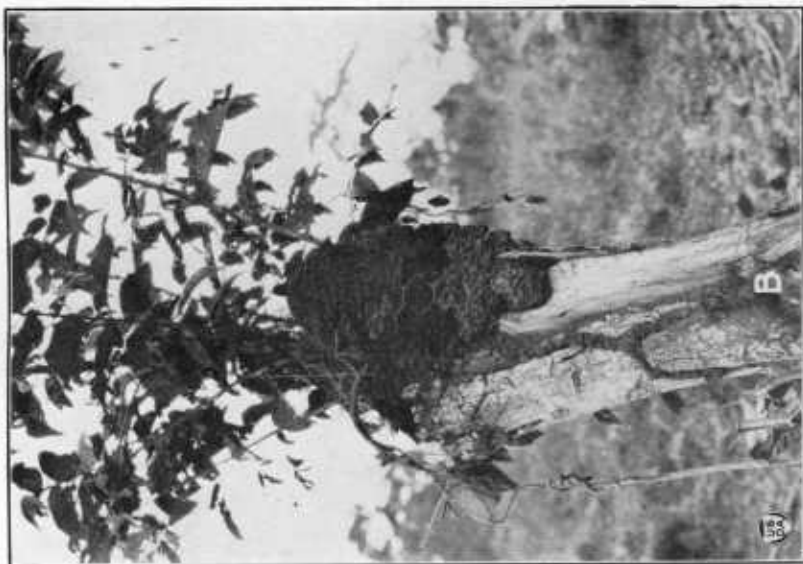
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PLATE I

Nasutitermes cornigera

A.—“Nigger-head” tree nest.

B.—“Nigger-head” tree nest.



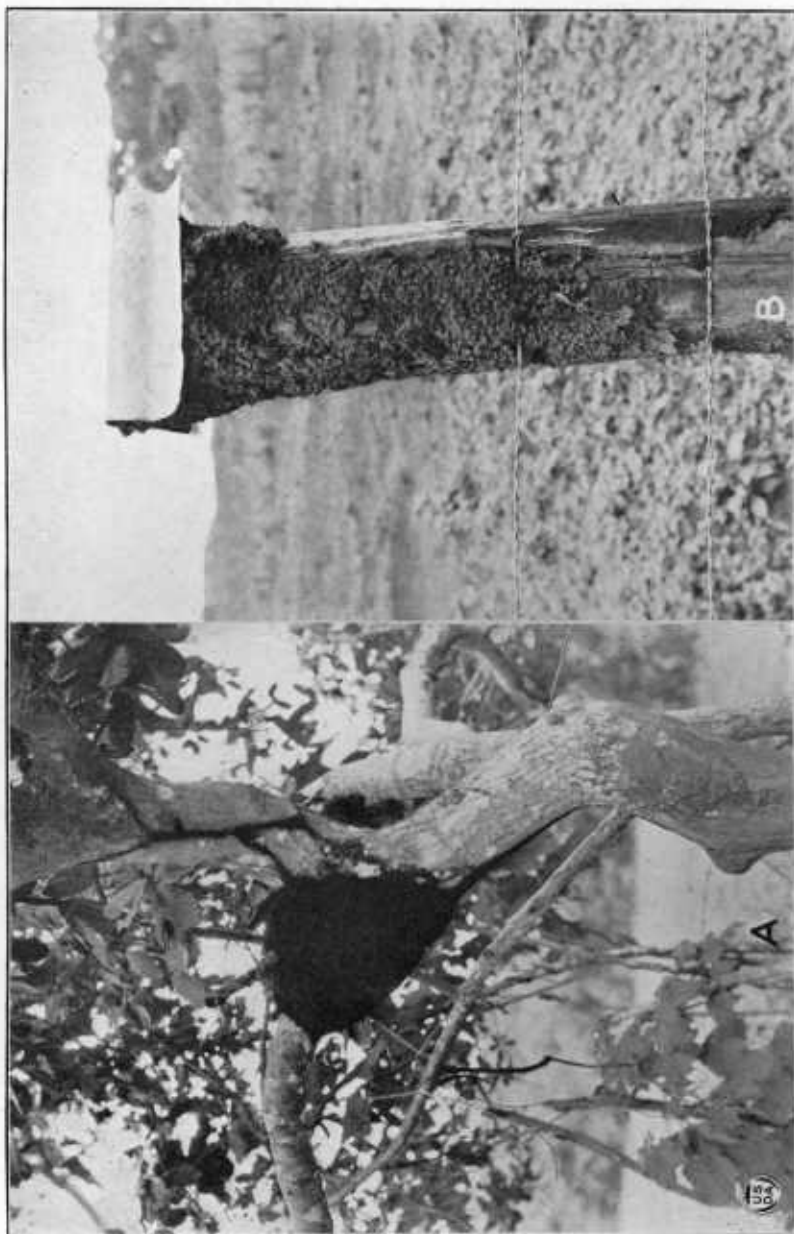


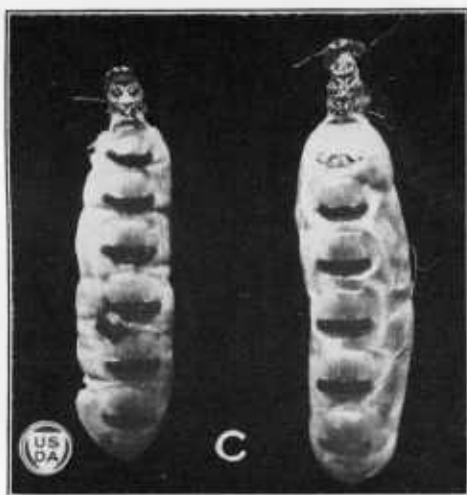
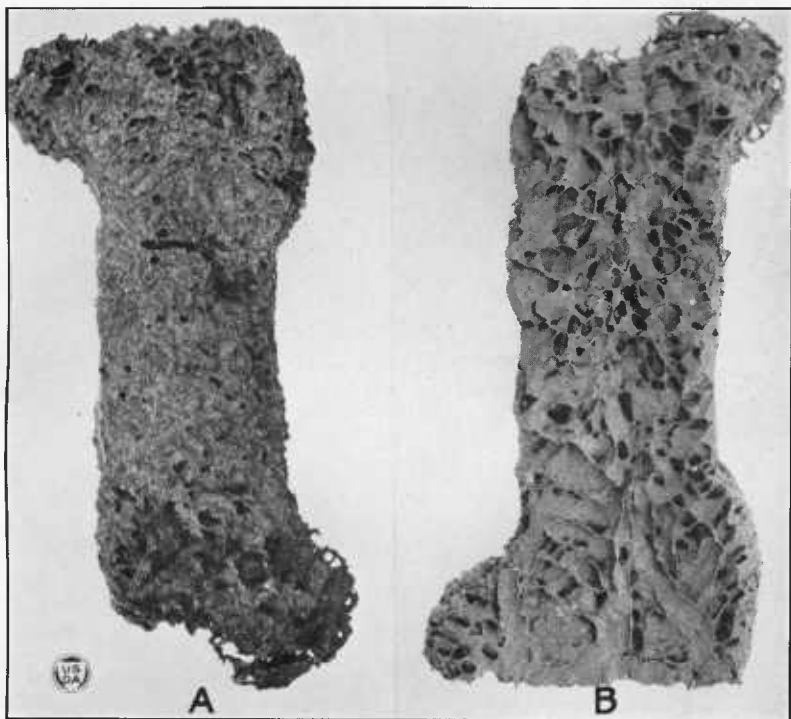
PLATE 2

A.—“Nigger-head” tree nest of *Nasutitermes cornigera*.

B.—Nest of *Nasutitermes guayanae* var. *columbicus*. Note the tin capping on the top of the post to prevent it from becoming water-soaked through rains. The termites have attacked the post from below and have made use of the capping as a protection against the rain.

PLATE 3

- A.—Top view of nest of *Nasutitermes ephratae* taken from a studding in building, Ancon, Canal Zone.
- B.—Bottom view of same nest, showing the structure.
- C.—First-form queens of *Nasutitermes cornigera*. Enlarged 2 X.



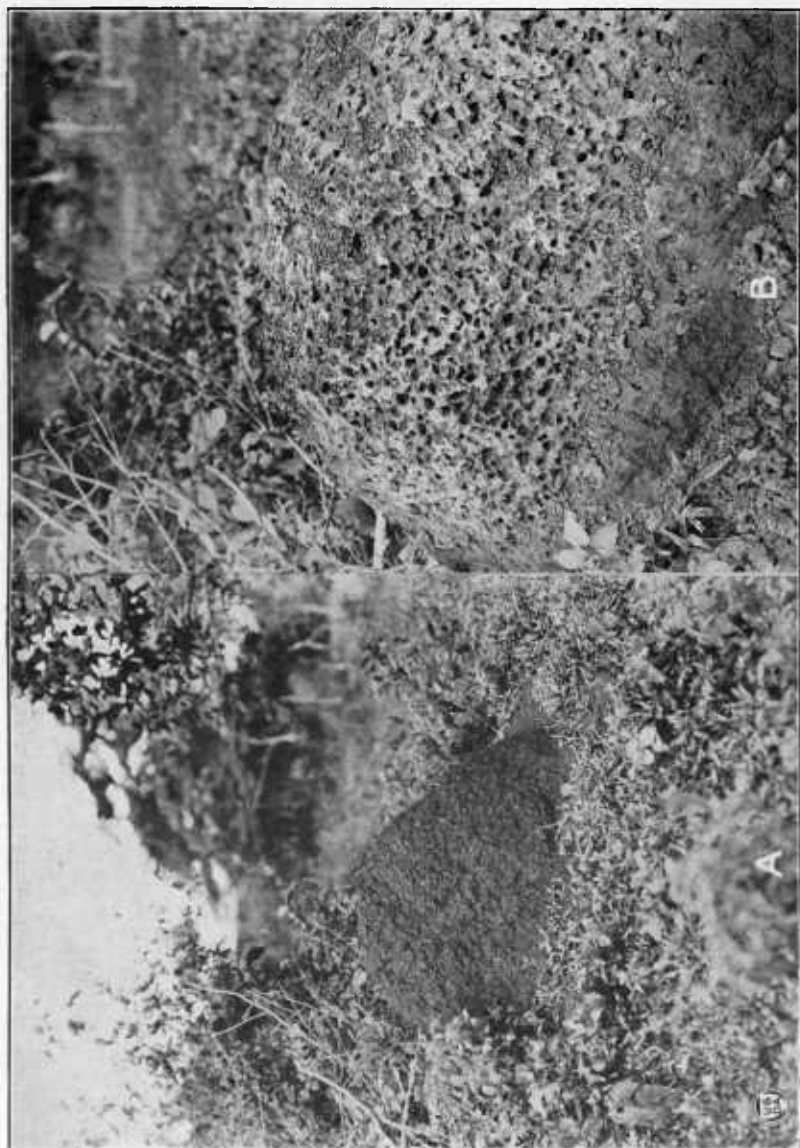


PLATE 4

Amitermes medius

A.—Exterior view of a nest.

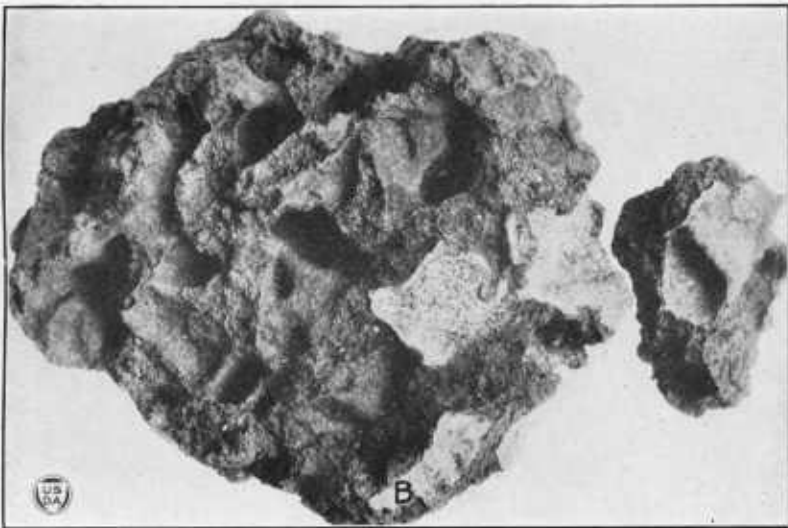
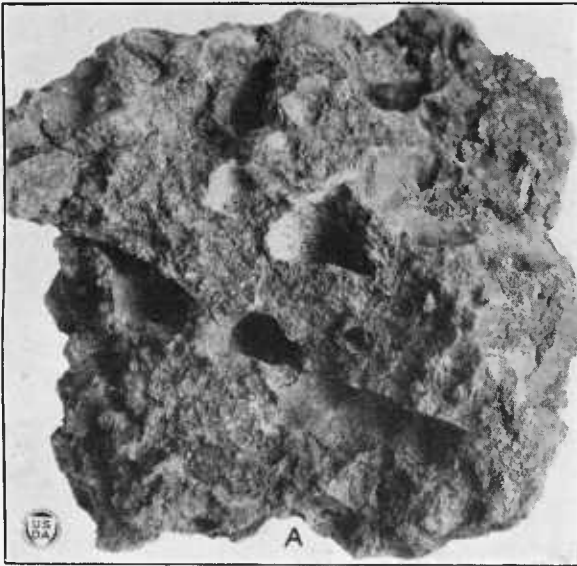
B.—Longitudinal section of nest, showing its interior structure.

PLATE 5

Amitermes medius

A.—Portion of mound nest showing galleries and cells. Las Sabanas, C. Z.

B.—Portion of the same nest showing galleries and cells. Note the galleries and cells lined with white in which the winged adults were always congregated.



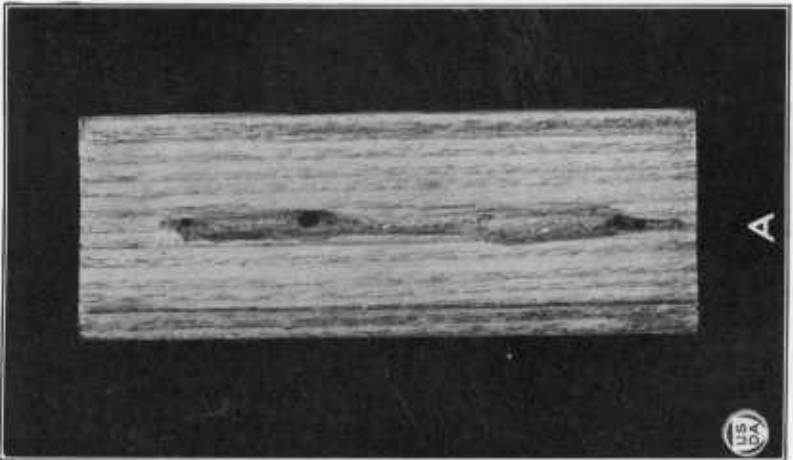
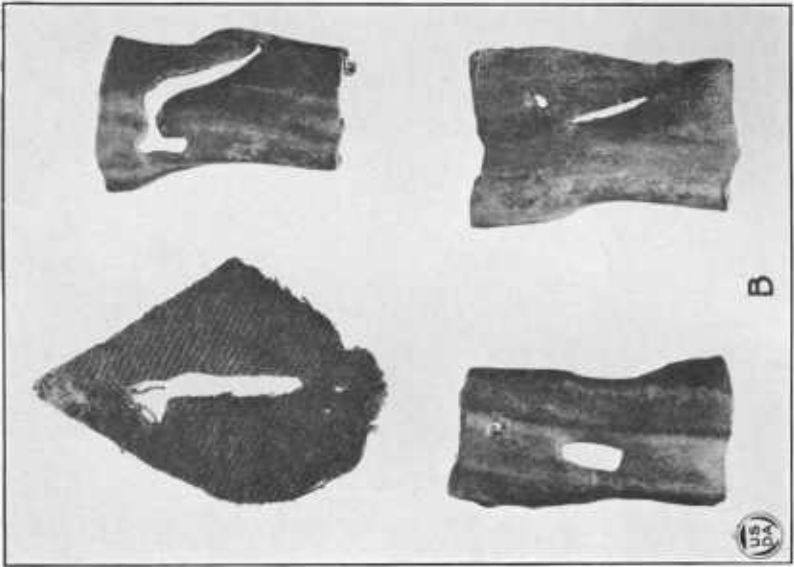


PLATE 6

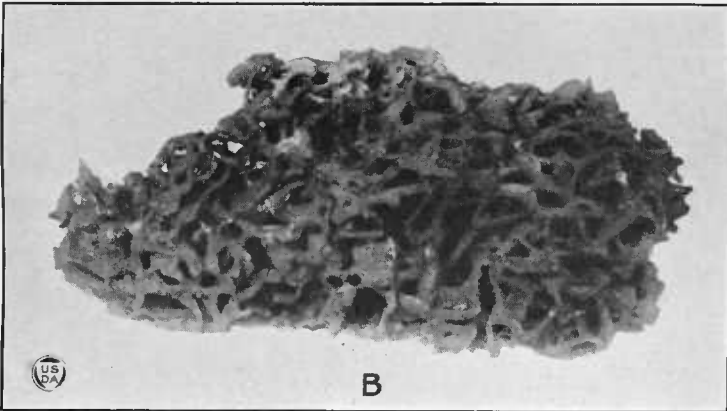
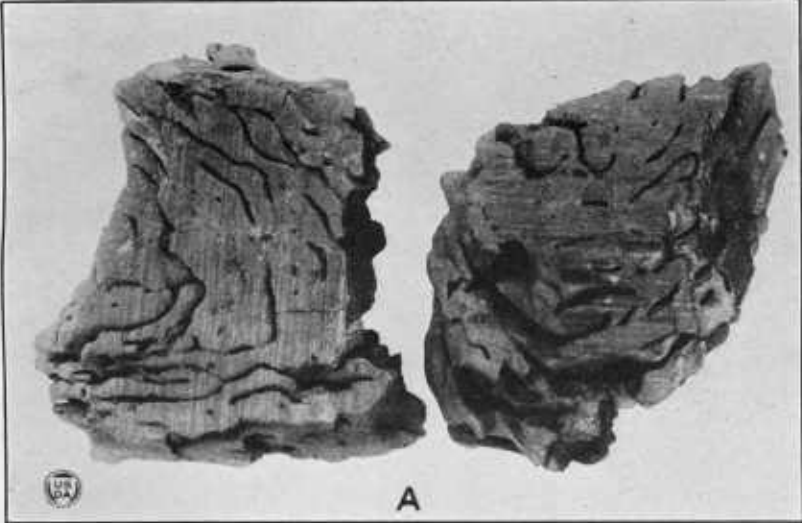
A.—Block of ash wood used by Dudley and Beaumont in studying *Kaloterms* in Panama; the best type of termitarium for studying *Kaloterms*.

B.—*Coptotermes niger*. Damage to lead sheathing of underground cable and perforations in tarred parcelling. Gold Hill, C. Z., Panama, October 29, 1916.

PLATE 7

A.—“Guayacan” (*lignum vitae*) entirely disintegrated by termites; all of the wood has been digested and excreted and then packed solid. From Balboa Shops, Canal Zone.

B.—Another section of the same species of wood showing structure built up of excreted wood by the termites. Note that it is a honeycombed instead of a compact mass as in A. *Lignum vitae* is one of the hardest woods known in the Tropics.



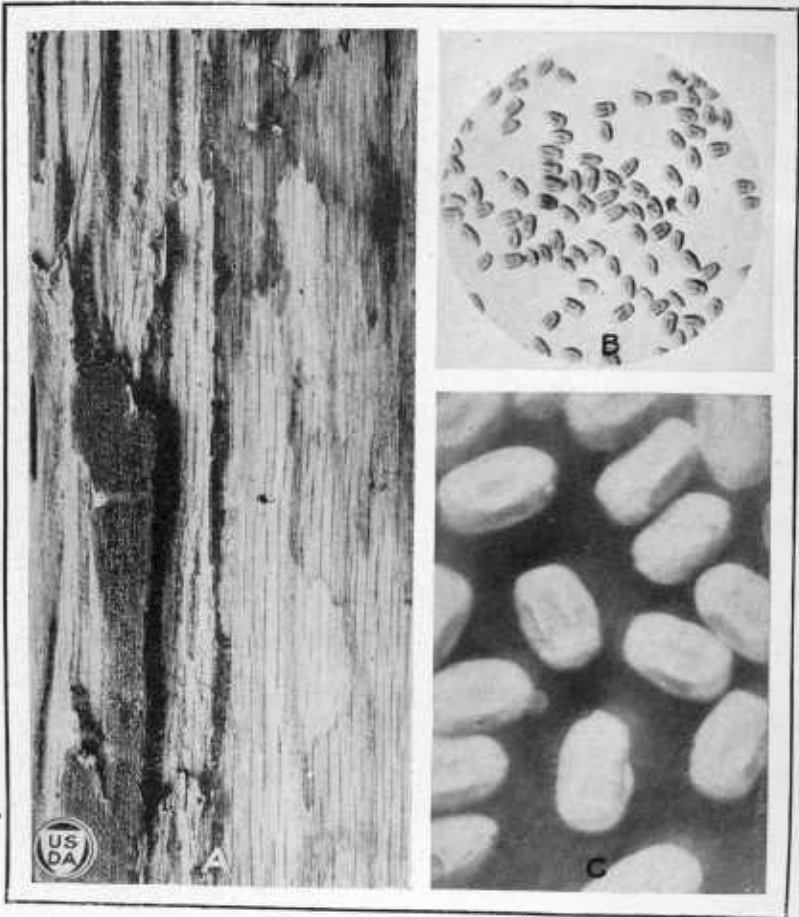


PLATE 8

Cryptoterme thompsonae

A.—Section of oak base of revolving bookcase damaged by *Cryptoterme thompsonae*, Ancon, C. Z.

B.—Pellets of excrement from this wood. Natural size of pellet 0.54 by 0.85 mm.

C.—Same as B. More highly magnified to show impressions.