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REPORT ON FRESH-WATER COPEPODA
FROM PANAMA, WITH DESCRIPTIONS
OF NEW SPECIES

(WITH FIVE PLATES)

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REPORT ON FRESH-WATER COPEPODA FROM PANAMA, WITH DESCRIPTIONS OF NEW SPECIES¹

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PLANKTON COLLECTIONS OF THE SMITHSONIAN BIOLOGICAL SURVEY OF THE PANAMA CANAL ZONE

These collections were made by Meek and Hildebrand, in connection with their work on fishes in the seasons of 1911 and 1912, by Goldman in 1912, and by Marsh who was present in Panama for four weeks in 1912 for the express purpose of making such collections. Most of the collections were made within the limits of the Canal Zone. A few collections were made in eastern Colombia, some on Rio Bayana and its tributaries, some on the Chagres and Trinidad outside the Zone and some in the neighborhood of Chorrera and of old Panama.

The general character of the country is not especially favorable to the growth of plankton organisms either in variety or numbers. There are no lakes in the Canal Zone and comparatively few permanent pools.

The continental divide is close to the southern shore of the isthmus. From the summit of the divide to high tide on the Pacific side is only about six miles. The slope consequently is very steep and whatever water falls runs away almost immediately. During the season when the collections were made there was practically no rain on this slope, so that it was difficult to find any fresh water. Consequently nearly all collections on the southern slope within the limits of the Canal Zone were made either in water which had been artificially impounded, or in the standing water in the deeper parts of streams that were otherwise dry.

The northern slope extends from the divide to the Atlantic, a distance, in a straight line, of something over thirty miles. Two considerable rivers come into the Canal Zone from this slope, the Rio Chagres and the Rio Trinidad. On the lower reaches of these

¹ The present paper is the nineteenth dealing with the results of the Smithsonian Biological Survey of the Panama Canal Zone.

ivers, and this is especially true of the Trinidad, are extensive swamps. The Chagres is a swift flowing stream, sometimes torrential in character, and does not furnish a suitable environment for any extensive development of plankton organisms. The swamps form a suitable environment for plankton, but, connected together as they are, would not lead one to expect any great variety.

The Gatun Lake will eventually be a large body of water with a surface of 164 square miles and a depth of 47 feet. At the time the collections were made, the lake was very small. Especially careful collections were made in this lake and in the neighboring waters and in sufficient numbers to give a good idea of its flora and fauna.

As has been stated before there are no natural lakes in the Canal Zone. The Canal Commission, however, has built, for sanitary purposes, a series of reservoirs and these, having been in existence for a considerable period, may be considered as lakes. Following is a list of these reservoirs with the dates of their construction. These dates are stated as given by Downes (Downes, 1910, 1). The depths given are the maximum depths at the time the collections were made.

	Built	Elevation	Depth
Cocoli	1909	36 feet	33 feet
Rio Grande	1906	240 "	50 "
Camacho	1907	370 "	45 "
Carabali	1906	76 "	10 "
Agua Clara	1910	68 "	30 "
Brazos Brook	1906	48 "	25 "

While the Rio Grande is considered as constructed in 1906, it is really an old French reservoir which was built sometime between 1882 and 1889 and has had a continuous existence since that time; it covers an area of 72.77 acres.

Besides these reservoirs there is the Mindi reservoir in the neighborhood of the Brazos Brook reservoir which was to be abandoned soon after the collections were made, and, at that time, no attempt was made to keep it in sanitary condition.

There is a reservoir at Toro Point but this, when visited, was found dry. These reservoirs were made by constructing dams in places where the waters of small streams could be impounded. The beds were cleared of vegetation except in the case of the Cocoli, and after construction, the shores were kept clear of vegetation to a distance of fifty or more feet from the margin. The condition of the waters in these reservoirs has been explained in detail by Downes (Downes, 1910). The reservoirs were all "plankton-poor." This is what

would be expected from their environment which produces permanent bottom stagnation. In cold climates the bottom waters of lakes have a more or less complete stagnation in summer and in winter, the stagnation being more complete in the smaller bodies of water in which winds have no opportunity to produce bottom currents, but in spring and in fall, because of the change in temperature, there is a complete overturning of the water. No such change, of course, takes place under the constant temperature conditions of the Canal Zone, so that only the surface waters contain the oxygen which is necessary for the life of the plankton organisms. This has led to a practical difficulty in the use of the waters for sanitary purposes, and it has been found necessary in some cases to so arrange the outflow pipes from the reservoirs that the water shall always be taken from near the surface and thus avoid the foul odors of the deeper waters. While the foregoing statement is true in regard to the general condition of the waters of the reservoirs, it must not be understood as meaning literally that the oxygen always diminishes in exact ratio to the depth. Local and meteorological causes may produce some modifications of the general statement. This has been discussed by Downes who gives a series of charts of dissolved oxygen (Downes, 1910, 9 and 10). Downes also treats of the general chemical character of the waters and of their bacterial content.

The present report deals only with the copepods, and, inasmuch as the collections will be put into the hands of other specialists to treat of the other organisms, it is not pertinent to this report to say much of the character of the plankton as a whole until after the more complete examination of the collections has been made. Attention, however, may be called to the fact that the plankton of the Isthmus not only lacks great variety of species, but also with few exceptions, lacks great numbers of individuals. Diatoms were perhaps as abundant as would be expected, and in some cases the number of individuals was enormous. The filamentous algæ were present, but not especially abundant. The desmids were present in some collections in phenomenal numbers. This was noticeably true of some species of *Micrasterias* and *Closterium*. One or two of the pond collections consisted largely of *Micrasterias*. The desmids were quite numerous in the Carabali reservoir, a reservoir which according to Downes has given much trouble. Downes states that *Anabæna* occurs in this reservoir but it was not noticed at the time these collections were made.

The Protozoa and Rotifera were present in comparatively small numbers.

The Cladocera and Ostracoda, too, were not numerous. The small numbers of Cladocera presented a striking contrast to similar collections made in the United States.

DESCRIPTION OF THE COPEPODA

PSEUDODIAPTOMUS CULEBRENSIS, new species

The cephalothorax is oval (pl. 1, fig. 1), the first segment being about one-third its total length, and the first two together considerably exceeding one-half the total length. The segments fit closely together with no overlap so that the dividing lines between the segments are not very distinct on the lateral margins. The dorsal surface of the fifth cephalothoracic segment is thickly beset with short hairs. The angles of the last cephalothoracic segment are rounded and armed with hairs.

The first and second segments of the female abdomen (pl. 1, fig. 2), are about equal in length, and the third is about one-half the length of the second. The furcal rami are long and slender and somewhat less in length than the combined length of the second and third segments. There is a row of hairs on the left lateral margin of the third segment and the inner margins of the furcæ are ciliate.

The abdomen of the male (pl. 1, fig. 4) is long and slender, all the segments being of approximately the same width, and the three preceding the last, armed on the posterior border with a row of small spines. The furcal rami are short, somewhat exceeding in length the last abdominal segment, and ciliate on the inner margin.

The antennæ are composed of 22 segments and somewhat exceed in length the cephalothorax. The part of the male right antenna beyond the geniculating joint (pl. 1, fig. 7) is composed of two segments. The form of the swimming feet is typical of *Pseudodiaptomus* (pl. 1, fig. 5).

In the female fifth feet (pl. 1, fig. 3) the endopodites are wanting. The distal margin of the second basal segment is armed on one side with a row of blunt spines and has a small lateral hair at almost one-third its length. The exopodite consists of two segments and a hook articulated to the second segment. Each segment of the exopodite is armed at its outer distal angle with a long and slender spine. The second segment has, in addition, on its inner distal margin, two spines, one short, the other two-thirds as long as the spine on the outer margin and ciliated. The terminal hook is slender and acute, about equal in length to the first segment of the exopodite: except for a sharp curve at its base it is straight. It bears on the inner margin of the base a short blunt spine.

In the fifth feet of the male (pl. 1, fig. 6) the first basal segments have a row of a few long acute spines on the posterior surface. The second basal segment of the right foot is much wider at the proximal margin than at the distal, due mainly to a curved projection on the inner margin. This curved projection is armed with long acute spines. On the posterior surface a cuticular ridge runs diagonally across the segment, and this is armed over its proximal third with a row of sharp spines. There are two stout hairs about midway of its posterior surface near the outer margin; opposite these hairs there are on the outer margin a few short hairs, and the distal angles have a few hairs.

The first segment of the exopodite is as wide as long. There is an acute spine at its outer distal angle, and a stout process on the dorsal surface near the distal end; this process is about one-half as long as the segment. Upon the middle of the posterior surface is a stout hair about as long as the process, and from the middle of the interior margin projects laterally a long hair. There are a few stout spines near the inner distal angle of the segment.

The second segment of the exopodite is somewhat shorter than the second basal segment and its outer margin is very nearly the arc of a circle. The lateral spine is situated a little distad of the middle of the outer margin, is straight, about as long as the first segment of the exopodite and denticulate on the margin. The terminal hook is sickle-shaped, about as long as the rest of the exopodite, has two short hairs near its proximal end and is denticulate on the inner margin.

There is no endopodite on the right foot.

The second basal segment of the left foot is about as long as broad, and extends somewhat beyond the middle of the corresponding segment of the right foot. Its inner margin is armed with long acute spines, and it has a hair on the posterior surface near the inner distal angle. The first segment of the exopodite is longer than wide, and approximately quadrangular in outline.

The second segment of the exopodite is about equal in length to the first, is curved, the outer margin being convex and the inner concave, and is armed with three blunt spines. The endopodite is composed of a single segment and is considerably longer than the first segment of the exopodite.

In all the specimens seen the right egg sac of the female was apparently atrophied. The left sac contains about eight eggs while there is no evidence of eggs in the right sac which is much smaller. A simi-

lar condition has been recorded by Dahl in regard to *Pseudodiaptomus richardi* Mrazek. He says (Dahl, 1894, p. 11): "Interessant ist die Art dadurch, dass sie als einzige mir bekannte Calanide zwei und zwar zwei ungleichliche Eiersäcke besitzt. Der linke Sack ist immer grösser und enthält 10-12 Eier, während man in rechten deren 4-5 findet."

Average length of female 1.22 mm. Length of male 0.883 mm.

The type specimens were collected by Messrs. Meek and Hildebrand in Rio Culebra, a branch of the Rio Chepo, in Panama, in brackish water.

The type of the genus, *Pseudodiaptomus pelagicus* was described by Herrick (Herrick, 1884) from material collected in Mississippi Sound in brackish water. Since that time ten other species have been described. Three, *P. acutus*, *P. gracilis* and *P. richardi*, were described by Dahl (Dahl, 1894) from material collected at the mouth of the Amazon. Two, *P. hessei* Mrazek (Mrazek, 1894) and *P. serricaudatus* Th. Scott (Scott, 1893), were in the mouth of the Congo. *P. salina* Giesbrecht (Giesbrecht, 1896) occurs in the Red Sea. *P. stuhlmanni* Poppe and Mrazek (Poppe and Mrazek, 1895) was found in the Quilimani River on the east coast of Africa. *P. lobipes* Gurney (Gurney, 1907), was found in tanks at Calcutta, *P. poppei* Stingelin (Stingelin, 1900) in the fresh waters of Celebes, and *P. forbesi* Poppe and Richard (Poppe and Richard, 1890), in Lake Sitai and river Whangpoo near Shanghai.

Thus of the eleven described species apparently four were found in fresh water, one in salt water, and the others in brackish waters.

P. culcbrensis is the first member of the genus to be described from the west coast of America, and is very distinct in its structure from the other species. Inasmuch as the genus is practically world wide in its distribution, it seems probable that further collections will bring to light many more species.

PSEUDODIAPATOMUS CRISTOBALENSIS, new species

The first segment of the cephalothorax exceeds one-third the total length of that part of the animal, and the first two somewhat exceed one-half the length. The last segment is terminated with a rather prominent acute spine on each side (pl. 2, fig. 5).

The abdomen of the male (pl. 2, fig. 1) is slender. The last segment is about one-half as long as the preceding. The furcal rami are about twice as long as the last abdominal segment and are ciliate on the interior margin.

The antennæ are composed of 21 segments, and about equal in length the cephalothorax. The part of the male right antenna beyond the geniculating point is composed of two segments.

In the fifth feet of the male the first basal segment of the right foot is short (pl. 2, fig. 3) as broad as long and has on its inner margin a few very short spines. In the second basal segment the length is to the breadth as four to three; it has a patch of rather short spines near its inner margin and a small lateral hair on the outer margin at about two-thirds its length. It has a row of spines in the distal margin of the anterior surface. The first segment of the exopodite is about as broad as long. The outer distal angle is prolonged into a dentate process. The inner margin is armed with two or three rows of stout spines and upon the posterior surface not far from the inner distal angle is a large spine. The second segment of the exopodite is about equal in length to the second basal segment. The outer margin is convex, while the inner is slightly concave. The distal end is about twice as broad as the proximal. The lateral spine is near the distal end, is straight, acute, and about as long as the first segment of the exopodite. Nearly opposite the lateral spine there is, on the inner margin, a short hair. The terminal hook is symmetrically curved, denticulate on the inner margin and somewhat shorter than the rest of the exopodite. It has two short spines near the proximal end. There is no endopodite on the right foot.

The second basal segment of the left foot (pl. 2, fig. 2) is not quite twice as long as broad, is quadrangular in general outline, and bears two small lateral spines a little beyond its middle. It has a row of spines on the distal margin on the anterior surface. The first segment of the exopodite is quadrangular, broader than long, and bears a stout spine at its outer distal angle. On the distal margin on the anterior surface is a row of spines. The second segment is twice as long as the first. About midway of its length it has a stout spine on the outer margin, and opposite this a small one on the inner margin. The distal margin is setose. At the inner distal angle is a stout serrate spine, and another similar spine near the inner margin at about three-fourths the length of the segment. The left endopodite is club-shaped, setose at tip, with two somewhat long setæ, and extends about one-third the length of the second segment of the exopodite. Length 0.1 mm.

The female of this species is unknown. In connection with the males two immature females were found. One certainly did not belong to this species. The other probably did, but was too immature to make a description possible.

The species is so clearly distinct from other species that it has seemed best to give the description in spite of the fact that the females are unknown.

Pseudodiaptomus cristobalensis was found in the collections made in the old French canal, in salt and brackish water, and has been given this specific name as it may be considered characteristic of the brackish water of the Atlantic side of the isthmus. It seems probable that further collections will bring to light at least one other species of this genus.

DIAPTOMUS GATUNENSIS, new species

A small species. The first cephalothoracic segment is about twice as long as the second. Each of the succeeding segments is slightly shorter than the one anterior to it. The last cephalothoracic segment is armed with an acute spine on each side (pl. 1, fig. 9), and has on the posterior border of each side about three small blunt spines. The general form of the cephalothorax is a narrow oval. The dorsal surface of the fifth cephalothoracic segment near its posterior border is thickly covered with minute spines. These spines are much more numerous in the female than in the male.

The first segment of the female abdomen (pl. 2, fig. 7) slightly exceeds the rest of the abdomen including the furca. It is dilated laterally, its greatest width being to its length as about three to four. It is armed on each side with an acute spine of moderate size. The second segment is less than half the length of the third. The furcal rami are somewhat shorter than the third abdominal segment and are ciliated on the inner margin.

The antennæ reach considerably beyond the end of the furca. The right male antenna is swollen anterior to the geniculating joint; the antepenultimate segment has a hyaline lamella extending its length and projecting from its distal end in a blunt point (pl. 2, fig. 10).

The spines of the first basal segments of the female fifth feet (pl. 1, fig. 8) are large and prominent. The lateral hair of the second basal segment is of usual size.

The first segment of the exopodite is about twice as long as wide. The second segment, with the hook, is nearly as long as the first segment, and bears a rather small spine on its outer distal angle. The inner margin of the hook is finely denticulate. The third segment is distinct and bears two slender spines, the inner of which is nearly twice as long as the outer. The endopodite is composed of a single segment, is about one-half as long as the first segment of the exopodite, and has inconspicuous setæ near the tip.

The spines of the first basal segments of the male fifth feet (pl. 2, fig. 4) are acute, with a prominent mammilliform base. The second basal segment of the right foot is somewhat longer than wide; the lateral hair is situated at four-fifths of its length. The first segment of the exopodite is ordinarily wider than long, and has a short cuticular ridge near its distal margin on the caudal aspect. The second segment exceeds in length the combined length of the first segment and the second basal segment, and is about twice as long as wide. About midway of its caudal surface there are three cuticular ridges. The lateral spine is situated near the distal end of the segment, is stout and straight, finely denticulate on the margin, and is somewhat shorter than the segment. The terminal hook is falciform, with a nearly symmetrical curvature, finely denticulate on the inner margin, and about equals in length the combined length of the rest of the exopodite and the second basal segment. The endopodite is triangular in form, not exceeding in length the first segment of the exopodite, and has a few short setæ near the tip of the inner margin.

The left fifth foot of the male extends a little beyond the distal margin of the first segment of the exopodite of the right foot. The second basal segment is about four-fifths the length of the corresponding segment of the right foot, is trapezoidal in shape, its distal margin being about two-thirds as long as the proximal; the lateral hair is situated at three-fourths its length. The first segment of the exopodite is about three-fourths the length of the second basal segment. It is curved, the convexity being exterior, and bears a setose pad on its inner surface. The terminal segment is nearly as wide as long, is armed at the end with two small papilliform processes, and has on the inner margin near the end a minute setose papilliform process. The endopodite is triangular, about as long as the first segment of the exopodite, and setose on the inner margin near the end.

Length of female 1.48 mm. Length of male 1.31 mm.

This was found in great numbers in a collection made in the Black Swamp near the old line of the Panama Railroad.

It occurred also in a pond at Bohio which had been there since the time of the French excavations.

DIAPTOMUS LEONINICOLLINUS, new species

A small species. The form and details of structure of the cephalothorax and abdomen are like *D. gatuncensis*. As in that species the antennæ extend beyond the furca, and the antepenultimate segment of the right antenna of the male has a hyaline lamella of the same form (pl. 2, fig. 8).

The fifth foot of the female (pl. 2, fig. 9) is like that of *D. gatunensis* except that the endopodite is more slender and longer, being two-thirds the length of the first segment of the exopodite.

The spines of the first basal segments of the fifth feet of the male (pl. 2, fig. 6) are acute on a prominent mammilliform base. The second basal segment of the right foot is longer than wide, and has a conical projection on its caudal surface. The lateral hair is situated at four-fifths of its length. The first segment of the exopodite is twice as long as wide, its distal angles are prolonged into blunt, rounded projections, and near the inner distal angle it has on the caudal surface a curved cuticular ridge. The second segment is considerably shorter than the combined length of the first segment and the second basal segment, is approximately oval in outline, its greatest width being about two-thirds its length. The lateral spine is situated near the end of the segment, is stout and straight, finely denticulate on the margin, and less than one-half the length of the segment. The terminal hook is falciform in its general shape, but with the tip recurved, is denticulate on the inner margin, and is considerably less in length than the combined length of the rest of the exopodite and the second basal segment. The endopodite is rudimentary, being a triangular projection armed with short setæ on the inner margin.

The left fifth foot of the male is like the corresponding foot in *D. gatunensis*.

Length of female 1.581 mm. Length of male 1.362 mm.

This was found in a collection made by Meek and Hildebrand near Lion Hill, C. Z.

It will be noticed that *D. leonicollinus* is somewhat larger than *D. gatunensis*. The principal distinctive points, however, are in the structure of the fifth feet. These differences in a genus like *Diaptomus*, which shows so little variation in specific characteristics, are amply sufficient for the establishment of the species.

DIAPTOMUS MARSHI Juday

1913. *Diaptomus marshi* JUDAY, p. 804, figs. 1 and 2.

A small species. The first cephalothoracic segment (pl. 3, fig. 5) is about as long as the combined length of the three following segments. The last cephalothoracic segment is armed on each side with two rather blunt spines.

The first segment of the female abdomen (pl. 3, fig. 4) considerably exceeds in length the rest of the abdomen including the furca; it is dilated in front and bears upon each side a small blunt spine. The

second abdominal segment is very short being only about one-fourth the length of the third.

The third segment and the furcal rami are about equal in length. The furcal rami are ciliated on the inner margin. The egg sac of the female has about 16 eggs.

The antennæ reach the end of the furca. The right antenna of the male is swollen anterior to the geniculating joint; the antepenultimate segment has no special armature.

The spines of the first basal segments of the fifth feet of the female (pl. 3, fig. 1) are stout and blunt.

The lateral hair of the second basal segment is small. The first segment of the exopodite is about three times as long as wide. The second segment, with the hook is about as long as the first. The inner margin of the hook is finely denticulate. The third segment is distinct and bears two spines, the inner being about twice as long as the outer. The endopodite is composed of a single segment in the Guatemala specimens, but in the Panama material it is indistinctly two-segmented; it is about two-thirds as long as the first segment of the exopodite and bears two spines near the tip.

The spines of the first basal segments of the male fifth feet (pl. 3, fig. 2) are of fair size and stout. The second basal segment of the right foot is longer than wide, with a blunt projection on its inner margin at about one-third its length. The lateral hair is small and situated near the distal end of the segment. The first segment of the exopodite is about two-thirds as long as wide, the outer margin being considerably longer than the inner; it has an arcuate cuticular ridge on the posterior surface near the distal end of the segment and, projecting from this, a stout, blunt spine: back of this is a second cuticular prominence of varying size. The second segment is about as long as the second basal segment and has an elongated oval outline. The lateral spine is situated at about the middle of the segment, is slightly curved, and about equals in length the combined lengths of the first and second segments of the exopodite; the inner margin of the spine bears five to seven blunt teeth. These teeth are seen more distinctly in the magnified figure (pl. 3, fig. 3). This dentate lateral spine is unique, not having been noted in any other species. The terminal hook is falciform with a symmetrical curvature, and in length about equals the rest of the foot exclusive of the first basal segment. The endopodite of the right foot is triangular, equalling in length the inner margin of the second basal segment and is setose at the tip.

The left fifth foot of the male reaches the second segment of the right exopodite. The second basal segment is about three-fourths the length of the corresponding segment of the right foot, is trapezoidal in form, and bears the small lateral hair near the distal end. The first segment of the exopodite is somewhat shorter than the first basal segment, and is much narrower at its distal end. It has a setose pad on the inner surface. The terminal segment is about two-thirds as long as the first and ends in a digitiform process. About midway of its length is a stout curved spine, and there is a setose pad on its inner margin.

The endopodite is composed of one segment and about equals in length the first segment of the exopodite.

Length of female 1.35 mm. Length of male 1.1575 mm.

This was first found in Guatemala by Juday, near Puerto Barrios and Los Amates, and was described by him in Trans. Wisconsin Acad., Vol. 17, Pt. 2, pp. 803-806.

Inasmuch as it is a new species of considerable interest in connection with the fauna of Panama, it has seemed best to describe it in some detail in this place, with figures which will show the characteristic features of the species.

In Panama it occurred in the Comacho reservoir and in Rio Trinidad.

CYCLOPS LEUCKARTI Claus

Cyclops leuckarti was found generally distributed in the Canal Zone, as would be expected, it being a cosmopolitan species.

It occurred in all the sanitary reservoirs and in most of the other fresh-water collections. The synonymy of this species has been discussed in a former publication (Marsh, 1910, 1081-85), and it is not necessary to enter upon that subject here. The Panama specimens agree very closely with the types found in other localities. Plate 3, fig. 6, shows the connecting membrane of the fourth feet; the two blunt spines are characteristic of this species and of *tenuis*. Judging from the figure of Schmeil (Schmeil, 1892, pl. 3, fig. 6) these spines are much more prominent in European specimens than in those from America. Plate 3, fig. 14, shows the labrum. In many of the Panama specimens it was noticed that the hyaline membrane of the sixteenth segment was minutely serrate (pl. 3, fig. 9). This was true also of some specimens collected near Havana, Cuba. This apparently has never been noted in individuals from other localities, except that it is figured, without remark, by Kokubo, 1912, from material collected in Japan.

CYCLOPS ALBIDUS Jurine

Cyclops albidus was found only in the collections made in the Black Swamp.

No significance is to be attached to this restricted distribution, as the species is found the world over; it simply means that it probably does not occur in any great abundance in the Canal Zone, at least at the time of year when the collections were made.

CYCLOPS SERRULATUS Fischer

Cyclops serrulatus occurred on the northern slope in the Comacho reservoir, in a pond at Bohio, in the Black Swamp, and in the Rio Trinidad and the water immediately connected with it. On the southern slope it was found at Miraflores and in stagnant water on the savannas near Panama.

CYCLOPS PRASINUS Fischer

Cyclops prasinus occurred in only a few localities. It was found in the Black Swamp, a region that is to be covered by Gatun Lake, in Gatun Lake, in a stream near the Alhajueta caves, and in a pond near Bohio.

CYCLOPS TENUIS Marsh

1910. *Cyclops tenuis* MARSH, p. 1085, pl. 75, figs. 4-9, pl. 79, fig. 5.

Cyclops tenuis was originally described from material collected at Calabasas, Arizona, and up to the present time has been found in no other locality. Its occurrence in the Canal Zone is therefore a matter of considerable interest. It belongs to the *leuckarti* group resembling that species in general form, armature of the fifth feet, and spinous armature of the membrane connecting the fourth feet, but differing in size, lack of armature of terminal segments of the antennæ and of crenulations on the maxillipede, and in the form of the fifth feet and of the receptaculum seminis.

It is very closely related to *C. oithonoides*, from which it distinctly differs in the fact that the antennæ are shorter and do not have a hyaline membrane on the terminal segments; the receptaculum seminis, too, is different from that in *C. oithonoides*.

The specimens from the Canal Zone correspond very closely with those from southern Arizona, but were much smaller. The average length of females from Gatun Lake was 0.683 mm., from the Trinidad River 0.66 mm., and from Agua Clara Reservoir 0.63 mm. Most of the egg-bearing females had four eggs in each sac; none have

been noticed with more than seven. There was considerable variation in the relative lengths of the terminal setæ of the furca.

Plate 3, fig. 12, shows the typical form from Calabasas in which the second seta from the outside is considerably longer than the fourth. In specimens from the savannas near Panama (pl. 3, fig. 11) the second and fourth are equal in length, while in others (pl. 3, fig. 10) from the Trinidad River, the fourth is very short. Schmeil considers the relative length of these setæ in *C. oithonoides* of specific importance, but this does not seem to be the case in *C. tenuis*. There does not seem to be anything in the relative length of the setæ that is characteristic of one slope of the isthmus as compared with the other, for specimens collected at Miraflores from the southern slope had the same relative length as those collected in the Trinidad River on the northern slope.

It will be noticed that the dorsal seta in the specimen figured from the savannas is abnormally long. This was not a uniform condition in the specimens from this locality, but was found in some individuals. There was a wide range of variation in this seta, a variation which was not distinctly correlated with local distribution.

Plate 3, fig. 7, shows the fifth foot of a specimen collected at Bohio. The inner spine of the terminal segment was not in all cases distinctly serrated. Plate 3, fig. 13, shows the connecting membrane of the fourth feet, and plate 3, fig. 8, shows the form of the receptaculum seminis.

Cyclops tenuis was found on the southern slope at Miraflores, Cocoli Reservoir, and on the savannas near Panama. On the northern slope it was found in a pond near Bohio, in Gatun Lake, Trinidad River, in a spring at Toro Point, and in the reservoirs on the northern slope, namely Comacho, Carabali, Mindi, and Agua Clara. It may be considered one of the most characteristic copepods of this region.

Cyclops oithonoides has been reported from Haiti, Richard '95, p. 1, and Paraguay, Daday, 1905, 142. Inasmuch as in neither of these cases have the details of the anatomy been given, it seems possible that the authors had *C. tenuis* rather than *C. oithonoides*.

CYCLOPS DENTATIMANUS, new species

A slender species. The last cephalothoracic segment is armed on each side with a stout ciliated seta.

The abdomen (pl. 4, fig. 10) is slender. The first segment is enlarged at the anterior end, and equals in length the two succeeding

segments and one-half the third. The second, third, and fourth segments are about equal in length.

The furcal rami (pl. 4, fig. 6) somewhat exceed in length the last cephalothoracic segment. The lateral setæ are situated at the distal third. The longer of the terminal setæ is nearly as long as the abdomen and furca.

The first antennæ (pl. 4, fig. 8) are short and composed of twelve segments.

The inner margin of the claw of the maxillipede is armed with five prominent teeth. These are shown in plate 4, fig. 9, and more clearly in the figure of the claw (pl. 4, fig. 12). The presence of these teeth is a unique feature and the specific name is given because of this structure.

The rami of the swimming feet are two-segmented. The spinous armature of the terminal segments of the exopodites is represented by the formula, 3, 4, 4, 3. Plate 4, fig. 7, shows the fourth foot, and plate 4, fig. 5, the terminal segment of the endopodite of the first foot. The connecting membrane between the fourth feet is armed with two rows of fine spines.

The fifth feet (pl. 4, fig. 11) are one-segmented. This segment is elongated, its length being about three times its width. It is armed at the distal end with a minute spine and a seta, which is a little more than twice as long as the segment.

Cyclops dentatimanus was found on the savannas between Panama and Old Panama in a stagnant stream in which were large numbers of *C. æquoreus* and *C. panamensis*. In the collection a glance was sufficient to show its specific distinction from *C. panamensis* because of its larger size and short antennæ. Only a few individuals were found of this species. Two of them were mature females. As they were dissected before measurements were taken, on the assumption that a larger number would be found, the description is incomplete as far as the morphology of the cephalothorax is concerned. The species, in its general structure is almost identical with *Cyclops anceps* Richard (Richard, 1897), which was found in Brazil. The receptaculum seminis, however, is of a different form, and Richard does not mention the peculiar structure of the maxillipede, which was so noticeable in *C. dentatimanus*. It is highly improbable that such a structure would have escaped the notice of so skilled and experienced an investigator as Richard. Daday (Daday, 1902b, 443), who afterwards identified *C. anceps* in material from Chili, does not mention any unusual form of the maxillipede. Later he records

C. anceps from Paraguay (Daday, 1905, 133-134) and from the East Indies (Daday, 1906, 181). In regard to the Paraguay material he says (Daday, 1905, 134): "am unteren Maxillarfuss ist die sichelförmige Krallen des vorletzten Gliedes sehr kräftig, nahe zur Basis mit kurzen Zähnchen bewehrt." His figure, however, shows nothing to compare with the teeth in *C. dentatimanus*, and we may assume that he refers to the minute teeth which are found on this segment in other species of Cyclops.

CYCLOPS PANAMENSIS, new species

A slender, graceful species. The cephalothorax is oval, its length comparing with its breadth as about 9 to 5. The length of the abdomen exclusive of the furcal rami about equals the breadth of the cephalothorax. The last cephalothoracic segment is armed on each side with a prominent seta, and the margins have minute spines.

The abdomen (pl. 4, fig. 1) is slender. The first segment is enlarged at its anterior end, and somewhat exceeds in length the two succeeding segments. The remaining segments of the abdomen equal each other in length.

The furcal rami are slender and are nearly equal to the combined length of the two preceding segments. The lateral setæ are situated at the distal third of the furcæ. Of the four terminal setæ, the outer and inner are weak and short, the inner being considerably shorter and smaller than the outer. The longest of the terminal setæ about equals in length the combined length of the last three abdominal segments and the furcæ.

The first antennæ (pl. 4, fig. 3) are composed of eleven segments and reach to about half the length of the second cephalothoracic segment. The segments have the customary armature of setæ but have no distinctive structures.

The rami of the swimming feet are two-segmented. The spinous armature of the terminal segments of the exopodites is represented by the formula 3, 4, 4, 3. The first segments of the rami are armed on the distal border by a row of minute spines. The membrane connecting the feet of the fourth pair is armed on each side with three blunt spines. Plate 4, fig. 4, shows the fourth feet.

The fifth feet (pl. 4, fig. 2) are one-segmented. This segment is short and broad, its length only slightly exceeding its width. The inner distal angle is prolonged into a fine needle-like spine; this is apparently a part of the segment, and is not separated by a joint. At

the outer distal angle it bears a stout seta which is of about the same length as the seta upon the last cephalothoracic segment.

The egg sacs contain from seven to ten eggs each.

The average length of the mature females is 0.696 mm.

Found on the savannas between Panama and Old Panama.

CYCLOPS VARICANS Sars

The occurrence of *Cyclops varicans* in America has been discussed in a former paper (Marsh, 1910, 1101). While there was good reason to suppose that this species, of world-wide distribution, belonged also to the fauna of North America, in the absence of figures and descriptions there was still some doubt. Daday has reported it in Patagonia (1902a, p. 208) and Paraguay (1905, p. 135), while van Douwe (1912, 315) has reported it in Brazil. Only a few individuals were found in the Panama collections and these in only one locality, the Black Swamp, along the old line of the Panama Railroad. These individuals were mature, however, and corresponded in all details to the typical forms. The first antennæ are short and composed of twelve segments (pl. 5, fig. 4).

The swimming feet are two-segmented, the formula for the spines of the terminal segments being, 3, 4, 4, 3. Plate 4, fig. 13, shows the third foot.

The last cephalothoracic segment is armed on each side with a long seta. The fifth foot consists of a single long slender segment terminated with a seta (pl. 5, fig. 5).

The female carries about twelve eggs in each sac.

Plate 5, fig. 1, shows the form of the abdomen.

CYCLOPS QUINQUEPARTITUS, new species

This interesting species occurred only in collections made in the Black Swamp along the line of the Panama Railroad. Only a few individuals were found. It was at first supposed to be *Cyclops phaleratus*. Careful examination showed that it corresponded in structure to *C. phaleratus* in all particulars except that the first antennæ are composed of only five segments.

No egg-bearing females were found, but they were apparently mature, the swimming feet being fully developed and the general appearance of the animal indicating maturity. No detailed description is necessary as it corresponds to *C. phaleratus* in all particulars except the segmentation of the first antennæ. It is somewhat smaller than *phaleratus*.

In plate 5, figs. 3, 2, and 7, are given drawings of the first and second antennæ and of the fourth swimming feet.

Van Douwe, 1912, 315, reports *Cyclops phaleratus* from Brazil, but states that the forms, although mature, had antennæ of seven segments. It seems possible that further study of South American and Central American material may result in the establishment of a group of *Cyclops* species closely related to *Cyclops phaleratus*.

CYCLOPS ÆQUOREUS Fischer

The literature and synonymy of *Cyclops æquoreus* have been given in a former paper (Marsh, 1910, 1106). The species is very widely distributed, being found as far north as Finland (Martens, 1910, 110), and as far south as Algeria (Blanchard and Richard, 1891, p. 515). It has been found in Madeira and in the Sea of Aral. Thus far there have been only two recorded localities in America. Herrick found it in waters connected with the Gulf of Mexico (Herrick and Turner, 1895, 122), in Mississippi Sound, and Mr. E. Foster has collected it in Lake Ponchartrain. Considerable interest, therefore, attaches to its occurrence in Panama. It occurred in a sluggish stream on the savannas near Panama and in an old well in Old Panama. In both cases the water was fresh, but it might have easily migrated to those locations from brackish water. Inasmuch as figures of the species as occurring in America have not been published, it has been deemed best to illustrate the typical peculiarities of the species. Plate 5, fig. 8 shows the antenna of the female, plate 5, fig. 6, the abdomen and fifth foot, and plate 5, fig. 9, the fourth swimming feet.

The formula for the spines of the terminal segment of the exopodites of the swimming feet is 3, 4, 4, 3.

GENERAL OBSERVATIONS ON THE DISTRIBUTION OF THE COPEPODA FOUND IN PANAMA

The presence of *Cyclops albidus*, *Cyclops leuckarti*, *Cyclops ser-rulatus*, and *Cyclops prasinus* has no significance from the standpoint of the distribution of species. These species are cosmopolitan, and one would expect to find them in Panama. A new locality for a species has some interest, of course, but in these cases it only corroborates what we had known before of the world-wide distribution of these forms.

More interest attaches to *Cyclops varicans*, for, if this occurs in the United States, it certainly is uncommon, while apparently it is characteristic of the fauna of South America. The same may possibly be true of *Cyclops tenuis*. In the discussion of this species it is remarked that *Cyclops oithonoides* has been reported from

South America and from Haiti, and it is suggested that this may have been *C. tenuis*. In that case we should consider *C. tenuis* as a South American form with a northern limit of southern Arizona.

Cyclops dentatimanus and *C. panamensis* are South American in their general relationships.

Cyclops æquoreus is distributed widely, but has never before been reported from the west coast of America. It seems rather strange that it did not appear in the collections from the east coast, but those collections were few in number, and it is probable that further work will show that it is found there also.

The genus *Pseudodiaptomus* has been found in Europe, Asia, Africa, and North and South America. Both the species from the Pacific coast and that from the Atlantic coast are closely related to South American forms, that from the Atlantic coast being very close to one found in the mouth of the Amazon.

The three species of *Diaptomus*, too, find their nearest relatives in South America.

It is evident then, that the general character of the copepod fauna of the Canal Zone is much more closely related to the South American fauna than to that of North America. When we compare the north and south sides of the isthmus we find common to the two slopes *Cyclops leuckarti*, *C. tenuis*, and *C. serrulatus*. *C. æquoreus* we know is not peculiar to the Pacific slope. *C. albidus*, *C. prasinus*, *C. varicans*, *C. quinquepartitus*, *Diaptomus marshi*, *D. leoninicolinus*, *D. gatunensis*, and *Pseudodiaptomus cristobalensis* are found on the Atlantic side but not on the Pacific.

Peculiar to the Pacific slope are *Cyclops dentatimanus*, *C. panamensis*, and *Pseudodiaptomus culcubrensis*. It will be noted that no species of *Diaptomus* are recorded from the Pacific slope. It does not follow, however, that none are present. Some immature specimens and one mature female were found, but no males, so that no diagnosis of species could be made. We certainly cannot consider *Cyclops varicans* as peculiar to the Atlantic side, for it is a South American species. In fact there is a reasonable doubt whether any of the species of *Cyclops* found on the northern slope are peculiar to that locality. Probably the three species of *Diaptomus* found on the northern side may be considered characteristic of that slope. So, probably the two new species of *Cyclops* found on the south side, *C. dentatimanus* and *C. panamensis* are peculiar to that slope. The species of the brackish water genus *Pseudodiaptomus*, too, are peculiar, that on the south shore differing from that on the north shore, but both are closely related to South American species.

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PLATE I.

- FIG. 1.—*Pseudodiptomus culbrensis*, cephalothorax $\times 110$.
FIG. 2.—*Pseudodiptomus culbrensis* ventral surface of abdomen of female
 $\times 153$.
FIG. 3.—*Pseudodiptomus culbrensis*, fifth feet of female $\times 223$.
FIG. 4.—*Pseudodiptomus culbrensis*, abdomen of male $\times 153$.
FIG. 5.—*Pseudodiptomus culbrensis*, fourth foot $\times 223$.
FIG. 6.—*Pseudodiptomus culbrensis*, fifth feet of male $\times 438$.
FIG. 7.—*Pseudodiptomus culbrensis*, terminal segments of right antenna of
male $\times 438$.
FIG. 8.—*Diptomus gatunensis*, fifth foot of female $\times 213$.
FIG. 9.—*Diptomus gatunensis*, one side of last cephalothoracic segment $\times 213$.

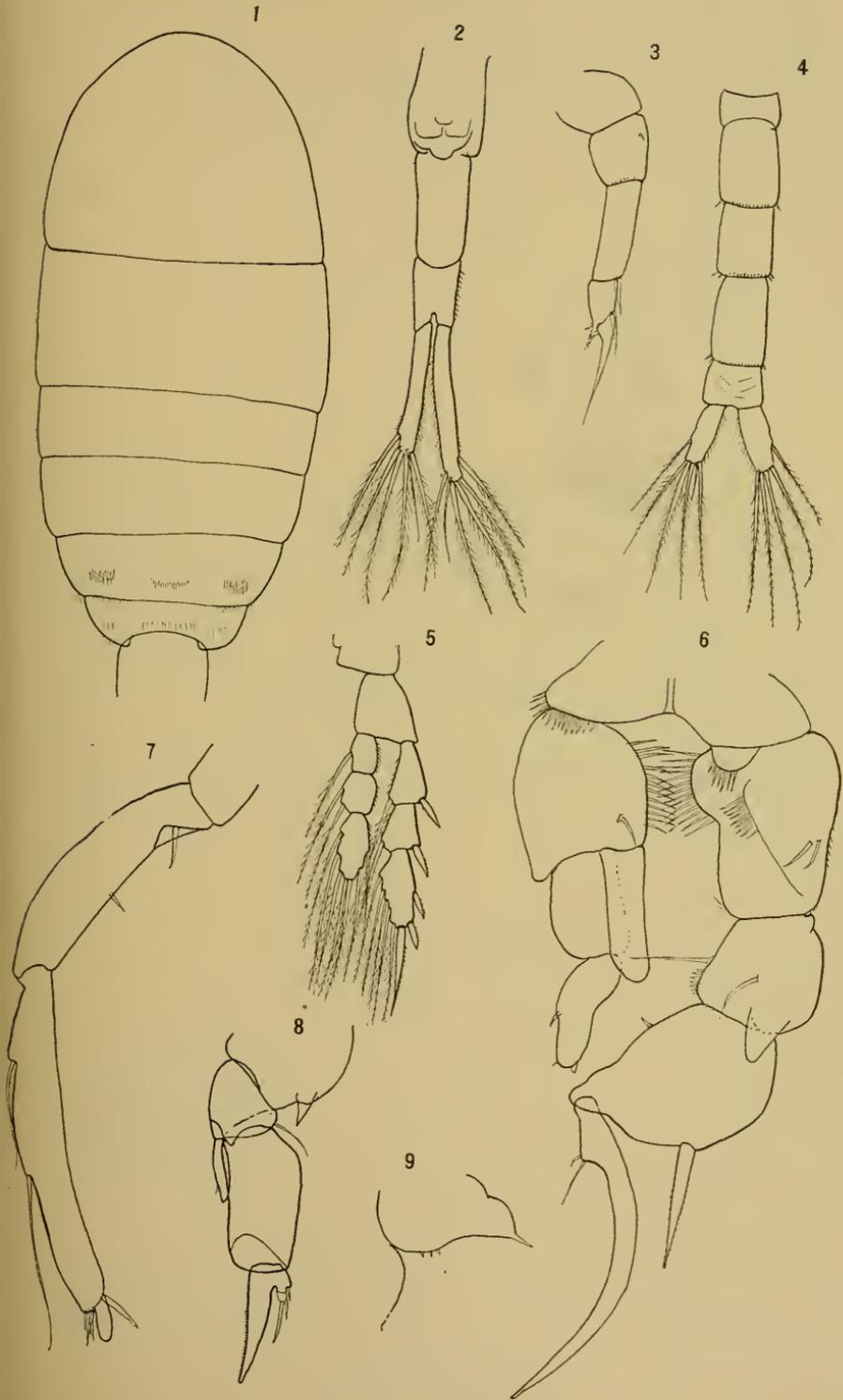
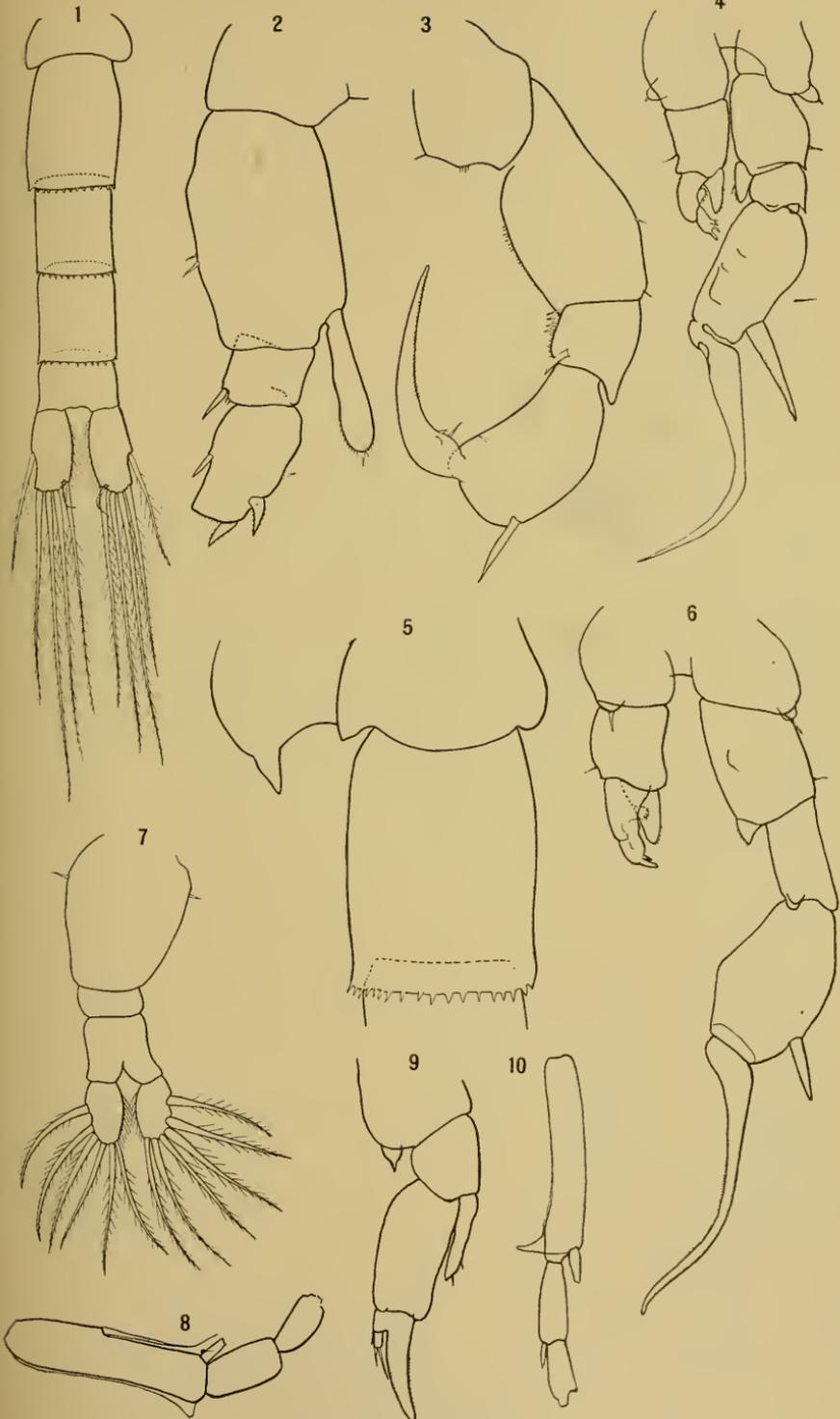


PLATE 2

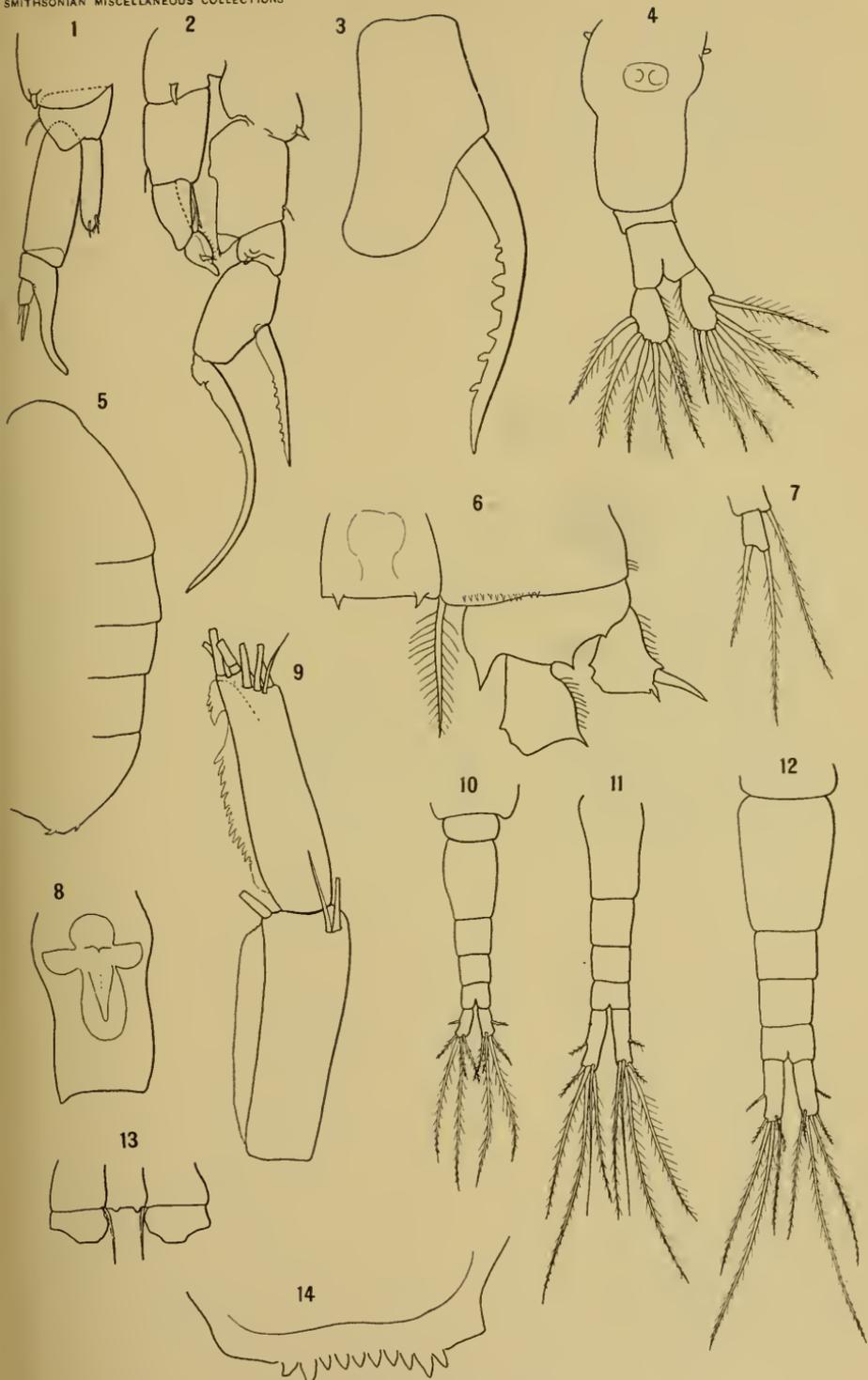
- FIG. 1.—*Pseudodiaptomus cristobalensis*, abdomen of male $\times 223$.
FIG. 2.—*Pseudodiaptomus cristobalensis*, left fifth foot of male $\times 438$.
FIG. 3.—*Pseudodiaptomus cristobalensis*, right fifth foot of male $\times 438$.
FIG. 4.—*Diaptomus gatunensis*, fifth feet of male $\times 223$.
FIG. 5.—*Pseudodiaptomus cristobalensis*, one side of last cephalothoracic segment of male $\times 438$.
FIG. 6.—*Diaptomus leoninicollinus*, fifth feet of male $\times 223$.
FIG. 7.—*Diaptomus gatunensis*, abdomen of female $\times 110$.
FIG. 8.—*Diaptomus leoninicollinus*, terminal segments of right antenna of male $\times 223$.
FIG. 9.—*Diaptomus leoninicollinus*, fifth foot of female $\times 223$.
FIG. 10.—*Diaptomus gatunensis*, terminal segments of right antenna of male $\times 223$.



COPEPODA FROM PANAMA

PLATE 3

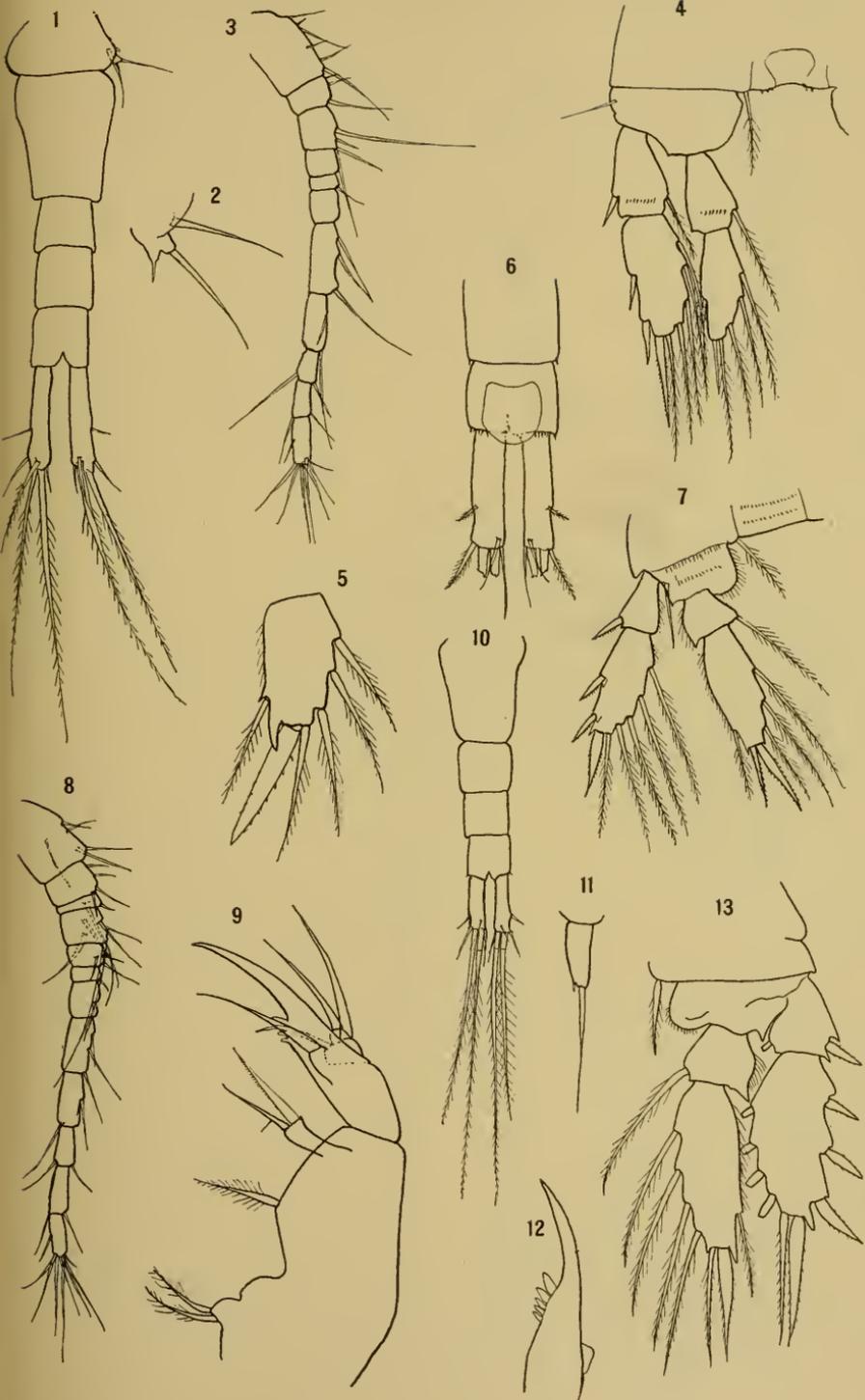
- FIG. 1.—*Diaptomus marshi*, fifth foot of female $\times 223$.
FIG. 2.—*Diaptomus marshi*, fifth feet of male $\times 223$.
FIG. 3.—*Diaptomus marshi*, second segment of right fifth foot of male $\times 438$.
FIG. 4.—*Diaptomus marshi*, abdomen of female $\times 110$.
FIG. 5.—*Diaptomus marshi*, profile of cephalothorax of female $\times 223$.
FIG. 6.—*Cyclops leuckarti*, basal segments and connecting membrane of fourth feet of female $\times 223$.
FIG. 7.—*Cyclops tenuis*, fifth foot $\times 438$.
FIG. 8.—*Cyclops tenuis*, receptaculum seminis $\times 223$.
FIG. 9.—*Cyclops leuckarti*, terminal segments of antenna of female $\times 438$.
FIG. 10.—*Cyclops tenuis*, abdomen of female from Rio Trinidad $\times 60$.
FIG. 11.—*Cyclops tenuis*, abdomen of female from savannas near Panama $\times 110$.
FIG. 12.—*Cyclops tenuis*, abdomen of female from Calabasas Ar.
FIG. 13.—*Cyclops tenuis*, basal segments and connecting membrane of fourth feet of female $\times 223$.
FIG. 14.—*Cyclops leuckarti*, labrum $\times 438$.



COPEPODA FROM PANAMA

PLATE 4

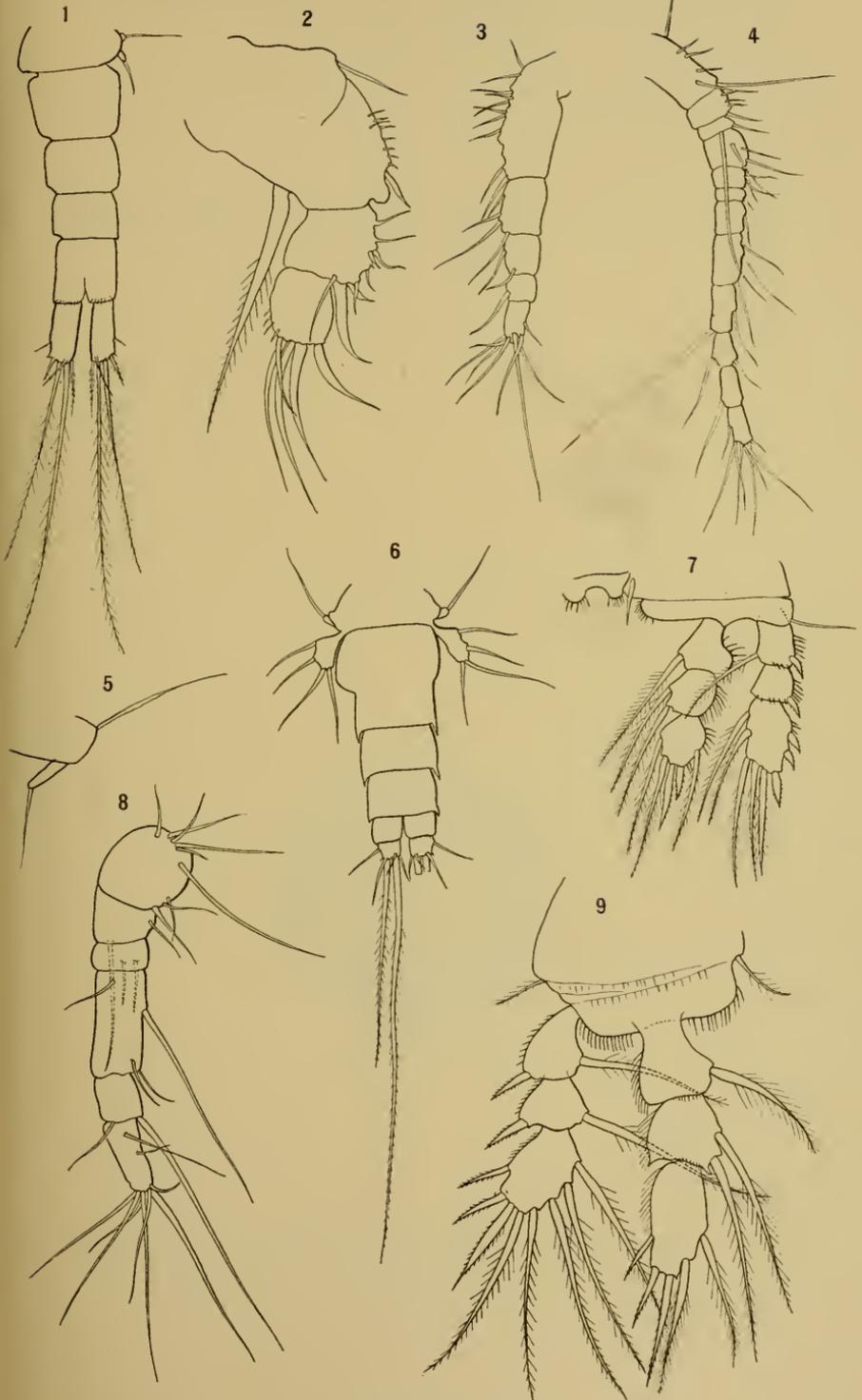
- FIG. 1.—*Cyclops panamensis*, abdomen of female $\times 223$.
FIG. 2.—*Cyclops panamensis*, fifth foot of female $\times 438$.
FIG. 3.—*Cyclops panamensis*, first antenna of female $\times 223$.
FIG. 4.—*Cyclops panamensis*, fourth foot of female $\times 438$.
FIG. 5.—*Cyclops dentatimanus*, terminal segment of endopodite of first foot $\times 438$.
FIG. 6.—*Cyclops dentatimanus*, terminal segments of abdomen and furca of female $\times 223$.
FIG. 7.—*Cyclops dentatimanus*, fourth foot $\times 223$.
FIG. 8.—*Cyclops dentatimanus*, first antenna of female $\times 223$.
FIG. 9.—*Cyclops dentatimanus*, maxillipede $\times 438$.
FIG. 10.—*Cyclops dentatimanus*, abdomen of female $\times 60$.
FIG. 11.—*Cyclops dentatimanus*, fifth foot $\times 438$.
FIG. 12.—*Cyclops dentatimanus*, claw of maxillipede $\times 438$.
FIG. 13.—*Cyclops varicans*, third foot $\times 438$.



COPEPODA FROM PANAMA

PLATE 5

- FIG. 1.—*Cyclops varicans*, abdomen of female $\times 223$.
FIG. 2.—*Cyclops quinquepartitus*, second antenna $\times 438$.
FIG. 3.—*Cyclops quinquepartitus*, first antenna $\times 223$.
FIG. 4.—*Cyclops varicans*, first antenna $\times 223$.
FIG. 5.—*Cyclops varicans*, fifth foot $\times 438$.
FIG. 6.—*Cyclops aquoreus*, abdomen of female with fifth feet $\times 223$.
FIG. 7.—*Cyclops quinquepartitus*, fourth foot $\times 223$.
FIG. 8.—*Cyclops aquoreus*, first antenna of female $\times 438$.
FIG. 9.—*Cyclops aquoreus*, fourth foot $\times 438$.



COPEPODA FROM PANAMA