

Plate 41. *Procamburus vazquezae* (Villalobos). Male, Form I.

1, caudal view of first pair of pleopods; 2, mesial view; 3, lateral view; 4, caudolateral view of the apical part of the pleopod; 5, mesial view of the same; 6, *annulus ventralis*; 7, mesial view of the apical part of the first pleopod of the male, Form II.

form II, develop very slowly; consequently, they are also very small in the young (Plate 40, fig. 9), hardly visible as a small tubercle adjacent to the proximal excavation. The first pair of pleopods are slender and slightly shorter than in the male, form I; the shoulder is well developed; the mesial process is flattened and slightly inclined over the apical surface; the central projection is barely evident in the form of a mammiform tubercle, split by a groove which begins on the basal portion of the mesial process (Plate 41, fig. 7).

Female. In general, the size of the females slightly exceeds that of the males. Many female specimens collected during the month of May carried eggs; these are large and few in number, averaging ten to twelve for each individual; the diameter of the eggs is 1.5 mm. The carapace exhibits punctations over all of its surface, those of the dorsal region
190 broadly dispersed; the punctations of the dorsolateral regions of the cephalic portion are larger and less well marked. The areola is narrow, but wider than in the males. The postorbital ridges are slightly convergent and terminate in a conical, sharp spine. The rostrum is broad and sharp; the acuminial spine slightly overreaches the distal articulation of the second antennular article; the rostral margins are almost parallel and terminate anteriorly in a tubercle with a blunt point; the rostral surface is distinctly grooved and slightly pubescent.

The epistome is triangular, similar to that of the male, form I (Plate 40, fig. 4).

The distal half of the external border of the antennal scale is slightly concave; the spine is sharp and straight, and reaches the distal articular border of the third antennular article.

The chela of the first pair of pereopods is broader and its fingers are shorter than in the male, form I; the surface of the palm is very densely covered with subsquamous tubercles, each with setae on the anterior border, which recline on the surface of the chela. The tubercles that are found on the proximal internal border of the dactylopodite are more numerous than in the male. The cutting border of the fingers exhibits dentiform tubercles along their entire length, but they are more numerous and consequently closer together than in the adult male.

The *annular ventralis* is tuberculiform, movable, circular in section near the apex, and with a circular depression in the apical region at the center of which there is a very shallow groove; but the true groove is located in the caudal region of the *annulus*, having the form of a C, at times reversed, and the borders that limit it are very elevated. Between the fifth pereopods, there is a tubercle which terminates apically in a very small spiniform process (Plate 41, fig. 6).

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	32.5	32.7	33.0
Length of carapace	15.5	15.0	16.0
Anterior part of carapace	10.2	10.0	11.0
Length of areola	5.2	5.0	5.0
Width of areola	0.2	..	0.4
Length of abdomen	17.0	17.7	17.0
Posterior width of rostrum	1.9	2.0	1.9
Length of rostrum	4.5	4.4	4.5
Length of chela	12.7	11.0	10.5
Length of movable finger	6.9	6.0	5.5

191 Locality. North beach of Laguna de Catemaco, Veracruz. Possibly it will be found along all of the shoreline of the lake.

Relationships. This species has affinities with the *mexicanus* group of the southern part of the Republic, relationships recognizable in the form of the apical part of the first pair of pleopods of the male and in the disposition of the mesial process. It is very near *Procambarus acanthophorus* and *P. mirandai*, but it differs from them in the notable reduction of its size and by the form and disposition of the spiniform processes. Undoubtedly, the closest relationships are with *Procambarus ruthveni*; not only is this indicated morphologically but also by their geographic distribution.

Procambarus ruthveni (Pearse)

- 1911 *Cambarus (Procambarus) ruthveni* Pearse, Thirteenth Rept. Mich. Acad. Sci., pp. 110 – 111, 4 figs.
- 1914 *Cambarus mexicanus* (Erichson). Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, p. 363.
- 1953 *Procambarus ruthveni* (Pearse). Villalobos, Mem. del Congreso Científico Mexicano. U. N. A. M., Vol. VII, pp. 363 – 364.
- 1954 *Procambarus ruthveni* (Pearse). Hobbs, Occ. Pap. Univ. Michigan (in press).
- 1954b *Procambarus ruthveni* (Pearse). Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXV, pp. 336-347.

Diagnosis. Rostrum moderately grooved, margins slightly convergent, terminating anteriorly in short, blunt tubercles, or in more or less rounded angular processes; acumen broad at base and sharp apically. Postorbital ridges terminating anteriorly in moderately well developed tubercles, barely evident or absent. Carapace with lateral spines, in some cases as small tuberculiform structures, or without them. Areola very narrow or obliterated. Epistome with anterior

emargination, lateral angles of which sometimes rounded or projecting in form of two small angular processes. Chelae of first pair of pereopods of equal size. Hooks on ischiopodites of third pair [of pereopods]. First pair of pleopods with declivity very sharp; mesial process slender, sharp, and recurved laterally; central projection sometimes presenting small angular process on distal margin. *Annulus ventralis* with more or less deep depression on apical surface. Tubercle between fifth pereopods of female with small apical spiniform process.

Male, form I. The carapace is slightly shorter or of the same length 192 as the abdomen (30.6-31.7; 33.5-33.6; 28.3-29.7). At the level of the caudodorsal margin of the cephalic groove, the height of the carapace is less than the width, greatest width of the carapace approximately at the midlength of the areola (14.2). The surface of the carapace is very densely punctate in the dorsolateral region, sparsely so in the dorsal part of the thoracic region, and even less so in the gastric region; the hepatic region is provided with numerous tubercles; the median and anterior thirds of the branchial region exhibit very numerous small tubercles which are even more numerous in the anteroinferior region; a very short and sharp spine occurs on each side of the carapace, located at the superior and subterminal portion of the groove that limits the hepatic region; in other specimens there is only an indication of an additional small tubercle, but it may not be present; this latter we found in two individuals. The branchiostegal spine is conical and sharp.

The areola is very narrow (0.4 mm) but in other cases it is obliterated; in the anterior and posterior regions of its surface, there are a few punctations; the length of the areola is half the length of the cephalic portion and 34.2 per cent of the total length of the carapace.

The rostrum is broad at its base and in the anterior part the acuminal spine reaches the proximal third of the third antennular article; the rostral margins are almost parallel, very slightly convex laterally, and terminate anteriorly in a more or less sharp angular process; at times two small, almost imperceptible tubercles may be seen, but in other specimens, on the contrary, the anterolateral angles of the rostrum are rounded. The acumen is broad at the base and sharp apically. The rostral surface is smooth, although some very small punctations may be seen in the median line, each with a seta that rests on the surface; the submarginal setae of the acumen do not extend over the margin. The ventral keel of the rostrum lacks the dentiform processes.

The postorbital ridges are slightly convergent, equal in length to the rostral margins; anteriorly they terminate in a short spiniform process that is inclined to the side. In other specimens, this process may be less well defined or absent (Plate 42, figs. 1 and 2).

The epistome exhibits certain variations, but one type may be

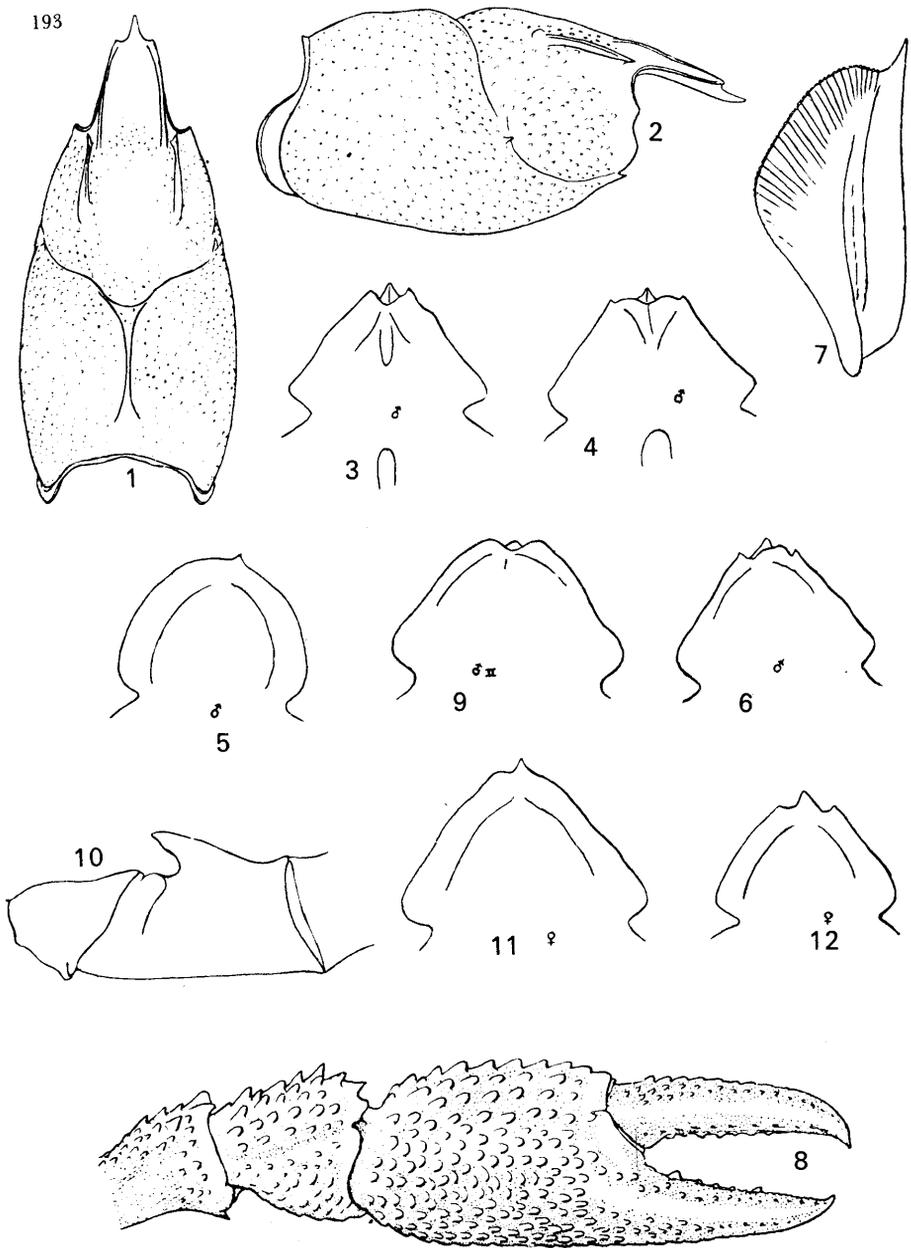


Plate 42. *Procambarus ruthveni* (Pearse). Male, Form I.

1, dorsal view of the carapace; 2, lateral view of the same; 3, 4, 5, and 6, different forms of the epistome; 7, antennal scale; 8, chela; 9, epistome of the male, Form II; 10, ischiopodite of the third pereopod of the male, Form I; 11 and 12, forms of the epistome of the female.

194 recognized (Plate 42, fig. 3) in which the contour is triangular with a more or less irregular emargination possessing two adjoining projecting angles; the epistome of other specimens (figs. 4 and 6) follows the same disposition; only one specimen (fig. 5) exhibits a semicircular epistome, but with the spiniform process on the left side of the anterior margin.

The abdomen is almost smooth, although there are a few small punctations on the surface of the somite, more abundant in the pleural regions. The distolateral angles of the first section of the telson exhibit two spines; one of them, the external, is very long, extending beyond the smaller by one-third or one-half of its length (the posterolateral spiniform angle of the telson is not included in these data).

The antennal flagellum, projected over the body, reaches the fifth abdominal somite. The antennal scale is moderately broad and its external border is slightly convex in the proximomedian part and slightly concave in the distal; the spine of the antennal scale is broad at its base and sharp in the anterior region; it is gently inclined to the side and reaches the distal articular border of the third antennular article; the greatest width is located a little beyond midlength and is less than half the total length of the scale (Plate 42, fig. 7).

The first pair of pereopods exhibit chelae of similar size; they are as long as the length of the body to the fifth abdominal somite, and in some specimens to the midlength of the cephalic part of the telson. The ischiopodite bears a series of three or four spiniform tubercles on its inferior border. The length of the meropodite is equal to that of the dactylopodite; its upper margin is scabrous; the tubercles are more numerous and larger in the distal part, and among them one of large size is conspicuous; a double row of spines is present on the lower margin, a characteristic of the other species of the genus; the spines of the internal row are very large and sharp and alternate with other smaller ones. The carpopodite is as long as the internal margin of the palm of the chela; on the dorsal surface there is a conspicuous deep groove and from it the internal surface of the article bears numerous heavy tubercles that become spiniform on the anterointerior margin of the article; the external surface is comparatively smoother than the internal, exhibiting only subsquamous, flattened and very isolated tubercles. The propodus is densely tuberculate; the tubercles of the internal part of the palmar region are very large, spiniform, and less numerous than those on the rest of the surface; those on the internal border are still more elevated, and there are nine or ten of them; the external dorsal region exhibits crowded subsquamous tubercles. The lower surface of the chela also has tubercles, but these are smaller and more widely dispersed. The movable finger is straight; the tubercles of

the palmar region invade the external base of the finger which exhibits a ridge extending its total length; in the proximal region of the cutting border, there stand out one or two large teeth, and on the remainder of the border there are small dentiform tubercles. The dactylopodite is longer than the immovable finger, slightly curved downward; in the proximal part of the dorsal surface there are very small tubercles that are present to the midlength of the finger; the ridge that runs along it is very low and completely smooth; on the cutting border, the teeth are more or less uniform in size; in the males, one large tooth situated at the end of the proximal third is well developed and conspicuous (Plate 42, fig. 8).

The ischiopodites of the third pair of pereopods exhibit a hook that is inserted on the median third of the article; its form is triangular, flattened in the same plane as is the ischiopodite; the base is more or less wide, the apex conical, a little incurved toward the appendix, and overreaching the articulation of the ischium with the basipodite (Plate 42, fig. 10).

The apices of the first pair of pleopods reach the coxopodites of the third pair of pereopods, are straight, and slightly unequal in length; the shoulder is as in the holotype and the inclination of declivity is approximately 35°; on the latter, there is a low prominence situated on the lateral part (Plate 43, figs. 1, 2, 3, 4, and 5); the mesial process is slender, sharp, curved inward, and is flexed over the lateral region of the apical part (Plate 43, figs. 4 and 5A). The central projection is short, broad, and directed cephalomesially; its apical margin bears a small angular prolongation (Plate 43, figs. 4 and 5CE). In one large specimen, the mesial process is wide, almost straight, and slightly inclined laterally, as occurs in the holotype.

Male, form II. The specimen that we describe has a length of 41.7 mm; the carapace is finely punctate in the gastric region; the punctations of the dorsal region of the thoracic portion of the carapace are more conspicuous; the branchial region is finely granulate, the hepatic region with sparser large tubercles; the lateral tubercles, in place of spines, of the carapace are very small. The areola is obliterated a little behind the median portion of its length.

The postorbital ridges are almost parallel and terminate anteriorly
196 in a very small spine.

The rostrum is short and subplane; the rostral margins are convergent and terminate anteriorly in rounded angles; the acumen is short, broad at the base, and sharp at the distal extremity (a strong similarity exists between the rostrum here described and that of the holotype).

The epistome (Plate 42, fig. 9) does not differ in general form from

that described for the male, form I, but in this case the anterior emargination is symmetrical with lateral angles rounded; nevertheless, in this character there is a similarity to the holotype.

The chelae of the first pair of pereopods are short and the palmar region wide; the tubercles of the surface are more sparing and much less well developed than in the male, form I. The dactylar part of the propodus or immovable finger is very wide at the base and straight; on the proximal cutting border there are three hardly discernible teeth; two smaller ones are evident on the remaining part of the border. The dactylopodite, or movable finger, is short, recurved toward the immovable finger, provided with tubercles in the proximal half of the upper surface; on the cutting border the dentiform processes are arranged along the entire length, progressively diminishing in size toward the extremity of the finger.

The ischiopodite of the third pair of pereopods exhibits only a hint of the hook, in the form of a rounded angular process preceded by an emargination (Plate 43, fig. 6).

The first pair of pleopods are slender in the proximal half and more robust in the distal, their apical parts reaching the caudal region of the coxopodite of the third pair of pereopods. The declivity of the shoulder is almost a right angle. The mesial process is subcylindrical, little sharp at the apical extreme, short, and slightly inclined laterally; the central projection is short, more or less flattened laterally, and projects cephalodistally (Plate 43, fig. 9).

Female. This is the largest specimen we have collected (total length 78.5 mm). The carapace is strongly punctate in the dorsal portion, but the punctations disappear in the gastric region; the branchial regions are finely granulate; in the hepatic region, the granules are a little larger and less numerous; the cephalic groove is very deep; the lateral spine of the carapace is well developed.

The areola is obliterated in the median portion of its length.

198 The postorbital ridges are slightly convergent, and terminate anteriorly in a very sharp, spiniform, slightly incurved tubercle.

The rostral margins are convergent, terminating anteriorly in an angular process which may be considered to be almost a small tubercle; the acumen is narrow at the base and the acuminal spine terminates at the level of the first third of the third article of the antennular peduncle. The rostral surface is slightly grooved with a group of punctations situated in a triangular area at the base of the rostrum; the remaining surface is smooth.

The cephalic section of the telson exhibits two spines in its distolateral angles, similar to those of the male, form I.

The epistome of this specimen (Plate 42, fig. 11) is quite distinct from the usual form that we have described for the male, form I; its

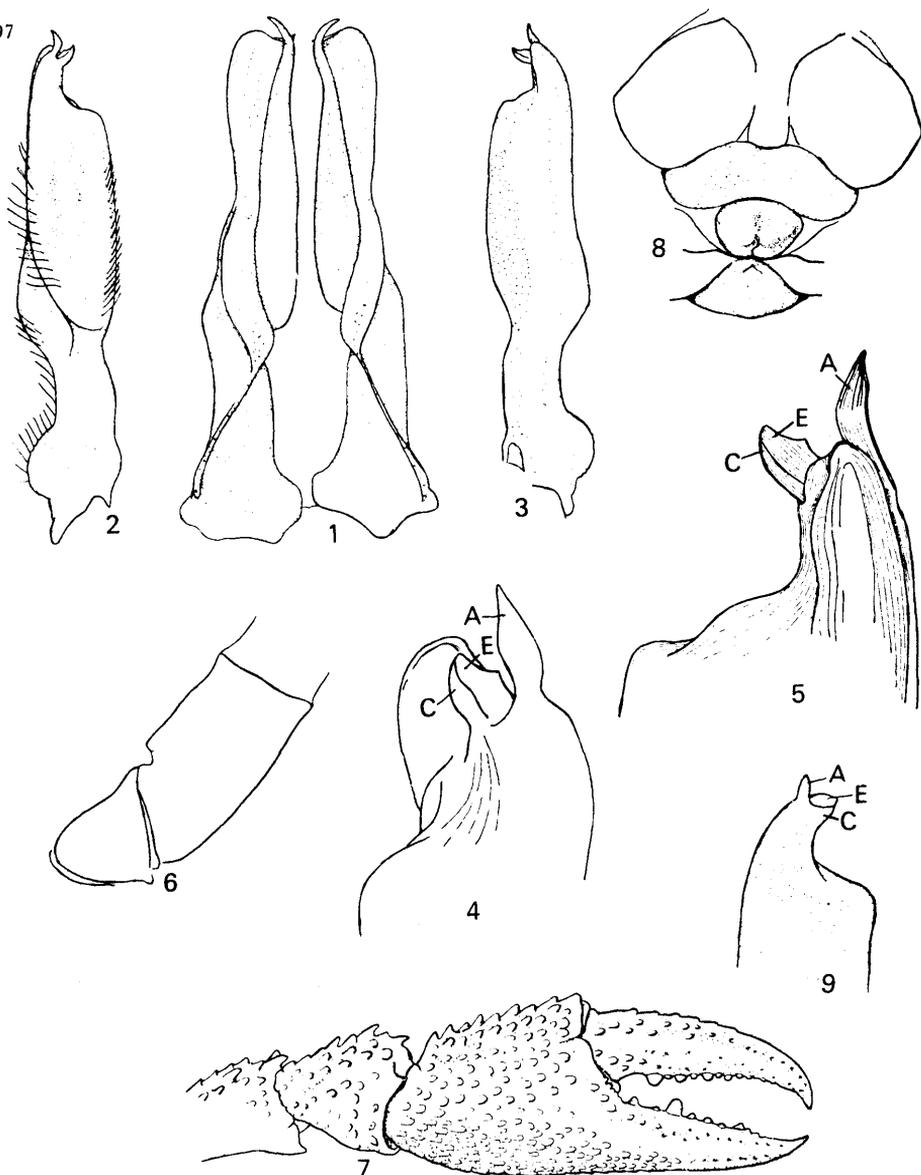


Plate 43. *Procambanus ruthveni* (Pearse). Male, Form I.

1, caudal view of the first pair of pleopods; 2, mesial view; 3, lateral view; 4, cephalomesial view of the apical region of the pleopod; 5, lateral view of the same; 6, ischiopodite of the third pereiopod of the male, Form II; 7, chela of the female; 8, *annulus ventralis*; 9, view of the apical region of the first pleopod of the male, Form II (A, mesial process; CE, central projection).

contour is triangular, slightly asymmetrical anteriorly. Other specimens exhibit an epistome similar to that of the male, form I (Plate 42, fig. 12).

The first pair of pereopods (Plate 43, fig. 7) are very robust; the length projected over the body reaches the middle of the sixth abdominal segment. The carpopodite exhibits a very deep groove on the dorsal surface; the internal region is provided with large tubercles, less numerous and prominent than in the male; the external region bears a few small subsquamous tubercles near the border of the groove; the remainder of the surface has only large pits in the form of a half moon. The chela is broad, depressed, and the surface is heavily tuberculate; the tubercles of the internal margin are elevated and almost spiniform, giving the profile a serrate aspect; the tubercles of the dorsal internal surface are less prominent than in the male, form I. The external border is more or less angular, and bears crowded subsquamous tubercles. The finger region of the propodus is straight, broad at the base, sharp apically; a clearly delimited ridge is present on the upper surface; the basal external surface is provided with subsquamous tubercles that extend to the second third of the finger; the proximal region of the cutting border exhibits two teeth of moderate size, followed by a large one, and the latter by three teeth of decreasing size; beyond these, there is a dentiform process inserted on the lower part of the border, finally, in the distal third, there is a series of four or five very small teeth. The dactylopodite, or movable finger, does not have as well defined a ridge as does the immovable finger; the internal surface bears subsquamous tubercles that extend a little more than half its length; beyond, only setiferous punctations are arranged in a longitudinal series; the internal border is provided with nine subsquamous tubercles that diminish in size progressively to become almost imperceptible; the cutting border has numerous dentiform tubercles that begin in the proximal subarticular region with one large one; following there are three of lesser size of which the middle one is largest; immediately thereafter another as large as the first, and finally nine or ten regularly spaced teeth.

The *annulus ventralis* (Plate 43, fig. 8) exhibits very definite characters, perhaps associated with the size and age of the specimen; it is tuberculiform, its articulation permitting great movement cephalo-caudally, and able to turn in caudodorsal position between the sternite of the fourth and fifth pairs of pereopods; it presents a well defined median depression situated in the cephaloapical region where the margins are elevated in two mammiform processes. The groove begins in the apical cavity of this depression, and, for that reason, has a clear caudal position; it describes a curve in the form of an arc, convex to the right, on one or the other side of the groove there is another hemi-

spherical process less conspicuous than the anterior ones. Between the fifth pereopods, there is a conical tubercle gently inclined toward the *annulus* and which terminates in a small spine, also conical and not very sharp, which coincides with the extreme dorsal end of the groove of the *annulus ventralis*.

Measurements in millimeters

With the object of making the variations in this species more clear, in this case we follow the form in which Hobbs arranged the measurements in his redescription of the types of *P. ruthveni*; at the same time, we present together with the measurements of the types, which are within parentheses, measurements of our specimens which serve for this description.

To the data which Hobbs presented, we wish to add two measurements that seem to us of certain importance: the total length and the anterior width of the rostrum.

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	Male, Form I		Male, Form II				Females				
Total length	65.2	60.5 (58.5)	51.5	48.0	41.6	79.0	61.5	56.0 (51.7)	47.0		
Carapace height	14.9	13.9 (13.8)	13.0	11.0	10.0	19.0	15.0	12.6 (12.4)	11.1		
width	15.9	14.3 (14.0)	13.3	11.4	10.0	19.4	14.8	13.2 (12.8)	11.2		
length	33.6	30.9 (29.9)	28.0	24.6	21.0	41.2	31.0	28.4 (26.4)	24.4		
Areola length	12.0	10.6 (10.5)	10.0	8.4	7.3	14.3	11.0	10.1 (9.3)	8.3		
width	..	0.4 ..	0.2	0.3	0.1	..	0.2	0.2 (0.2)	..		
Rostrum length	7.8	7.5 (6.7)	6.4	5.9	5.2	9.5	6.8	6.4 (5.8)	5.8		
anterior width	2.7	2.0 ..	2.1	1.6	1.6	2.1	2.0	1.8 ..	1.3		
posterior width	4.5	4.2 (4.3)	4.4	3.5	2.9	5.4	4.5	4.0 (4.0)	3.5		
Chela											
length of internal margin of palm	11.3	9.2 (10.1)	8.7	7.4	5.6	10.8	7.9	6.8 (6.4)	5.8		
width of palm	10.0	7.6 (9.1)	8.0	7.0	6.1	11.0	8.0	7.9 (6.5)	6.3		
length of external margin of hand	26.6	21.6 (23.7)	21.0	17.0	13.6	29.0	20.7	16.8 (15.5)	14.4		
length of dactylopodite	15.4	12.8 (12.8)	12.0	10.0	8.0	16.7	11.4	11.0 (8.6)	9.6		

Localities. Cuatotolapan, Veracruz. Alt. S.N.M. 15 m (type locality) Pearse. 1 male, form I, 1 female with young, San Juan Díaz Covarrubias, 10km S.W. of Cuatotolapan, Veracruz, Alt. S.N.M. 15 m, 4 males, form I, 1 male, form II, 4 females.

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The specimens collected in San Juan Díaz Covarrubias have distinct burrowing habits. They were collected in pools of water along the roadside of the Carretera Transistmica. At the time in which we made our collection (December), the specimens were found within their burrows. These were recognized by the chimneys of pellets of mud which were observed on the bank of small pools; usually each burrow

has two entrances which, separated by some 20 cm, have independent tunnels; these, forming the rami of a Y, unite to form the principal tunnel which may reach a depth of 75 cm and may be vertical or inclined toward the pool.

Relationships. *Procambarus ruthveni* exhibits affinities with *P. vazquezae* and with the species of the southern part of the Republic, demonstrated by the form of the apical region of the pleopods of the male, form I; by this same character, it differs markedly from *Procambarus mexicanus*.

Discussion. For a long time, *P. ruthveni* was considered to be synonymous with *P. mexicanus*, furnishing a special desire on our part to collect material which would permit us to clarify this situation. On four or five occasions, we visited the area of San Andrés Tuxtla, attempting to obtain Pearse's species; later we sent a few specimens from these collections to Dr. Hobbs for his comparison with the types deposited in the Museum of Michigan [Museum of Zoology, University of Michigan], which gave occasion to Dr. Hobbs to prepare a redescription of these types, a copy of which, as of now unpublished, is in my possession by courtesy of said specialist.

There are two specimens upon which Pearse and Hobbs made the description and redescription, respectively, of the species; the latter is accompanied by excellent drawings and a table of measurements.

In December 1953, we had the opportunity to collect in San Juan Díaz Covarrubias, Veracruz, a good lot of material, a study of which showed great similarities to *P. ruthveni*; however, with some differences that, for a short time, made us think that we had specimens of a new subspecies. Thanks to the table of measurements of the types which Hobbs included in his redescription, we discovered that in reality our specimens coincide with the characteristics of *P. ruthveni* and furnished the occasion for broadening, with our description, our knowledge of the variability of the species.

Thus, comparing the localities of the types on one side and that of our specimens on the other, we find: (A) that San Juan Díaz is some 10 km distant from Cuatotolapan; (B) that the climatic and topographic conditions are the same, since both localities are at 15 m above sea level; (C) that the localities belong to the same hydrographic basin; and (D) that the types and the specimens from San Juan Díaz de Covarrubias also have the same habitat and the same habits.

Conclusion. The characteristics annotated in this study should be included among those of *Procambarus ruthveni*.

Procambarus ruthveni zapoapensis Villalobos

1954b *Procambarus ruthveni zapoapensis* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXV, pp. 347 - 355.

Diagnosis. Crayfishes of medium size. Rostrum subplane; rostral margins convergent, terminating abruptly anteriorly in angular process, without lateral spines, acumen narrow basally and sharp apically. Postorbital ridges terminating in very short spines. Carapace with very small lateral spines; areola very narrow. Epistome with emargination in anterior part, ending on each side in spiniform process. Chelae of first pair of pleopods of male unequal in size. Hook on ischiopodites of third pair of pereopods. First pair of pleopods of male with shoulder strongly inclined, mesial process flattened cephalocaudally, slightly inclined laterally. *Annulus ventralis* small, tuberculiform, with depression in cephalic portion. Tubercle between fifth pereopods of female terminating in small spiniform structure.

Male, form I. The carapace is shorter than the abdomen and flattened laterally; the surface is densely punctate, except for the gastric region which is smooth; the anterolateral portion exhibits numerous small tubercles that are more abundant and conspicuous in the hepatic region. The carapace exhibits two lateral spines, one on each side, situated on the posterior margin of the groove limiting the hepatic region; the branchiostegal spine is present. The cephalic groove is deep with three very regular undulations in the dorsolateral portion. The areola is narrow (0.4 mm). The postorbital ridges are parallel and terminate anteriorly in a short, spiniform tubercle. The rostrum is narrow basally, the acuminal spine reaching midlength of the third antennular article; the rostral margins are slightly convex, convergent, and terminate abruptly anteriorly in angular processes; there are no lateral rostral spines. The acumen is narrow basally, distinctly sharp; the surface of the rostrum may be considered to be subplane or slightly grooved; it is smooth, but exhibits isolated punctations at the base that are limited to a circular depression on the surface; anteriorly there are a few setae reclining on the surface, those inserted on the margin of the acumen overreaching the edge; the ventral keel of the rostrum is smooth (Plate 44, figs. 1 and 2).

The proportions of the different parts of the carapace are the following: the length of the areola is a little more than half the length of the cephalic portion; the posterior width of the rostrum is one-seventh the length of the total length of the carapace; the length of the rostrum goes into the length of the carapace four and one-half times; the posterior width of the rostrum is two or three times greater than the anterior width.

The epistome (Plate 44, fig. 3) is scutiform, at times with a median emargination the lateral angles of which are produced in two projecting angles. In general, it may be said that variations exist in the contour of the epistome, but always in them there is the tendency to show the type just described.

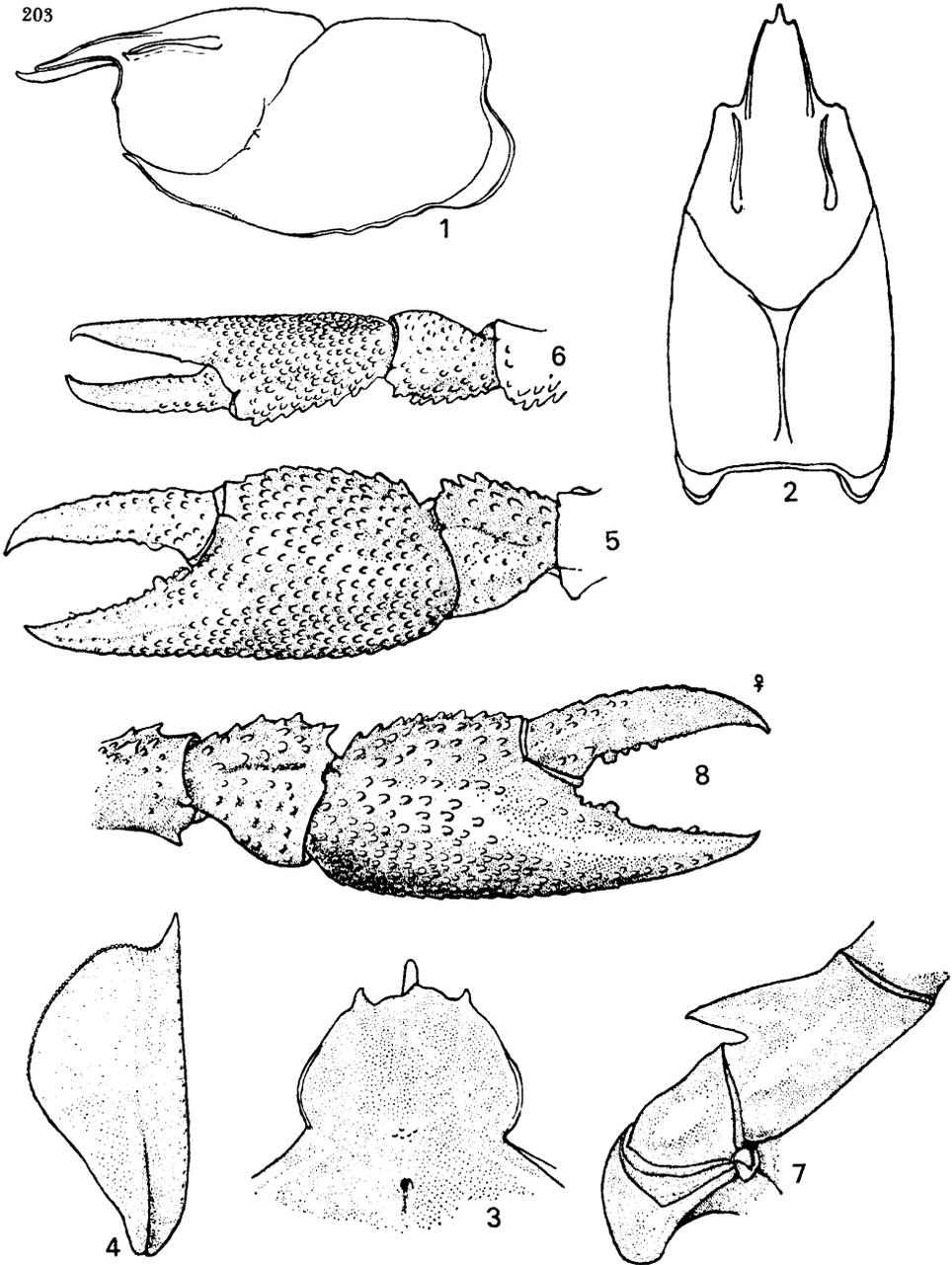


Plate 44. *Procambarus ruthveni zapaopensis* [sic] Villalobos. Male, Form I.

1, lateral view of the carapace; 2, dorsal view of the same; 3, epistome; 4, antennal scale;
5 and 6, chelae; 7, ischiopodite of the third pereiopod; 8, chela of the female.

The abdomen is almost smooth in the tergal region; only a few very small punctations are present in the posterior region of each somite; in contrast, in the pleural regions the punctations are more numerous but are still small. The anterior portion of the telson exhibits parallel margins, and the distolateral angles are provided with two spines, the internal forming part of the main piece of the telson and the external articulated.

The antennal scale (Plate 44, fig. 4) is of medium width, and its spine reaches the second third of the third antennular article; the external margin of the scale is slightly convex in its posteromedian portion and slightly concave in the distal half; the greatest width of the scale is slightly anterior to midlength, and less than half the width of the scale.

205 The first pair of pereopods are very characteristic in this species in exhibiting asymmetrical chelae, that is to say, one larger than the other; the smaller may be either left or right. This character is found principally in the adult males (Plate 44, figs. 5 and 6). The length of the major appendage, projected over the body, reaches over the sixth abdominal somite, and, when the appendage is very well developed, to the first section of the telson. The minor appendage may have the same length as the major one, but usually it is shorter. The meropodite is robust and short; the internal face is provided with subsquamous tubercles in the anterior half; the external face is apparently smoother and the only tubercles are dispersed in the upper part of the anterior third; the upper margin is densely tuberculate along the entire length and in the anterior part there is a conical, sharp, spiniform tubercle inclined forward that stands out conspicuously from the others; the lower margin is armed with a double series of short spines, conical and sharp, and very little inclined forward; in the internal row, two that are located more or less at the midlength of the article stand out slightly by their size. The carpopodite is short, with a more or less deep groove that extends the entire length of the article parallel to the internal margin; the dorsal internal surface is strongly tuberculate; the tubercles also invade the cavity of the groove; the dorsal external surface is smoother, but tubercles are present on the external border, uniquely very flattened in this case; the lower surface is armed with spiniform tubercles of which one large one stands out near the articular margin. The propodus of the major chela is broad and depressed; the external border is rounded, the internal cristiform; the surface of the palmar region is densely covered with tubercles which are more sparse in the center of the dorsal region and in all of the ventral region; the tubercles of the internal margin are sharp and elevated, giving this margin a serrate appearance; the dactylar portion of the propodus is almost straight, broad at its base, and the external dorsal surface covered with subsquamous tubercles; it presents, moreover, a ridge or rib, the base

of which is very broad, that extends the entire length of the finger; on the cutting border there is a large tooth in the proximal third; following is a double linear series of small hemispherical teeth, those on the lower part less numerous; sometimes other large teeth occur in the ultimate third of the finger, but implanted on the lower part of the cutting border. The dactylopodite, although longer than the immovable finger, does not overreach it when the terminal teeth are brought together; it is robust, almost straight, slightly concave on the inferior surface; it is provided with subsquamous tubercles on the proximal external half; it lacks a rib, or well defined thickened border; nevertheless its dorsomedian part is completely smooth and stands out clearly from the rest of the surface; in the dorsal internal region, there are a few subsquamous tubercles limited to the proximal half; the cutting border has two or three large tubercles in its posterior region; following are small denticles that diminish in size progressively and disappear in the subterminal region (Plate 44, fig. 5).

206 The smaller chela of the same pair of pereopods is slender, more densely covered with tubercles; the teeth of the cutting border of the immovable finger are very small, only one conspicuous in the proximal third; the dactylopodite, or movable finger, is straight, curved downward, slender, and the internal margin armed with subsquamous tubercles along its entire length, more numerous in the proximal third; the cutting border exhibits a single large tubercle in the proximal third; the others are exceedingly small, very close to one another, and visible only in the proximal two-thirds of the finger (Plate 44, fig. 6).

The ischiopodite of the third pair of pereopods is armed with a hook that is implanted on the proximal third of the article; the anterior margin of the hook is continuous insensibly with the margin of the article which presents the form of a ridge or keel; the basal section of the hook is flattened in the same plane as the article, but from there, the hook is more conical, nevertheless flattened on its axial face, which is provided with numerous short setae; the distal third of the hook overreaches the articulation of the ischium with the basipodite; on the internal part of the hook, the ischiopodite exhibits an emargination (Plate 44, fig. 7).

The first pair of pleopods reach, with their apical parts, the coxopodites of the third pair of pereopods; they are straight, slender distally, flattened laterally in their distal two-thirds, very slightly unequal in length; the shoulder is well formed and its declivity is approximately 35° , presenting a slightly concave plane inclined toward the lateral region of the appendage (Plate 45, figs. 1, 2, and 3). The mesial process (Plate 45, figs. 4 and 5A) is foliaceous distally, narrow proximally, slightly inclined toward the side of the apical part of the appendage. The central projection (Plate 45, figs. 4 and 5CE) is

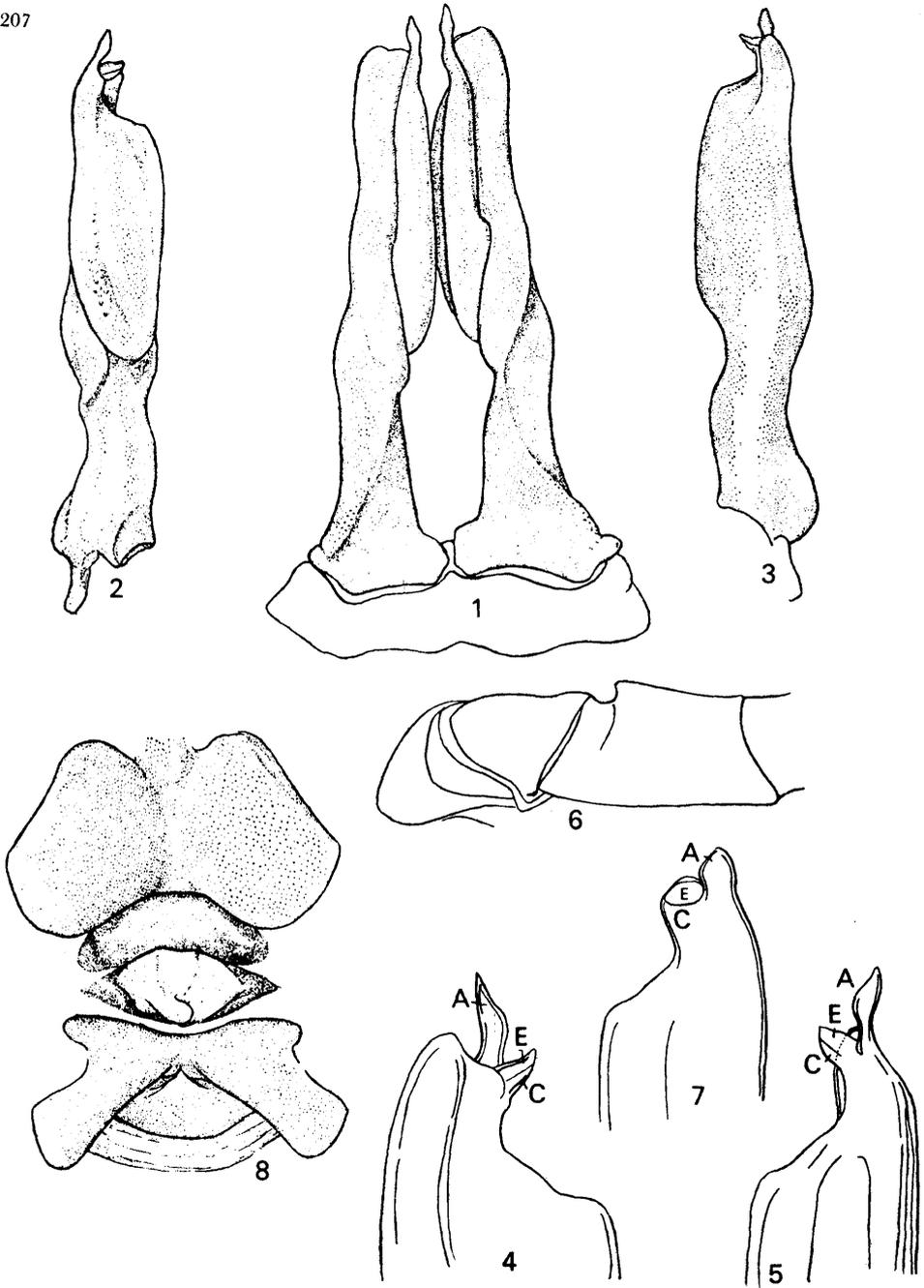


Plate 45. *Procambarus ruthveni zapoapensis* Villalobos. Male, Form I.

1, caudal view of the first pair of pleopods; 2, mesial view; 3, lateral view; 4, lateral view of the apical part of the same; 5, mesial view of the apical part; 6, ischiopodite of the third pereiopod of the male Form II; 7, apical region of the first pleopod of the male, Form II (A, mesial process; CE, central projection); 8, *annulus ventralis*.

flattened laterally, straight, quadrangular at its base and triangular at the apex. In the mesial region of the appendage, there is a ridge which extends from the basal region of the mesial process and is prolonged to the subapical region of the central projection; here on this ridge the cephalic process should be found but there is no structure to denote its existence. In the apical part of the caudolateral surface, there is a cephalocaudally flattened prominence which continues mesially with the apical margin of the central projection; this prominence overreaches in height the central projection and reaches half the length of the cephalic process.

208 **Male, form II.** In the juvenile specimens, the carapace is considerably smoother than in the male, form I, and in the gastric region there are widely dispersed, very small punctations; the areola is slightly wider than in the adult specimen; the postorbital ridges terminate in spines sharper than in the adult; the spines of the carapace are also very sharp; the rostrum is subplane but slightly concave in the anterior part; the rostral margins are almost straight and very convergent; the anterolateral angles are obtuse and the acumen is rather short and very narrow at its base; the acuminal spine is sharp and projects to the distal third of the third article of the antennular peduncle.

The epistome does not exhibit an anteromedian emargination but in this site there is a median angular structure; however, two small prominences may be observed, one on each side and very near the anteromedian angle.

The abdomen is completely smooth over its entire surface, and the distolateral angle of the first section of the telson exhibits two spines, without counting the external spiniform angle typical of this section of the telson.

The chelae of the first pair of pereiopods are very small but unequal in size; the external margin of the chela is slightly concave; the fingers are cylindrical and the cutting borders exhibit exceedingly small teeth. The palmar region is completely covered with tubercles.

The ischiopodites of the third pair of pereiopods exhibit a semi-circular emargination proximally, beyond which arises a rudiment of the hook which has the form of an angular structure of 45° (Plate 45, fig. 6).

The first pair of pleopods exhibit a shoulder with the same declivity as that in the male, form I, but it is nearer the apical region; the mesial process is a rhomboidal plate narrowly united to the central projection which resembles a hemispherical tubercle with a line that divides it into basal and apical parts; this line is continuous with the cephalic margin of the mesial process (Plate 45, fig. 7).

Female. The carapace is apparently smoother than in the male, form I; the anterior part of the gastric region completely lacks

punctations; the posteromedian part of the hepatic region has tubercles; the lateral spines of the carapace are strong, sharp, and slightly curved inward. The areola is very narrow. The postorbital ridges are convergent and terminate in a spiniform tubercle. The apical spine of the rostrum reaches the distal third of the third antennular article; the rostral margins are weakly convergent and terminate anteriorly in an angular, almost spiniform structure; the acumen is very narrow at its base; the rostral surface is distinctly grooved and smooth.

209

The epistome is triangular in shape, flat, and lacks the anterior spiniform prominences.

The abdomen, as in all females, is wider anteriorly than the posterior region of the cephalothorax; the surface of the somites is very smooth, except for a few punctations in the pleural regions of each. The lateral margins of the first part of the telson are parallel and two spines are present in each of its distolateral angles.

The spine of the antennal scale reaches the middle part of the third article of the antennular peduncle.

The chelae of the first pair of pereopods are usually small but equal in size. The surface of the palmar region exhibits fewer tubercles than the chela of the male. The cutting border of the fingers is armed with tubercles that are disposed as in the male (Plate 44, fig. 8).

The *annulus ventralis* (Plate 45, fig. 8) is tuberculiform, cleft in its median portion by a longitudinal depression in the major axis of the body. The groove is disposed in the caudal region of the *annulus*, beginning in the apical part and terminating in the basal portion. Between the fifth pereopods of the female there is a tubercle terminating in a small spiniform process.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	70.0	59.0	51.7
Length of carapace	35.0	29.5	25.0
Anterior part of carapace	22.7	19.7	17.0
Length of areola	12.3	9.8	8.0
Width of areola	0.4	0.4	0.4
Length of abdomen	35.0	29.5	26.7
Posterior width of rostrum	5.0	4.4	3.8
Length of rostrum	8.0	7.4	6.2
Length of major chela	26.2	11.7	13.7
Length of minor chela	21.5	11.0	13.0
Length of movable finger of major chela	14.2	6.3	8.4
Length of movable finger of minor chela	11.0	6.3	8.3

Locality, Zapopan de Cabana, 11 km S.S.E. of Catemaco, Veracruz. Rio Papaloapan Basin. Altitude 500 m above sea level.

210 **Relationships.** *Procambarus ruthveni zapoapensis* has close affinities with *Procambarus ruthveni* (Pearse), evident both in their morphology and geographic distribution.

The characteristics that lead us to consider this a subspecies of *P. ruthveni* are the following :

<i>P. ruthveni zapoapensis</i>	<i>P. ruthveni</i>
I. Rostral margins convergent.	I. Rostral margins little convergent.
II. Areola narrow, never obliterated.	II. Areola very narrow, sometimes obliterated.
III. Epistome with its anterolateral margins distinctly convex; anterolateral spines very far apart.	III. Epistome with its anterolateral margin straight; anterolateral spines less far apart.
IV. Chelae of first pair of pereopods unequal in size in males.	IV. Chelae of first pair of pereopods equal in size in males.
V. Apex of hooks on ischiopodites of third pair of pereopods of male considerably overreaching articulation of ischium with basipodite.	V. Apex of hooks on ischiopodites of third pair of pereopods of male barely overreaching articulation of ischium with basipodite.
VI. Declivity of shoulder of first pair of pleopods of male smooth, in form of plateau slightly inclined laterally.	VI. Declivity of shoulder of first pair of pleopods of male with hump or prominence.
VII. Mesial process foliaceous, directed distally or slightly inclined laterally.	VII. Mesial process narrow, recurved and inclined laterally.
VIII. <i>Annulus ventralis</i> slightly cleft in its apical part.	VIII. <i>Annulus ventralis</i> deeply cleft in its apical part.

Procambarus mirandai Villalobos

1954b *Procambarus mirandai* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXV, pp. 355 – 363.

Diagnosis. Areola broad; carapace without lateral spines; single branchiostegal spine. Rostrum slightly grooved; rostral margins subparallel, converging at anterior extremity; angular structures in place of lateral spines; acumen short. Anterior part of telson with three spines in each distolateral angle. Eyes reduced; cornea slightly depigmented. Chelae of first pair of pereopods of male slender and rather long.

212 Ischiopodite of third pair of pereopods with hooks. First pair of pleopods of male, form I, slender; mesial process spiniform, recurved and inclined laterally; shoulder well developed. *Annulus ventralis* small, tuberculiform, and cleft in cephalic part.

Male, form I. Of regular size. The carapace is clearly wider than the abdomen; the surface is finely punctate; the punctations are more apparent in the dorsal region of the thoracic portion and almost imperceptible in the dorsal region of the cephalic part; the lateral

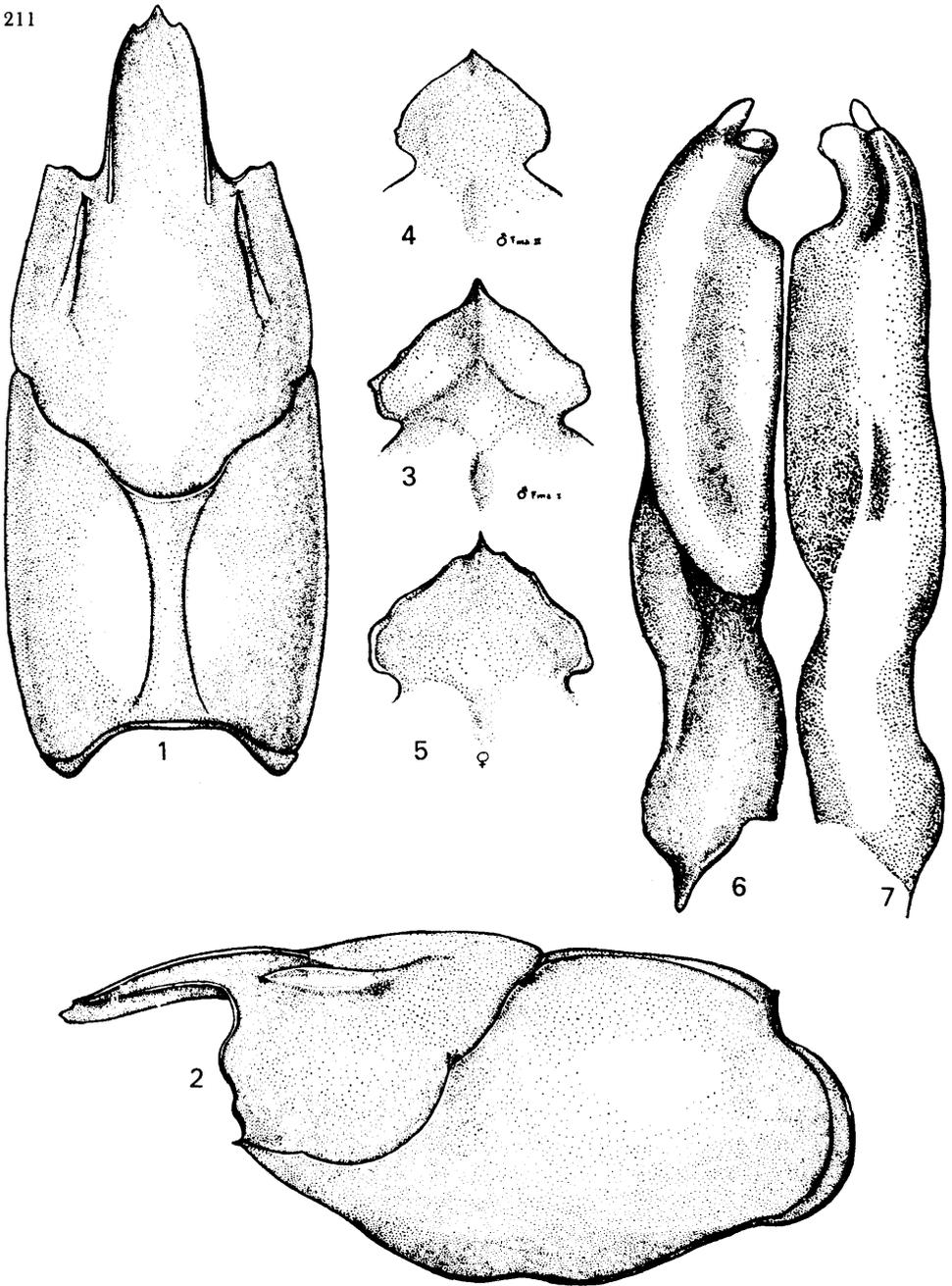


Plate 46. *Procamburus mirandai* Villalobos. Male. Form I.

1, dorsal view of the carapace; 2, lateral view of the same; 3, epistome; 4, epistome of the male, Form II; 5, epistome of the female; 6 and 7, mesial and lateral views of the first pleopod of the male, Form II.

regions exhibit tubercles, the size of which increases on the lower part of the carapace. There are no lateral spines on the carapace; at times a small tubercle similar in form to those of the surface of the carapace, but slightly larger, may be located in the site normally occupied by the lateral spine.

The branchiostegal spine is conical and sharp, located posterior to the cephalic groove, but very near it. The postorbital ridges are convergent and terminate anteriorly in a short, sharp, spiniform process.

The rostrum is wide throughout its entire length; only in the apical region does it become narrow; the surface of the rostrum is slightly grooved and smooth; there are no lateral spines or angular structures on the rostrum; at times any irregularity is so little apparent in this part of the rostral margins that they appear to continue insensibly with the acumen; the latter is broad at its base, short in length, and the acuminal spine reaches the anterior third of the second antennular article. The ventral keel of the rostrum has no dentiform processes (Plate 46, figs. 1 and 2).

The areola is broad, its surface is slightly depressed and provided with punctations which are sparse in the anterior region but abundant in the posterior.

The epistome is pentagonal in form; the margins that originate in the apical region are long, the sides near the base being very short; the surface of the epistome is slightly concave, rather, the margins are elevated above it (Plate 46, fig. 3).

The sternite between the first and second pairs of pereopods exhibits a keel with two or three tuberculiform processes of which two are rather prominent. The tubercle on the sternite between the second and third pereopods is very reduced.

The proportions between the different parts of the carapace are the following: the length of the areola is almost exactly half the length of the cephalic portion; the width of the areola is seven times less than the length; the length of the rostrum is one-fourth that of the carapace; the 214 posterior width of the rostrum is seven and one-half times less than the length of the carapace and three times less than the anterior width.

The antennal scale (Plate 47, fig. 1) is wide; the external margin is slightly convex in its proximal half and slightly concave in the distal. The greatest width of the scale occurs at midlength, and is equivalent to a little less than half the distance between the base and the spine; the latter is short, conical, and slightly inclined to the side. The antennal flagellum is as long as the space between the anterior extremity of the rostrum and the sixth abdominal somite.

The first pair of pereopods exhibit large flattened chelae (Plate 47, fig. 2); conspicuous is the great increase in length of the propodus and

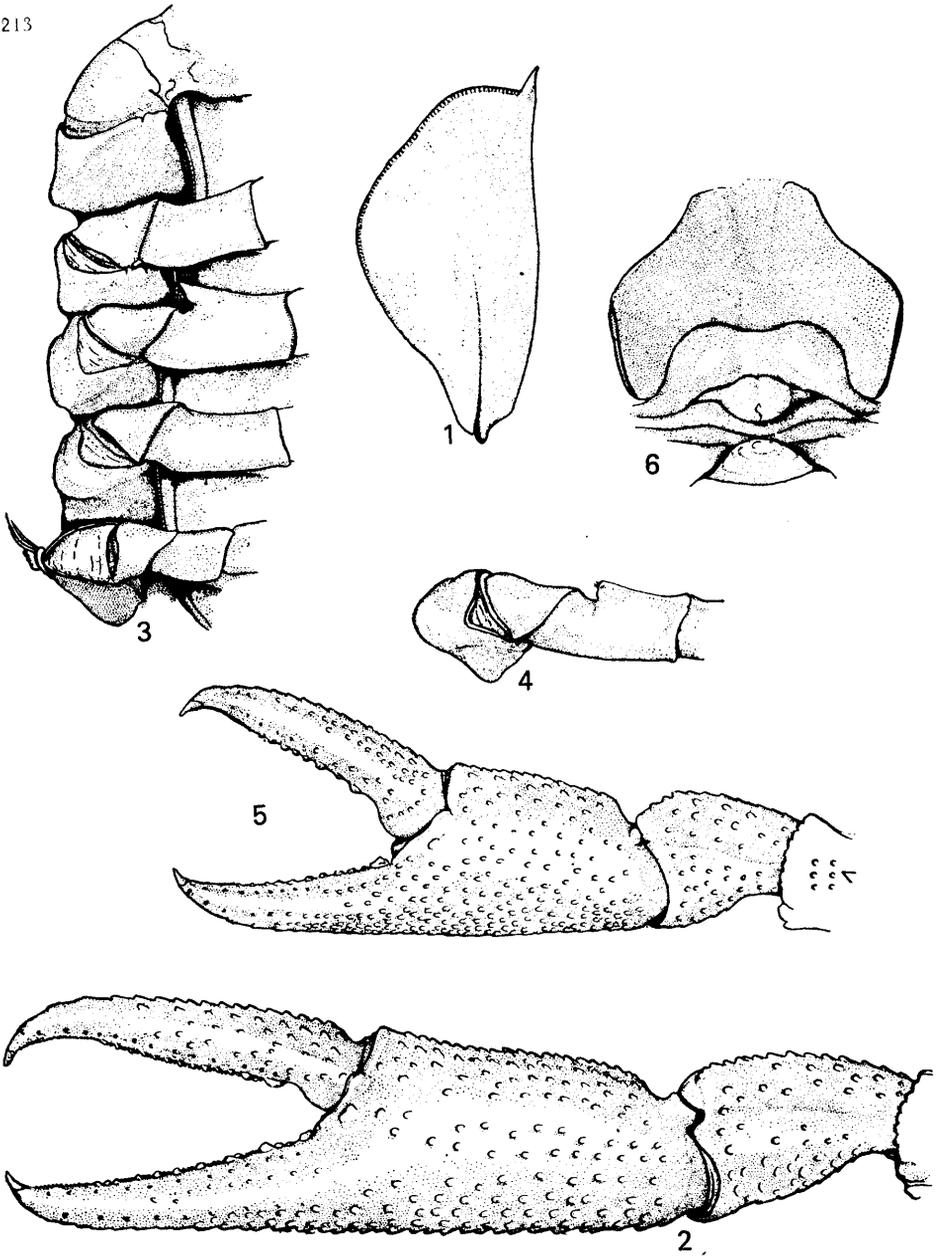


Plate 47. *Procambanus mirandai* Villalobos. Male. Form I.

1, antennal scale; 2, chela; 3, pereiopods I to V; 4, ischiopodite of the third pereiopod of the male, Form II; 5, chela of the female; 6, *annulus ventralis*.

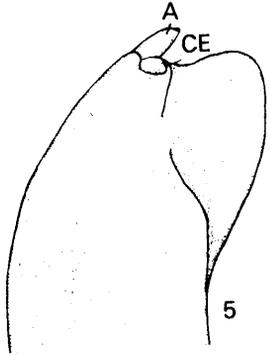
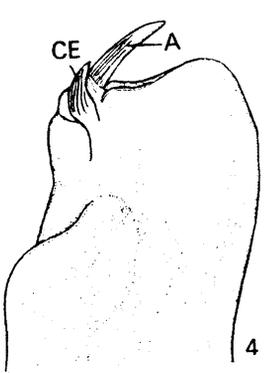
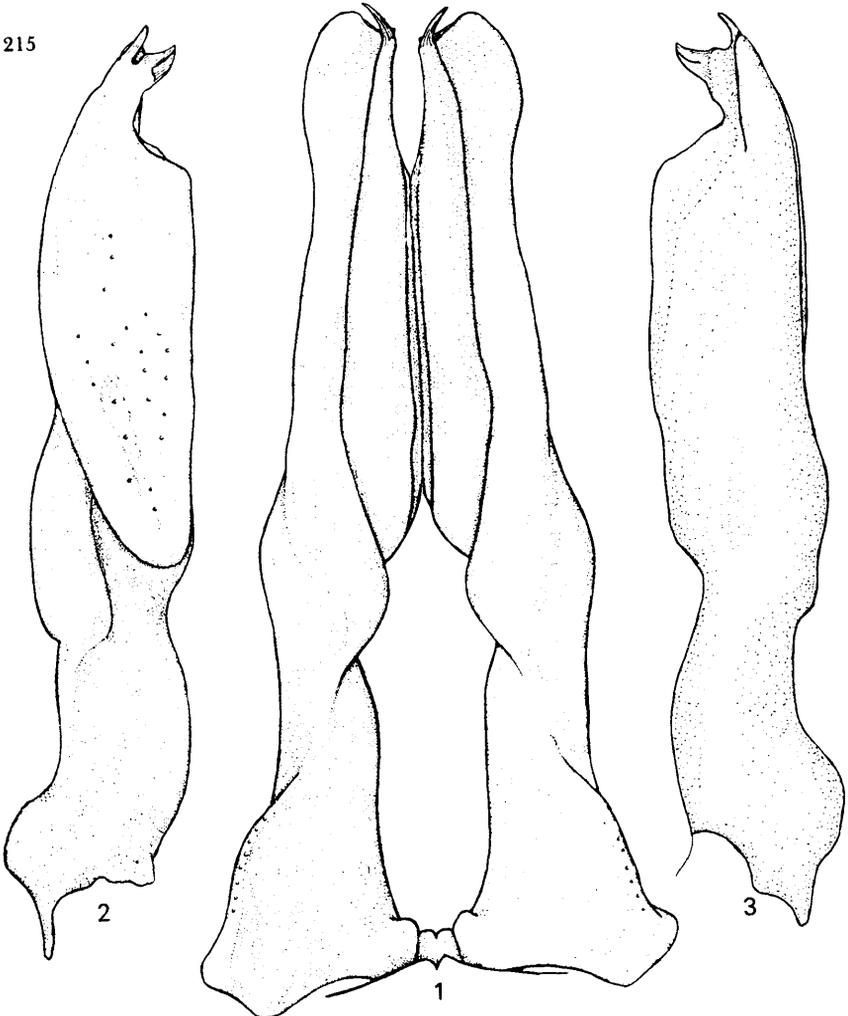
of the dactylopodite. The total length of the appendage, projected over the body, reaches the sixth abdominal somite. All of the surface of the chela is densely covered with small tubercles of more or less the same form, although those that are implanted on the margins are a little more elevated. Such tubercles are also located on the upper face and proximal region of the fingers, along almost the entire length of the internal border of the dactylopodite, and on the external margin of the immovable finger. The internal margin of the propodus is inclined from in front to behind, the greatest width being in the distal region of the palm. The immovable finger is broader at the base than the dactylopodite; on the upper face, one hardly notices a ridge or rib; the cutting margin exhibits teeth along its entire length, the larger ones situated near the base; the teeth of the distal third of the finger are arranged in a double row. The dactylopodite is slender, slightly incurved at the free extremity; on the surface there is no trace of a ridge or rib; the lack of tubercles is noticeable only in the distal half. The cutting border exhibits dentiform tubercles disposed similar to those of the immovable finger. The length of the dactylopodite is equal to that of the palm and half the length of the carpopodite. The carpopodite has the form of an inverted truncate cone; its surface is covered with tubercles except for a band that runs longitudinally on the upper face of the article; the tubercles on the internal region are more prominent than those on the external. On the other hand, there is a notable reduction in the sharpness of the spiniform processes that are normally found on the anterior articular border. The greatest width of the carpus is exactly half the greatest width of the propodus. The upper border of the meropodite exhibits a surface provided with tubercles that are
216 arranged in transverse series, and subterminally one spiniform tubercle is prominent; the lateral faces are smooth in their proximal two-thirds; the lower border exhibits conical, spiniform, forwardly directed tubercles, the size of which increases distally; near the anterior articular border there is one that is larger than the others.

The ischiopodite of the third pereopods exhibits a hook the form of which is a cone depressed in the anteroposterior plane; its apical region distinctly overreaches the articulation of the basipodite with the ischiopodite (Plate 47, fig. 3).

Among the lot of specimens collected in Cerro Hueco, Chiapas, we have found two males, form I, in which the ischiopodites of the second

Plate 48. *Procambarus mirandai* Villalobos. Male, Form I.

1, caudal view of the first pair of pleopods; 2, mesial view; 3, lateral view; 4, cephalic view of the apical region; 5, cephalic view of the apical part of the first pleopod of the male, Form II.



and third pairs of pereopods are provided with a hook. As we know, normally the species of the *mexicanus* Section exhibit hooks only on the ischiopodites of the third pair. Taking into consideration the fact that there may be variability in some species in regard to the number and position of such hooks, we believe that this phenomenon should be taken as an anomaly of the species, a rule which in the cases mentioned by Hobbs, the tendency is to reduce the normal number and in this case to be augmented to two pairs, as they exist in the species of the genus *Cambarellus*. On the other hand, it is pertinent that the abnormal specimens were found in the same locality.

The apical region of the first pair of pleopods reaches the posterior part of the coxopodites of the third pair of pereopods. The shoulder is well developed; the declivity has an inclination of approximately 40°, and its profile with the cephalic margin is an obtuse angle, the vertex of which is more or less rounded (Plate 48, figs. 1, 2, and 3); the mesial process is relatively short, almost spiniform, recurved, and gently inclined laterally (Plate 48, fig. 4A); the central projection is directed in such a manner that its surfaces remain oriented toward the sides; its apical part is a little recurved toward the end of the appendage (Plate 48, fig. 4CE). A character of the first pair of pleopods of the male, form I, that I consider to be important is a zone situated on the lower part of the mesial face in which the chitin is thinned in such a manner as to make it transparent.

Male, form II. In these specimens, the distance between the two anterolateral angles of the rostrum is much shorter than in the male, form I. The carapace is smooth.

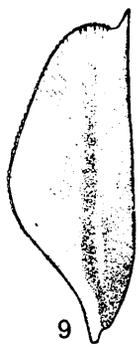
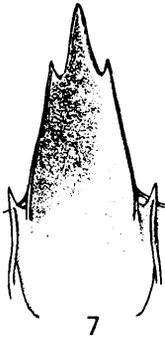
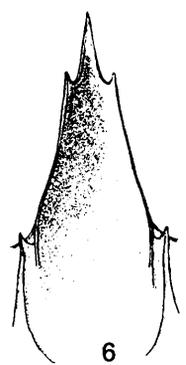
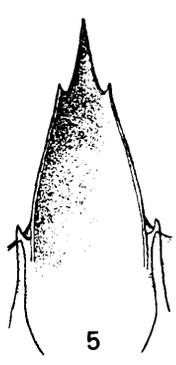
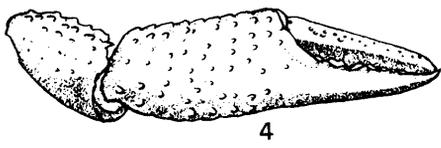
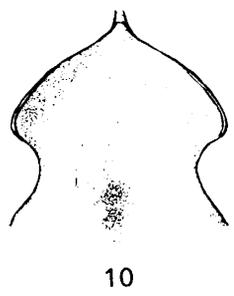
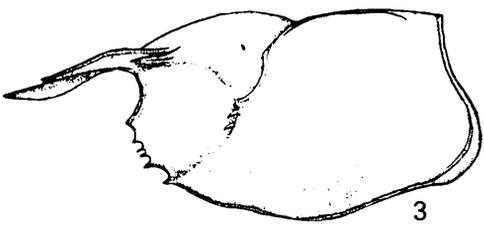
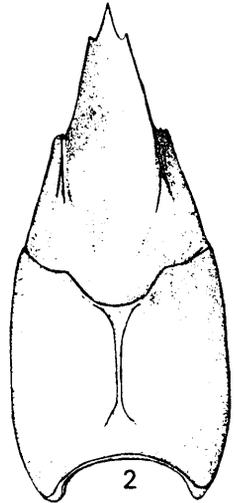
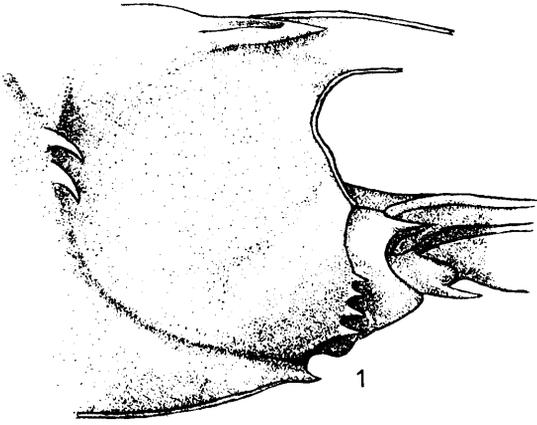
The borders of the epistome are more rounded although it does not differ in its general form (Plate 46, fig. 4)

217 The chelae of the first pair of pereopods are more slender than those of the male, form I; the greatest width of the carpopodite is greater than half the width of the chela; the length of the dactylopodite is equal to that of the palm of the chela and the proximal third of the carpopodite. The lower margin of the meropodite exhibits a well defined spine situated approximately at midlength of the article.

The ischiopodite of the third pair of pereopods exhibits a much reduced hook, the proximal extremity of which is sharp, resembling, for the most part, the general form of the hook in the adult male (Plate 47, fig. 4).

Plate 49. *Procambarus acanthophorus* Villalobos. Male, Form I.

1, lateral view of the anterior part of the carapace; 2, dorsal view of the carapace; 3, lateral view of the same; 4, chela; 5, rostrum of the male, Form II; 6, rostrum of the female; 8, ischiopodite of the third pereopod of the male, Form I; 9, antennal scale of the same; 10, epistome of the same.



The first pair of pleopods exhibit blunt apical structures, thus the mesial process is conical and short; the central projection resembles a tubercle in which the centrocaudal and centrocephalic processes may be seen (Plate 48, fig. 5).

Female. The rostrum is similar to that of the male, form II, although the surface is flatter. The surface of the areola is more deeply depressed in the median portion, the suprabranchial grooves appearing as true ridges.

The chelae of the first pair of pereiopods are clearly smaller than in those of either form of the male; however, the proportion of the dactylopodite in relation to the palmar region of the chela and the carpopodite is equal to that in the male, form I (Plate 47, fig. 5).

The *annulus ventralis* is tuberculiform, rhomboidal in section at its base; it is excavate in almost all of its cephalic portion, but the groove is restricted to the caudal region and has the form of an S (Plate 47, fig. 6).

Between the fifth pereiopods, there is a tubercle, the apical part of which is slightly sharp.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	51.0	53.2	41.6
Length of carapace	25.9	26.3	23.0
Anterior part of carapace	17.3	18.0	15.3
Length of areola	8.6	8.3	7.7
Width of areola	1.2	1.2	0.9
Length of abdomen	25.1	26.9	18.6
Posterior width of rostrum	3.5	3.6	3.6
Length of chela	25.2	19.5	13.8
Length of movable finger	14.2	11.5	7.7

218 **Locality.** Cerro Hueco, 4 km S.E. of Tuxtla Gutierrez, Chiapas. Approximately 750 m above sea level. The specimens were collected in a cave which is the exit of a subterranean river.

Relationships. In spite of the distinct cavernicolous habitat of this species, the relationships that might exist with *Procambarus rodriguezii* are difficult to establish; nevertheless, in certain characteristics that are not products of convergence, the two species coincide with one another. But by the form of the rostrum, of the hooks on the ischiopodites of the third pair [of pereiopods], of the shoulder on the first pair of pleopods and of the apical parts of the appendage, as well as by the width of the areola, *P. mirandai* is completely distinct from *P. rodriguezii*.

Procambarus mirandai has no characteristics that are as markedly troglobitic as *P. rodriguezii*, but worthy of taking into account are the depigmentation of the body, the relative reduction of the ocular

peduncle, the slight depigmentation of the cornea, and the slender form of the chela of the first pair of pereiopods.

Procambarus acanthophorus Villalobos

- 1948 *Procambarus acanthophorus* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XIX, No. 1, pp. 175 – 182, 2 pls.
1954b *Procambarus acanthophorus* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXV, pp. 363 – 364.

Diagnosis. Crayfish with long rostrum bearing lateral spines. Carapace with two lateral spines on each side; five branchiostegal spines; areola narrow. Chelae pubescent. Ischiopodite of third pair of pereiopods with hook. First pair of pleopods of male with shoulder; mesial process short and recurved; cephalic process present; central projection little developed. *Annulus ventralis* small. Tubercle between fifth pereiopods of female blunt.

Male, form I. It is of average size; the cephalothorax is broader than the abdomen; the surface of the carapace bears punctations that are more abundant in the dorsal region; by their size, they are divisible into three groups: the first characterized by numerous, very small punctations; the second consists of slightly larger and less numerous ones than the preceding; finally, there are groups of pits of large size but much less common. In the lower part of the pleural regions, numerous homogeneously distributed subsquamous tubercles are located. The hepatic region is almost smooth, but there are a few punctations. The anterior margin of the cephalic groove is ornamented by a kind of network formed by irregular depressions limited by ridges that do not reach in height the general surface of the carapace.

The rostrum is long, its surface distinctly grooved and without punctations. The rostral margins are convergent and terminate anteriorly in a chitinous lateral spine directed to the side. Behind this spine follows the acuminal region of the rostrum which is triangular and grooved; the acuminal spine is conical and sharp (Plate 49, fig. 5).

The postorbital ridges are parallel, we defined, and terminate in a conical, sharp, spiniform structure, bent slightly to the side.

The cephalic groove is deep and discontinuous on the sides; the part of the groove that limits the hepatic region posteriorly exhibits two sharp spines that are very close together and directed forward and downward. In addition to the branchiostegal spine, there are four other spiniform structures, decreasing in size upward, that are implanted between the antennal angle of the carapace and the branchiostegal spine, but nearer the latter (Plate 49, figs. 1 and 3).

The areola is very narrow, and the margins that delimit it disappear

in the posterior region. The median part of the areolar space lacks punctations, but these appear in the anterior and posterior regions (Plate 49, fig. 2).

The proportions that exist between the different regions of the carapace are the following: the length of the areola is exactly half the length of the cephalic portion; the greatest width of the rostrum is five and one-half times less than the total length of the carapace; the length of the rostrum is three times smaller than the length of the carapace.

The abdomen is narrower than the cephalothorax; the dorsal surface of the somites as well as the pleural regions are smooth except for punctations which are sparsely scattered. A single spine is present on the distolateral angles of the first section of the telson. The distal margin of the last section of the telson is almost straight.

The epistome is small, of regular form, and terminates anteriorly in an angular prolongation. The lateral margins are gently elevated (Plate 49, fig. 10).

221 The antennal scale is long with a deep groove which extends longitudinally along its surface; the greatest width of the scale is between the proximal and second third (Plate 49, fig. 9).

The first pair of pereopods have small chelae that are densely covered with setae; the latter occur distal to the subsquamous tubercles that stud the surface of the chela. The palmar section of the chela is ovoid, and its greatest width is located in the middle portion. The surface is covered with somewhat numerous, small, subsquamous tubercles; the fingers of the chela are short and straight; their cutting borders are armed with dentiform prominences which may be observed only when the setae which occur in the region are removed.

The carpopodite is slightly wider than the proximal region of the hand; it has the form of a truncate comb, and the external and superior lateral surfaces exhibit tubercles that diminish in number and size ventrally. Also, on the upper surface there is a certain development of the setae that gives this region a slightly pubescent aspect (Plate 49, fig. 4).

The meropodite is elongate with a spiniform tubercle on the dorsal margin. The internal side is scaly and the external rather smooth. The lower border exhibits conical spines inclined forward and arranged in two rows, one of them straight and bearing numerous spines, the other incurved and with a smaller number of spines; the space between the two rows contains abundant short setae.

The ischiopodites of the third pair of pereopods bear hooks; these are clawlike spiniform prominences that are borne on the distal extremity of the article, and their apices extend to the level of the proximal articulation. The hooks are gently recurved in the same direction as the article (Plate 49, fig. 8).

The coxopodites of the fifth pereopods exhibit small conical prominences on the internal part of the article.

The apical extremity of the first pair of pleopods reach the coxopodites of the fourth pair of pereopods. They are somewhat symmetrical, and the distal extremity is flattened cephalocaudally. The mesial process is short, slightly chitinized, recurved, gently inclined laterally, and flattened cephalocaudally; its terminal part is very sharp (Plate 50, figs. 1, 2, 3, 4A, and 5A). The cephalic process is small, pyramidal in form, and one of its vertices is continuous with the central projection (Plate 50, figs. 4 and 5B). The latter (Plate 50, figs. 4 and 5Z) has a trapezoidal contour, although observing the pleopod from the cephalic region, it presents a triangular appearance; its two elements are clearly distinguishable. The shoulder is little inclined and in the form of a slightly concave plateau (Plate 50, fig. 6).

Male, form II. The specimen selected for our description is as robust as the male, form I. The surface of the carapace is smooth. The rostral margins are more convergent and consequently the apical region appears sharper. The rostral surface is deeply grooved and smooth (Plate 49, fig. 6). The space between the branchiostegal spine and the antennal angle of the anteroinferior margin of the carapace presents only two spines, the inferior the larger. The two lateral spines of the carapace are present.

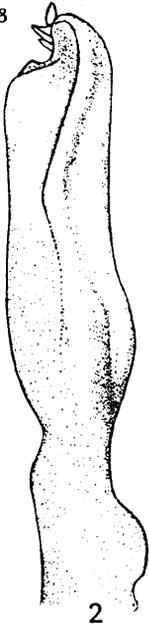
The chelae are smaller and less pubescent. The ischiopodites of the third pair of pereopods exhibit a very weakly developed prominence implanted on more or less the median part of the article.

In general aspect, the first pair of pleopods are similar to those of the male, form I, but a closer examination of the apical region reveals a lack of chitinization in the mesial process, which is shorter and more inclined; the cephalic process is absent; the central projection, in contrast, appears as a more or less hemispherical structure in which the two constituent parts may be seen. The shoulder is more inclined and is nearer the apical region (Plate 50, figs. 6 and 7).

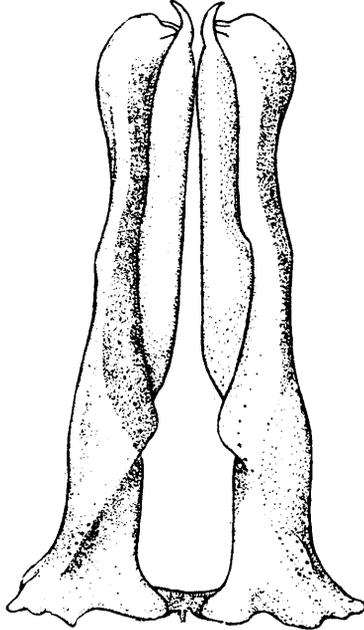
Female. It exhibits a carapace somewhat wider than the abdomen; its surface is smooth; the areola is narrow with a row of small punctations. There are two spines on each side of the carapace, as in the male. The number of branchiostegal spines is the same as that in the male, form I, but the superior one is very small. The rostrum is broader than that of the males, and the acuminal spine is enlarged (Plate 49, fig. 7).

The chelae are small, only slightly pubescent; the setae of the dactylar portion are large and more abundant. The carpopodite is almost the same width as the middle part of the chela.

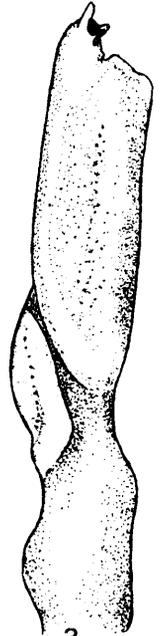
The *annulus ventralis* is very small, measuring 1.9 mm in width and 0.8 mm in length. It has a rhomboidal contour, and the groove begins



2



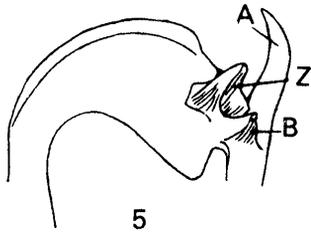
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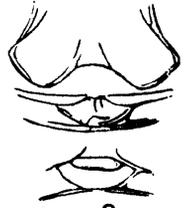
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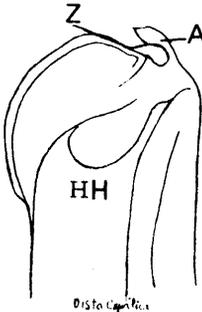
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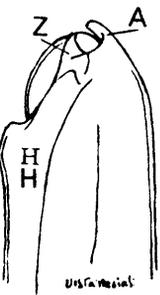
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224 in the subapical region of the cephalic face, from which it is directed obliquely in the caudal portion; in the basal region of the cephalic face there are two ridges separated by a more or less deep cavity; these disappear in the apical portion; the position of the ridges is slightly displaced to the left, and because of this the *annulus* is a little asymmetrical. There is a fusiform tubercle between the fifth pereopods which lacks a spiniform structure on the apical portion (Plate 50, figs. 8 and 9).

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	60.0	61.3	62.6
Length of carapace	30.3	30.0	30.5
Anterior part of carapace	20.4	20.6	20.6
Length of areola	9.6	9.4	9.9
Width of areola	0.4	0.4	0.4
Length of abdomen	29.7	30.7	32.7
Posterior width of rostrum	4.6	4.9	4.9
Length of rostrum	9.2	10.3	8.9
Length of chela	22.3	17.9	13.8
Length of palm	12.0	9.3	5.8
Length of movable finger	11.4	9.4	8.6

Localities. El Castillo, 4 km W. of Tuxtepec, Oaxaca. The specimens were collected in a small lake which at times becomes dry. Arroyo Cojinillo, Tierra Blanca, Veracruz. La Laja, Cuatotolapan, Veracruz (Pearse). Laguna de Catemaco, Veracruz (Pearse). Paso del Toro, Veracruz. Espagoyan, marsh which occurs on the shore of Laguna de Catemaco, Catemaco, Veracruz. Arroyo Novara, on the Rancho Novara, Cosamaloapan, Veracruz.

Relationships. *Procambarus acanthophorus* has close affinities with *P. llamasi* and *P. pilosimanus*, illustrated by the pilose character of the chelae and the lateral spines of the carapace, as well as by the branchiostegal spines.

Procambarus acanthophorus is the only species which exhibits a clearly distinguishable cephalic process. According to the apical contour of the

Plate 50. *Procambarus acanthophorus* Villalobos. Male, Form I.

1, caudal view of the first pair of pleopods; 2, lateral view; 3, mesial view; 4, cephalic view of the apical region of the first pleopod; 5, cephalomesial view of the same; 6 and 7, cephalic and mesial views of the apical part of the first pleopod of the male, Form II (A, mesial process; B, cephalic process; Z, central projection); 8, sternite of the fourth and fifth pereopods of the female; 9, *annulus ventralis*.

first pleopod of the male, form I, it is allied with those species that occupy the southern part of the Mexican Republic.

Procambarus llamas Villalobos

1954b *Procambarus llamas* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXV, pp. 364 – 371.

225 **Diagnosis.** Crayfishes of large size, total length 81 to 85 mm. Carapace with two lateral spines on each side. As many as four branchiostegal spines, normally three. Rostrum wide at base; margins convergent; lateral spine present; acuminal spine long and sharp-pointed, reaching distal articular margin of third antennular article. First pair of pereopods as long as body, dactylar portion of chela covered with setae; hook on ischiopodites of third pair of pereopods. First pleopods of male, form I, with mesial process flattened cephalocaudally; central projection weakly developed; shoulder with sharp declivity. *Annulus ventralis* of female with cephalic portion incised by sulcus. Tubercle between fifth pereopods of female conical.

Male, form I. The carapace is compressed, particularly so in the anterior part; the surface is very finely punctate in the cephalic region and on the dorsal part of the thorax; the branchial regions are provided with minute tubercles, distinguishable only with a hand lens. The lateral spines are present in the upper part of the groove that marks the posterior limit of the hepatic region; they are conical in form and the apex is directed forward and downward; usually there are three branchiostegal spines although there may be four, one of them situated posterior to the cephalic groove. In the lateral region of the carapace, there is a colorless stripe extending from one extremity to the other; posteriorly it is narrow, and its widest part a little anterior to the cephalic groove; in this region the inferior limit of the stripe is prolonged in a kind of lobule (Plate 51, fig. 1).

The areola is narrow; the suprabranchial margins that limit it are parallel along most of their lengths.

The rostrum is decidedly channeled and its surface smooth. The rostral margins are high, gently convex to the side, convergent forward, and they terminate in an angle that ends in a conical spine. The acuminal spine is long and sharp; its dorsal surface is similar in general form to that of the rest of the rostrum, and its apex reaches the distal articular margin of the third article of the antennular peduncle.

The proportions of the different parts of the carapace are as follows: the length of the areola is exactly one-half that of the cephalic portion; the posterior width of the rostrum is six and one-half times less than that of the carapace; the length of the abdomen is slightly less than the length of the carapace.

226 The postorbital ridges are slightly convergent anteriorly, terminating in a short conical spine (Plate 51, fig. 2).

The posterolateral angles of the first part of the telson bear two spines, not counting the spiniform angle which is very sharp.

The epistome is heptagonal, rather symmetrical; in some individuals, the margins of the epistome are irregularly notched by a few emarginations, the positions of which vary from one specimen to another (Plate 51, fig. 3).

On the sternite, there is a keel extending between the first and second pairs of pereopods; its free margin is provided with a series of small tubercles, of which there may be as many as four. The tubercle on the sternite between the second and third pairs of pereopods is greatly reduced.

The antennal scale is long (Plate 51, fig. 4); the external margin is slightly concave at the distal extremity, and the antennal spine is small; the latter is directed to the side and very slightly overreaches the anterior lobule of the lamellar part of the scale; the greatest width is slightly posterior to midlength. The antennal flagellum, extending over the surface of the body, reaches the ultimate portion of the telson.

The first pair of pereopods are very long, and the articles that are most lengthened are the meropodite and propodite (Plate 52, fig. 8). The internal margin of the ischiopodite is armed with small blunt tuberculiform processes. The entire surface of the meropodite is provided with numerous, small, more or less hemispherical prominences; those on the internal surface are most massive, and those of the inner inferior border are conspicuous by their large size. Near the distal extremity of the upper margin, there is a conical spine directed forward. On the external part of the lower margin, toward the middle of the article, there are two distinct conical spines that are directed forward, their tips the color of dark coffee; the space between them is equivalent to that between the anterior spine and the margin of the distal articular emargination; a sharp, conical spine is present on both the internal and external side of this emargination.

228 The carpopodite is a little less than one-third of the length of the chela. It is conical in form, with two emarginations on the distal articular margin. All of the surface of this article is provided with tubercles very similar to those of the propodus; they are more prominent on the internal region. On the internal articular margin of the distal extremity, there are two small spines. On the upper surface, there are minute tubercles in the longitudinal groove, which is hardly defined.

The chela is subcylindrical in its palmar portion, slightly flattened dorsoventrally, with the internal and external margins almost parallel, blunt in the proximal portion and very sharp toward the fingers. All of

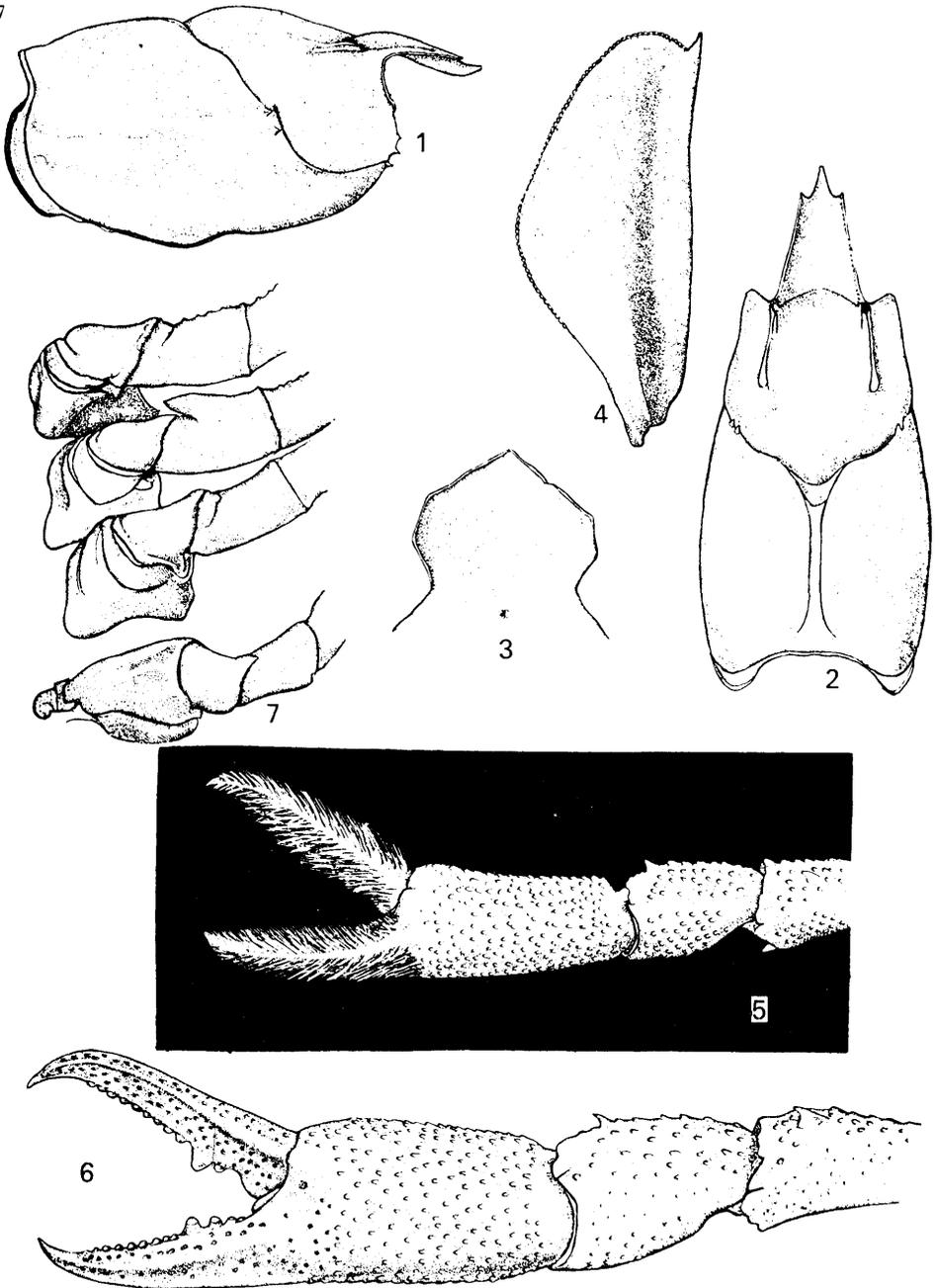


Plate 51. *Procambarus llamasii* Villalobos. Male, Form I.

1, lateral view of the carapace; 2, dorsal view of the same; 3, epistome; 4, antennal scale; 5, chela showing the pubescence of the fingers; 6, chela with setae removed; 7, pereiopods II to V.

the palmar surface is provided with the same kind of tubercles that we described for the surface of the other articles, but very abundant and subsquamous dorsally; whereas in the outer ventral region they are small, they are unlike those of the ventral internal region where the tubercles are similar in form to those of the dorsal surface. The dactylar region of the chela is covered with setae that give the fingers a pilose appearance. Both the immovable finger and the dactylopodite exhibit a dorsal ridge which extends the total length of each. The cutting border of the immovable finger is armed with dentiform tubercles of which two proximal ones are conspicuous because of their size. The dactylopodite, or immovable finger, exhibits a single tubercle larger than the others present along almost the entire length of the cutting border; this tubercle is also proximal in position. The length of the dactylopodite is equal to the length of the palmar region (Plate 51, figs. 5 and 6).

The ischiopodites of the third pair of pereopods are armed with a strong, conical hook, the apex of which clearly overreaches the articulation of the basipodite with the ischiopodite (Plate 51, fig. 7).

The first pair of pleopods are straight, and their apical portions reach the anterior part of the coxopodite of the fourth pair of pereopods. They are flattened laterally; also the distal region is broadened laterally (Plate 52, figs. 9, 10, and 11). The mesial process is straight and directed distally; it is flattened anteroposteriorly and is short and rounded terminally (Plate 52, fig. 12A). The central projection is very reduced and trapezoidal in form (Plate 52, fig. 12CE); the centrocaudal process is sharp (C); the centrocephalic (E) is quadrangular. The ridge that bears the cephalic process limits the central projection basally and is continuous with the centrocaudal process.

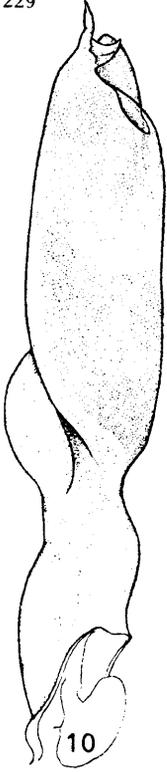
The shoulder is strongly inclined, and in the declivity there is a shallow depression; in mesial and lateral views of the pleopods, the shoulder is hardly noticeable.

Male, form II. The surface of the carapace is smooth. It exhibits only two branchiostegal spines on each side, the cephalic groove
230 ending between them. The lateral margins of the rostrum are decidedly convergent, convex to the side in their posterior portion; lateral spines are well developed, conical in form; the acuminal spine is narrow and sharp. The surface of the rostrum is concave, a character accentuated in the middle part.

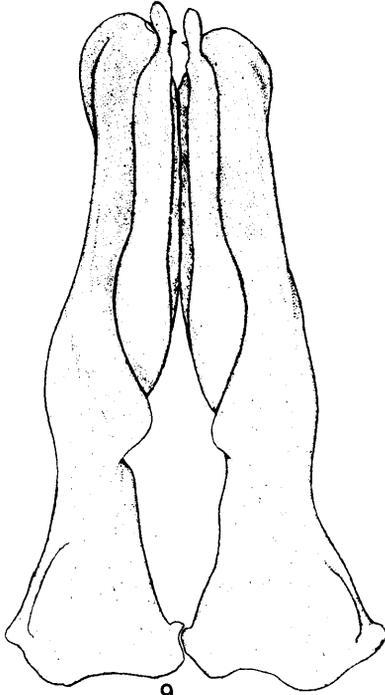
The epistome is broad, its margins rounded, thus rather different in contour from the epistome of the male, form I.

The keel of the sternite between the first and second pairs of pereopods has a dentiform tubercle which, as was pointed out for the male, form I, is larger than the other tuberculiform ones.

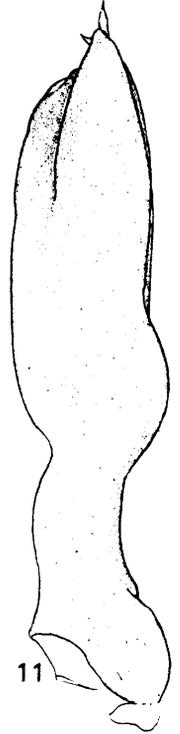
The ischiopodite of the third pereopods bears a mammiform process.



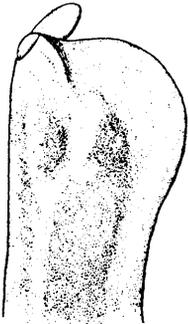
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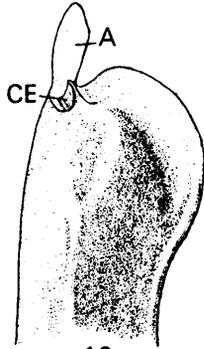
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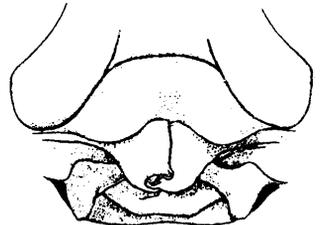
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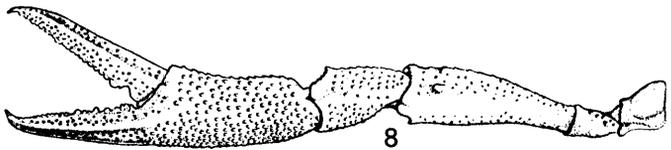
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The first pair of pleopods are slenderer. The mesial process is slightly angular and is inclined over the lateral apical region. The central projection is hemispherical. The cephalic process or cephalic ridge is situated below the central projection (Plate 52, fig. 13). The posterior angles of the first section of the telson exhibit two spines on each side, lacking the median one.

Female. Some female specimens are larger than the males. Taking as a base a female specimen, the length of which is 84 mm, we observed the following characteristics: the carapace is densely punctate; the punctations of the branchial region have a very small tubercle the size of which increases in the lower part.

The rostrum is decidedly grooved, deeper in the middle third; the rostral margins are slightly convex to the side, but definitely convergent toward the anterior, and terminate in robust spines. The acuminial spine is sharp.

The first pair of pleopods are shorter than in the male. The length of the chela projected over the body reaches the middle of the fifth abdominal somite. The meropodite has the same spines described for the male, form I, but the two on the lower border are better developed; the external surface of this article is almost smooth. The chela is shorter than in the male, and its length is two and one-half times greater than the length of the carpopodite. The palmar portion of the propodite is rather depressed; its external and internal margins are convergent toward the proximal extremity; the surface of the palmar region exhibits subsquamous tubercles with the same form and frequency as in the male. The dactylar portion of the chela is less pilose than in the males, the margins of the fingers being free of setae. The proximal region of the cutting border of the immovable finger exhibits three very
231 large teeth; the length of the dactylopodite is a little greater than the length of the palmar region; the cutting border of this article has a very large dentiform process on its proximal part.

The *annulus ventralis* is rhomboidal in contour at its base, with depressions on the anterolateral faces; its median part is cut by the groove which is directed obliquely toward the apical region, or its direction may be straight; there it forms a figure S, inclined from right to left; sometimes this S may be inverted as in the figure (Plate 52, fig. 14).

Plate 52. *Procambarus llamasii* Villalobos. Male, Form I.

8, first pereopod; 9, caudal view of the first pair of pleopods; 10, mesial view; 11, lateral view; 12, cephalic view of the apical region (A, mesial process; CE, central projection); 13, cephalic view of the apical region of the first pleopod of the male, Form II; 14, *annulus ventralis*.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	81.4	68.9	81.4
Length of carapace	40.9	31.8	40.5
Anterior part of carapace	28.1	21.5	27.0
Length of areola	12.8	10.0	13.5
Width of areola	1.0	0.4	1.0
Length of abdomen	40.5	37.1	40.9
Posterior width of rostrum	6.0	5.4	6.0
Length of chela	37.1	9.5	26.1
Length of movable finger	19.4	10.7	18.8

Locality. Santa Rita, 47 km E. of Escárcega, Campeche. These specimens were collected in a culvert on the Escárcega-Champotón highway. This locality corresponds to the "escurridero" of the Laguna de Silvituj.

This species is widely distributed inasmuch as specimens were collected in Escárcega and in the Estación Haro, some 70 km from Escárcega.

Relationships. *Procambarus llamas* has close affinities with *Procambarus pilosimanus*, from the southern part of Chiapas, and with *Procambarus acanthophorus* from the southern part of Veracruz.

Procambarus pilosimanus (Ortmann)

- 1906 *Cambarus* (*Procambarus*) *pilosimanus* Ortmann, Proc. Wash. Acad. Sci., Vol. VIII, pp. 6 – 10, fig. 2.
- 1911 *Cambarus pilosimanus* (Ortmann). Pearse, Thirteenth Rept. Michigan Acad. Sci., p. 110.
- 1914 *Cambarus pilosimanus* (Ortmann). Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, p. 362.
- 1954b *Procambarus pilosimanus* (Ortmann). Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXV, pp. 371 – 378.
- 232 **Diagnosis.** Smaller than *P. llamas*. Carapace broad; two weakly developed lateral spines on each side; two branchiostegal spines. Areola narrow. Rostrum less concave than in *P. llamas*, broader at base; lateral spines of rostrum present, very short. Acumen short, its apex reaching proximal third of last antennular article. First pair of pereopods shorter than length of body; chelae totally pubescent. Ischiopodites of third pair of pereopods of male with hooks. First pair of pleopods with shoulder poorly defined; central projection quadrangular. *Annulus ventralis* with groove restricted to apical region.

Male, form I. The carapace (Plate 53, figs. 1 and 2) is clearly

broader than the abdomen. The surface exhibits two types of punctations, some large and limited in number and the others small and numerous; some of the former have a very small angular prominence, hardly visible with a hand lens. The dorsal surface of the thoracic region is flattened. The cephalic groove is relatively deep. The two lateral spines of the carapace are conical, sharp, and slightly curved downward; only two branchiostegal spines are present, one in front and the other behind the groove that limits the hepatic region. The areola is very narrow, less than one millimeter wide; the areolar surface is smooth but with the aid of the microscope several rows of punctations may be seen. The postorbital ridges are convergent forward; the posterior extremity is very prominent, whereas the anterior terminates in a short, conical spine gently inclined to the side. The rostrum is broad; the rostral margins are almost straight but a little convex to the side; the lateral spines are short, farther apart than in *P. llamasi*; the acumen is triangular, not very sharp, and its apical extremity reaches the proximal third of the ultimate antennular article. The ventral keel of the rostrum is smooth.

The proportions of the different parts of the carapace are the following: the length of the areola is very little less than half of the cephalic portion; the posterior width of the rostrum is six and one-third times less than the length of the carapace; the length of the rostrum is three and one-half times less than the length of the carapace; the length of the cephalothorax is a little less than that of the abdomen.

234 The lateral margins of the first portion of the telson are subparallel, slightly convex in the posterior region; the distolateral angles of this portion bear one spine on each side although sometimes they may have two, but this is very infrequent (the spiniform angles of this section of the telson are not included in this character). The distal margin of the ultimate portion is rather straight.

The epistome (Plate 54, fig. 1) is approximately triangular, and the anterolateral margins are straight; the apex stands out clearly between the two emarginations. The margins are elevated slightly above the plane surface. Sometimes one of the anterior emarginations is deeper than the other.

The antennal scale (Plate 53, fig. 3) is narrow when compared with that of *P. llamasi*. The external margin is straight, and the spine of the scale is small, conical, and directed distally. The greatest width is located a little behind the middle of the scale and is equal to a little less than half of its length. The length of the antennal flagellum is almost equal to the total length of the body.

There is only one conical tubercle on the sternite between the fifth pereopods. The tubercle on the sternite between the second and third pairs of pereopods is absent.

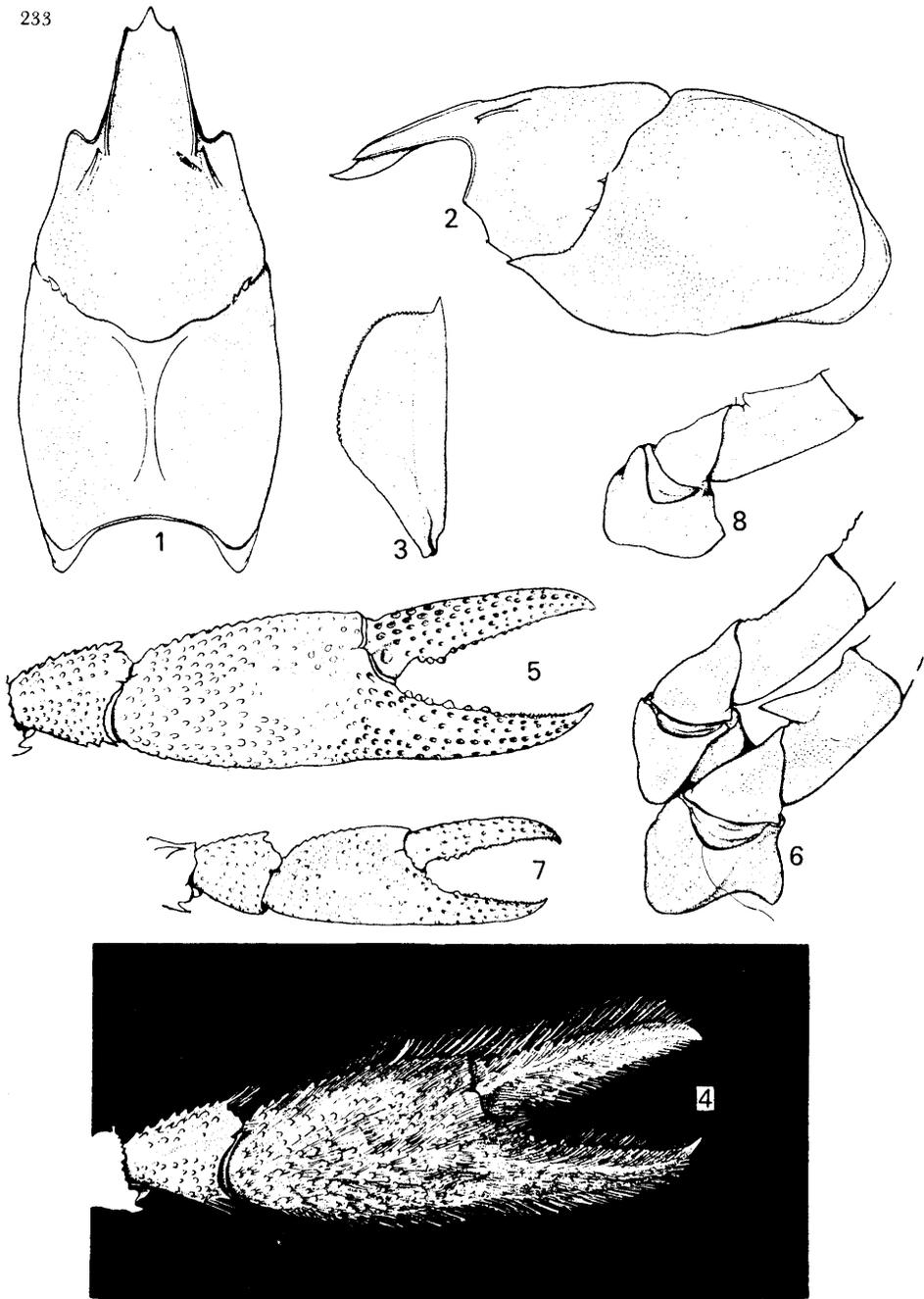


Plate 53. *Procambarus pilosimanus* (Ortmann).

1, dorsal view of the carapace; 2, lateral view of the same; 3, antennal scale; 4, chela showing the pubescence; 5, chela with setae removed; 6, second and third pairs of pereopods; 7, chela of the female; 8, ischiopodite of the third pereopod of the male, Form II.

The length of the first pair of pereopods is less than that of the body. The tubercles on the external and internal surfaces of the meropodite are very sparse; these are very small and are located mostly on the anterior part of the article; on the posterior these are very widely dispersed; the upper margin is provided with abundant tuberculiform prominences, the forms of which are much like those of the distolateral ones; a conical process much larger than the others in the area is present near the articular margin; the lower border is armed with conical tubercles the size of which gradually increases distally; it may be recognized that these structures are arranged in two rows, an internal and an external, and the surface between them is scabrous; two of these processes stand out in the external series; the posterior is smaller than the anterior, and the latter is located very near the articular emargination. The carpopodite is almost rectangular; its entire surface is covered with tubercles of the same kind as those on the meropodite; those that cover the internal surface are better developed; the upper surface exhibits a straight, shallow groove that extends almost the entire length of the article. The chela is completely covered with setae (Plate 53, fig. 4) that present a pilose aspect for which the species is named. The setae of the proximal portion of the propodus are very short, and, for this reason, this area seems relatively denuded. The length of the setae increases in the middle part of the chela, diminishing on the extremity of the fingers. The palm is depressed, the internal and external margins are gently convergent proximally. The surface of the palm is uniformly studded with small tubercles (Plate 53, fig. 5). The surface of the immovable finger is covered with large punctations from which arise the setae of this part of the chela; moreover, there is a rib or ridge which runs the entire length of the finger; the external profile of the finger exhibits a double ridge in the trough of which the setae are implanted; the cutting border exhibits dentiform processes which are arranged essentially in two series except in the proximal extremity where there are only two or three of them, very large in relation to the size of the others. The dactylopodite is straight and also exhibits a ridge or rib; the surface is similar to that of the immovable finger; the teeth of the cutting border have a similar disposition, but the proximal tooth is larger. The length of the dactylopodite is notably greater than the palmar length.

The third pair of pereopods exhibit a hook on the ischiopodal article, the apex of which decidedly overreaches the articulation of the basipodite and ischiopodite. Its form is that of a cone compressed in the same plane as that of the ischiopodite (Plate 53, fig. 6).

The first pair of pleopods are straight; their apical regions reach the caudal portion of the coxopodites of the third pair of pereopods. They are flattened laterally in their distal middle part and cephalocaudally in

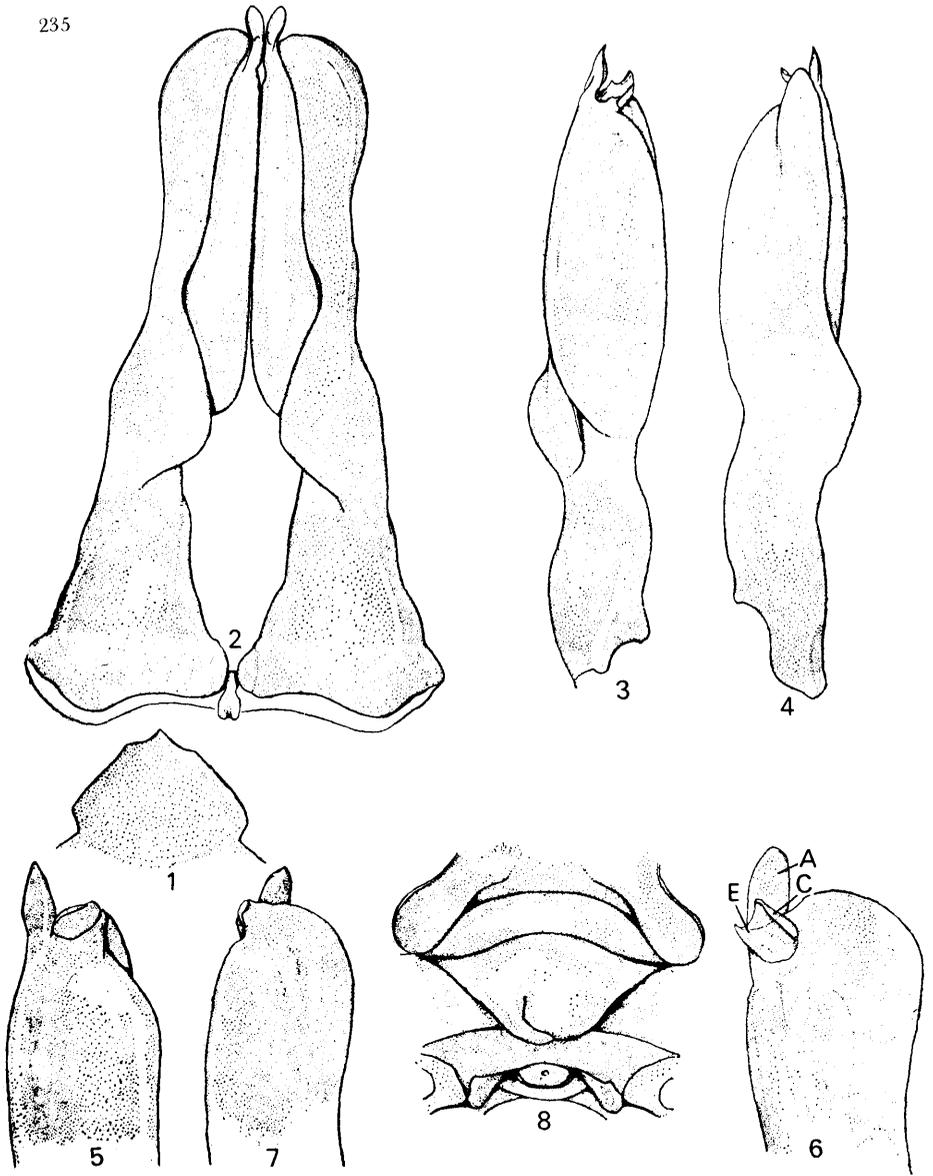


Plate 54. *Procambarus pilosimanus* (Ortmann). Male, Form I.

- 1, epistome; 2, caudal view of the first pair of pleopods; 3, mesial view; 4, lateral view; 5, mesial view of the apical part of the pleopod; 6, caudal view of the same; 7, lateral view of the apical part of the first pleopod of the male, Form II; 8, *annulus ventralis*.

the apical portion. The shoulder is very poorly developed; it is better to say that it is absent inasmuch as the declivity is so great that in mesial or lateral view of the pleopod this characteristic structure of the *mexicanus* group is not evident; instead, the cephalic margin is insensibly continuous all along the side of the appendage (Plate 54, figs. 2, 3, and 4). The mesial process (Plate 54, figs. 5 and 6A) is flattened anteroposteriorly; its contour is elliptical and slightly grooved. The central projection (Plate 54, figs. 5 and 6CE) is better developed than in *P. llamasii*; its contour is rectangular, and the free border a little concave; the centrocaudal process (C) is narrow at its base, and its distal part is slightly recurved; the centrocephalic process (E) is wide and less chitinized than the former.

237 **Male, form II.** The rostrum is broader and the surface more excavate. The punctations of the carapace are less apparent than in the male, form I. The cephalic groove is deep dorsally, and the surface of the thoracic region is not flattened. The posterior prominence of the postorbital ridges is lower. The two lateral spines of the carapace are small. Of the two branchiostegal spines, the posterior is larger than the anterior. The first pair of pereopods are shorter; its length projected over the dorsal region of the body reaches the third abdominal somite. The chelae are small and weakly pubescent, moreover, narrow and the surface less scabrous. The dentiform processes of the cutting borders of the fingers are small, but the proximal ones predominate by their size; they also conserve the disposition in two series with a very narrow intermediate zone provided with small plaquettes the color of dark coffee. The meropodite exhibits a single spine that is larger in size than the others on the lower border.

The ischiopodite of the third pair of pereopods exhibits only one small tuberculiform prominence (Plate 53, fig. 8). The first pair of pleopods are similar in form to those of the adult male except the central projection is not so well developed, although the triangular form of the centrocaudal process is already evident and the centrocephalic has the form of a conical tubercle, the vertex of which is slightly turned toward the distal portion. The mesial process preserves the shape already mentioned for the male, form I, but its apex is more or less sharp.

Female. The margins of the rostrum are more convergent than in the male, form II; the rostral surface is less concave than in either form of the male; the lateral spines of the rostrum are well developed in the young females, but as the size increases, these spines become shorter; the acumen is sharp. The spines of the postorbital ridges are sharp and diverge forward; the posterior extremity of each ridge is somewhat prominent. The lateral spines of the carapace are unequal; the inferior is larger.

The chelae of the first pair of pereiopods (Plate 53, fig. 7) are proportionately much wider than those of the male; in regard to the pubescence, it is similar to that of the male. The length of the dactylopodite is equal to the palmar length plus one-half the length of the carpopodite; the teeth of the cutting border of this article and those of the immovable finger are arranged in a single row.

The apical region of the *annulus ventralis* (Plate 54, fig. 8) is truncate. The subapical part of the cephalic surface is slightly cleft by a groove which is curved in an arc in the caudal portion. Between the fifth pereiopods, there is a tubercle terminating in a short spiniform structure.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	72.2	45.0	58.8
Length of carapace	36.0	21.7	29.2
Anterior part of carapace	24.0	14.5	19.5
Length of areola	12.0	7.2	9.7
Width of areola	0.3	0.3	0.3
Length of abdomen	36.2	23.3	28.6
Posterior width of rostrum	6.6	3.4	5.0
Length of chela	28.2	13.4	17.5
Length of movable finger	16.0	7.3	10.5

Localities. Types and cotypes of Ortmann, collected in Coche, on the Coban River, Guatemala. Exped. du Mexique (Mus. Paris, 10 males I, 3 males II, 9 females). With respect to this locality, Ortmann made the following statement: "I have not been able to locate this place, nor a river 'Coban'; but Coban is the well-known capital of the province of Alta Vera Paz. The river at Coban is called Rio Cahabon. Coban, Alta Vera Paz, is the locality for a species of *Cambarus* mentioned by Huxley (1878)."

Belize, Honduras Británica. Exped. du Mexique (Mus. Paris, 1 male I, Ortmann).

Campo Menzel, 36 miles from the mouth of Río Hondo, in the territory of Quintana Roo, México (MCZ No. 7405), Mr. J. L. Peters, 1 young female, 35 mm in length. By the characteristics recorded by Faxon (1914), we think that it is *P. pilosimanus*.

Gruta de Zapaluta, 30 km S. of Comitán, Chiapas. The collection was made in the cave in a secondary tunnel that turns to the left approximately 300 meters from the entrance. These crustaceans were found in the small depression where there is water; in such circumstances, the capture was relatively simple. Considering the site where they were taken being distinctly dark, none of its characteristics denote

an adaptation to this kind of situation; for this reason they may be considered to be troglloxenes that took refuge in the pools within the cave while the conditions outside were unfavorable. These specimens were those that served for our observations.

Another locality. Villa Margaritas, 18 km E.N.E. of Comitán, Chiapas. The specimens were collected in the canals of a marsh. In these we noted a depigmented stripe on the carapace very similar to that in *P. llamasì*

239 According to the localities cited, *P. pilosimanus* occurs in the northern part of Guatemala, Belize, and the southern part of Chiapas and Quintana Roo.

Relationships. According to Ortmann, *P. pilosimanus* has definite affinities with *P. williamsoni* (Ortmann) in its geographic distribution. It is pertinent to note that the presence of two lateral spines on the carapace establishes a certain similarity between these species. We find more resemblance with *P. llamasì* and *P. acanthophorus* in the pilosity of the chela and in the general form of the first pair of pleopods of the male, form I. Among the differences pointed out by Ortmann between *P. pilosimanus* and *P. williamsoni* are the following:

<i>P. pilosimanus</i>	<i>P. williamsoni</i>
Pilosity well marked in adult individuals.	Chelae not pubescent.
Two branchiostegal spines.	One branchiostegal spine.
Shoulder hardly visible on first pair of pleopods of male.	Shoulder prominent.

Conclusions. The problem presented to us by *Procambarus mexicanus* (Erichson) is relatively simpler than that we faced in the case of *Procambarus weigmanni* [sic] (Erichson), notwithstanding that in these two cases, the specimens considered to be types were lost from the Berlin Museum. The first species, that is *P. mexicanus*, is interpreted according to his description by differences from *Procambarus aztecus* described by Saussure eleven years later. We ventured to affirm the former because we believe that Saussure did not have an opportunity to observe Erichson's types. At that time, the key structure for considering the similarity between *P. mexicanus* and *P. aztecus* was the hook on the ischiopodites of the third pair of legs present in these two species. The differences, in contrast, such as the form of the chelae and the spines on the internal part of the carpopodite, were considered of sufficient taxonomic value for separating these species. They are not the same interpretations as those of Hagen and Faxon [who did not agree with this], but as we have noted, they always considered *P. mexicanus* and *P. aztecus* synonyms and *P. consobrinus* a synonym of *P. cubensis*.

Despite the fact that the original description of Erichson is too sketchy and even could be considered to be superficial (this in addition

to a lack of illustrations and definite locality), *P. mexicanus* may well be the species occurring in the area of Jalapa, Veracruz, described by Hagen and Faxon. Hagen studied a female identified by him as *Procambarus weigmanni* [sic]; except for the characteristics of this specimen, based on photographs obtained in the Academy of Natural Sciences of Philadelphia, catalogue number 4176, it belongs to a species of the *mexicanus* group. Later, Ortmann completed the description of *P. weigmanni* [sic] made by Hagen with the study of a male of a completely different species. Consequently we should consider that the female described by Hagen is the first specimen of *P. mexicanus* that was recorded after Erichson's description was published, even though Hagen used the name *P. weigmanni* [sic]. The locality "Mexico," however, is so imprecise that we cannot consider it as representing the [type-locality of the] neotype of the species.

The description that Faxon made of a male specimen deposited in the Academy of Natural Sciences of Philadelphia and obtained from "El Mirador," Veracruz, seems to us more suitable for representing *P. mexicanus*, because apart from having a precise locality, there exists the coincidence that Von Deppe¹, who surely also collected the *P. mexicanus* described by Erichson, carried on his work in the region of Jalapa, Veracruz, an area considered to be very similar to that of "El Mirador" of the same State.

Genus *Paracambarus* Ortmann 1906 (S. Hobbs 1942b)

Diagnosis. First pleopod of first form male terminating in three distinct parts; mesial process long and robust, directed caudally at 60° angle to principal axis of appendage; cephalic process small and in form of claw partly covering central projection; latter somewhat resembling beak of bird; rudiment of caudal process visible near apex where evident in lateral aspect. Shoulder lacking on anterior margin of appendage. Male with hooks on ischiopodites of fourth pereopods only. Third maxilliped of normal size, bearing row of teeth on internal margin of ischiopodite.

Paracambarus paradoxus (Ortmann)

1906 *Cambarus* (*Paracambarus*) *paradoxus* Ortmann, Proc. Wash. Acad. Sci., Vol. VIII, pp. 3 – 6, fig. 1.

¹Von Deppe came to México accompanying Christian Julius Wilhelm Schiede in 1828, and, leaving Veracruz, they explored the environs of Jalapa, ascended Orizaba, and in the cold season they visited Papantla and Misantla. (*La Naturaleza — Bosquejo de la Historia de la Exploración Botánica de México*, by W. B. Hemsley — This important article, that has been translated for *La Naturaleza*, is taken from the Cuaderno XXII of the *Botánica Central Americana*. London, March 1887.)

- 1942b *Paracambarus paradoxus* (Ortmann). Hobbs, Amer. Midl. Nat., Vol. 28, No. 2, pp. 337, 340, 341, 344.
- 241 1947a *Paracambarus paradoxus* (Ortmann). Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México., Vol. XVIII, No. 1, pp. 233 – 240, pls. 1 – 2.

Diagnosis. Rostrum short with high margins and without lateral spines. Areola narrow. Male with hooks on fourth pair of pereopods; ischiopodites of third pair of pereopods with rudiment of hook. First pair of pleopods unequal; mesial process conical, chitinous, very well developed and directed caudodistally. Female with spiniform process, laterally flattened in apical region, between fifth pereopods.

Male, form I. The cephalothorax is compressed laterally and has a width more or less equal to that of the first abdominal segment; the surface of the carapace exhibits numerous punctations which are more clearly visible in the cephalic region; the branchial regions are finely punctate and the hepatic regions exhibit small tuberculiform prominences.

The rostrum is short, grooved, and the surface smooth; the rostral margins are heavy, straight, and convergent; the rostrum lacks lateral spines and in the place where they are usually found, an angle is present at the base of the broad, short acumen; the acuminal spine has the form of a blunt tubercle directed upward and forward. On the lower face of the rostrum there is a carina which, beginning at the apical tubercle, runs the total length; in the posterior region of this keel there is a group of three tubercles implanted in an elevation of the carina (Plate 55, fig. 1).

The postorbital ridges begin a short distance in front of where the rostral margins end; they are parallel and end anteriorly in an exceedingly small spiniform process.

The cephalic groove is deep and with ample margins; laterally it becomes less deep and its continuity with the groove, which limits the hepatic region posteriorly, disappears (Plate 55, fig. 1).

The areola is narrow, weakly marked by the suprabranchial grooves; the areolar surface exhibits small punctations which are more noticeable in the area adjacent to the cephalic groove (Plate 55, fig. 2).

The proportions of the different regions of the carapace are the following: the length of the areola is slightly greater than one-half that of the cephalic region of the carapace; the posterior width of the rostrum goes into the total length of the carapace six times; the length of the rostrum is a little more than one-fifth the total length of the carapace (Plate 55, fig. 2).

- 242 The first segment of the abdomen is approximately the same width as the posterior part of the cephalothorax. The somites are almost smooth in the dorsal region with only a few isolated punctations; in contrast, the

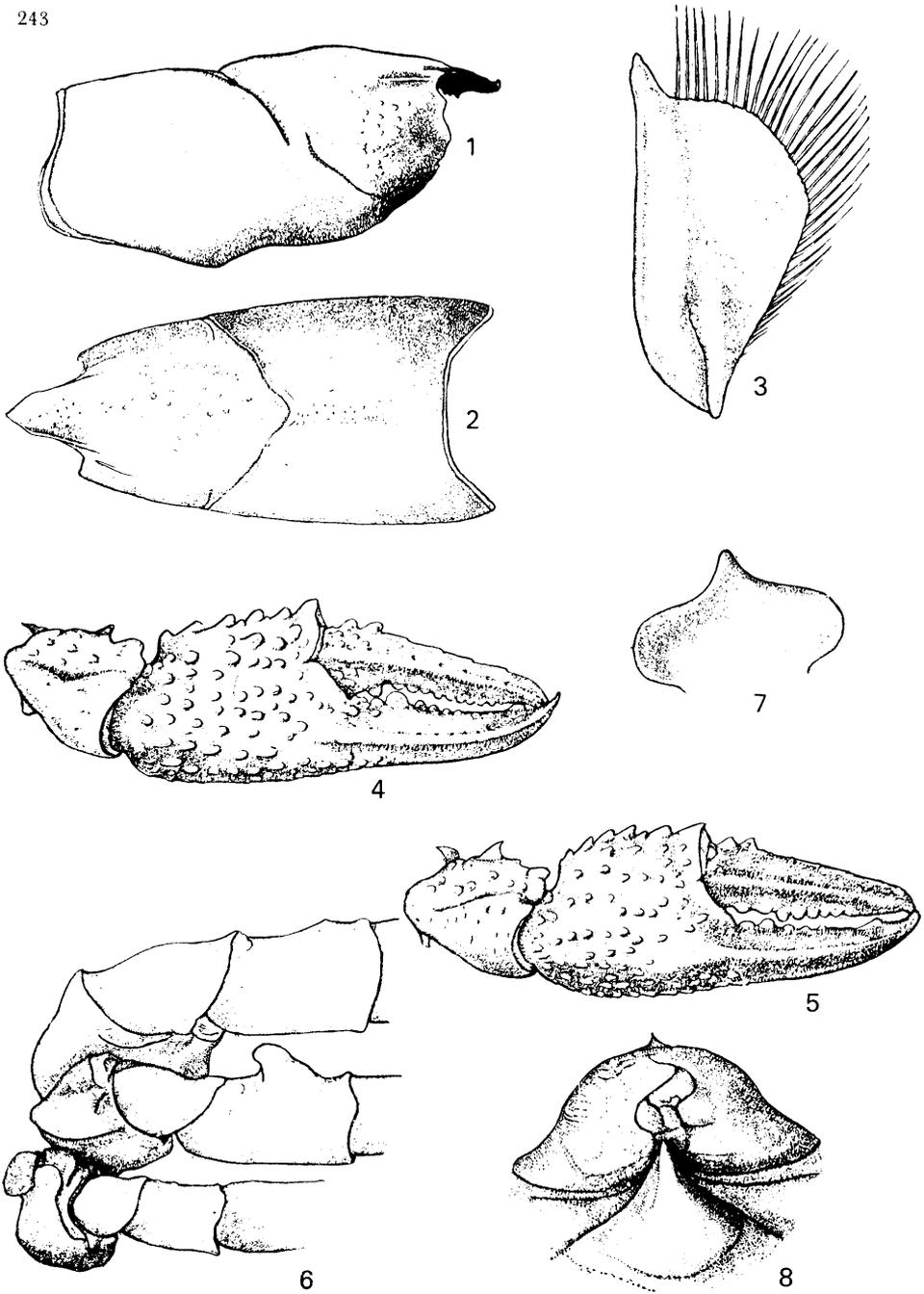


Plate 55. *Paracambarus paradoxus* (Ortmann). Male, Form I.

1, lateral view of the carapace; 2, dorsal view of the same; 3, antennal scale; 4, chela; 5, chela of the female; 6, ischiopodites of pereopods III to V of the male, Form I; 7, epistome of same; 8, *annulus ventralis*.

pleural regions as well as the telson and the two rami of the uropods have abundant punctations. The first section of the telson exhibits two or three spines on each side of its distal portion; the distal border of the ultimate portion is semicircular.

The epistome is symmetrical and scutiform with a median anterior angular prominence prolonged toward the dorsal region in a keel or crest; the contours are entire, rounded, and slightly elevated above the surface (Plate 55, fig. 7). The basal article of the antennules exhibits a robust spine on the lower internal margin; it is conical in form and slightly inclined forward.

The antennae exhibit a scale (Plate 55, fig. 3) with a strong spine which has a chitinized apex; the greatest width of the scale is anterior to its midlength; the latter is exactly double the former; the antennal flagellum hardly exceeds the length of the carapace when projected over it.

The first pair of pereiopods are robust; the meropodite is almost smooth along the entire length of the dorsal margin, exhibiting only a group of small tubercles near the articulation; among them one is conspicuous by its larger size; the inferior margin of this article exhibits two rows of tubercles united only near their extremities but clearly separated in the middle part of the length of the article; the spines of the internal margin are conical in form and are directed forward; the distal spine of this row is the largest and those that follow decrease in length toward the proximal end [of the podomere]; the spines of the external row are more tuberculiform; among them there is one large one located in the middle part of the row; the lateral regions of the meropodite are smooth. The external surface of the carpopodite is provided with setiferous punctations; the dorsal region exhibits a groove extending the total length of the article; the internal surface is provided with subsquamous tubercles. The chela is slightly depressed and the palm much shorter than the fingers; the dorsal face of the chela is provided with heavy subsquamous tubercles that continue onto the first third of the immovable finger. These prominences reach their greatest size on the margins; those of the internal border give it the appearance of an
244 indented crest which may be composed of as many as six tubercles, all of them directed forward. The external margin is rounded, different from the internal which is cristiform. The major part of the ventral face of the palmar region is smooth with a few tubercles very near the internal margin. The immovable finger is more robust than the dactylopodite and exhibits on each of its faces a ridge that runs the entire length; these ridges are limited laterally by coarse setiferous punctations; the teeth of the cutting border are distributed in the following manner: proximally there are two small teeth, then a large one, and following is a series of eight or nine teeth which diminish in

size progressively toward the distal extremity; moreover, there is another dentiform process on the subterminal region of the finger implanted on the lower part of the cutting border. The dactylopodite is less robust, slightly curved, with a ridge on both faces limited by punctations similar to those found on the immovable finger; the cutting border exhibits more dentiform tubercles than does the immovable finger; of them, one is conspicuously larger than the others (Plate 55, fig. 4).

The ischiopodite of the third pair of pereopods lacks hooks; however, in the distal region of the article there is a small conical prominence flattened in the same plane as the ischiopodite. The appearance and position of this structure leave no doubt that it represents a very reduced hook, corresponding to the ischiopodites of the third pair of pereopods, a generic characteristic of *Procambarus* (Plate 55, fig. 6).

The ischiopodite of the fourth pair of pereopods has a large tubercle in the form of a spoon, the concave surface of which is directed within and bears numerous short setae; the tubercle originates directly from the distal margin of the article, and its apical region terminates in a blunt surface. On the coxopodite of this same appendage, a spindle-shaped prominence is located on the internal part.

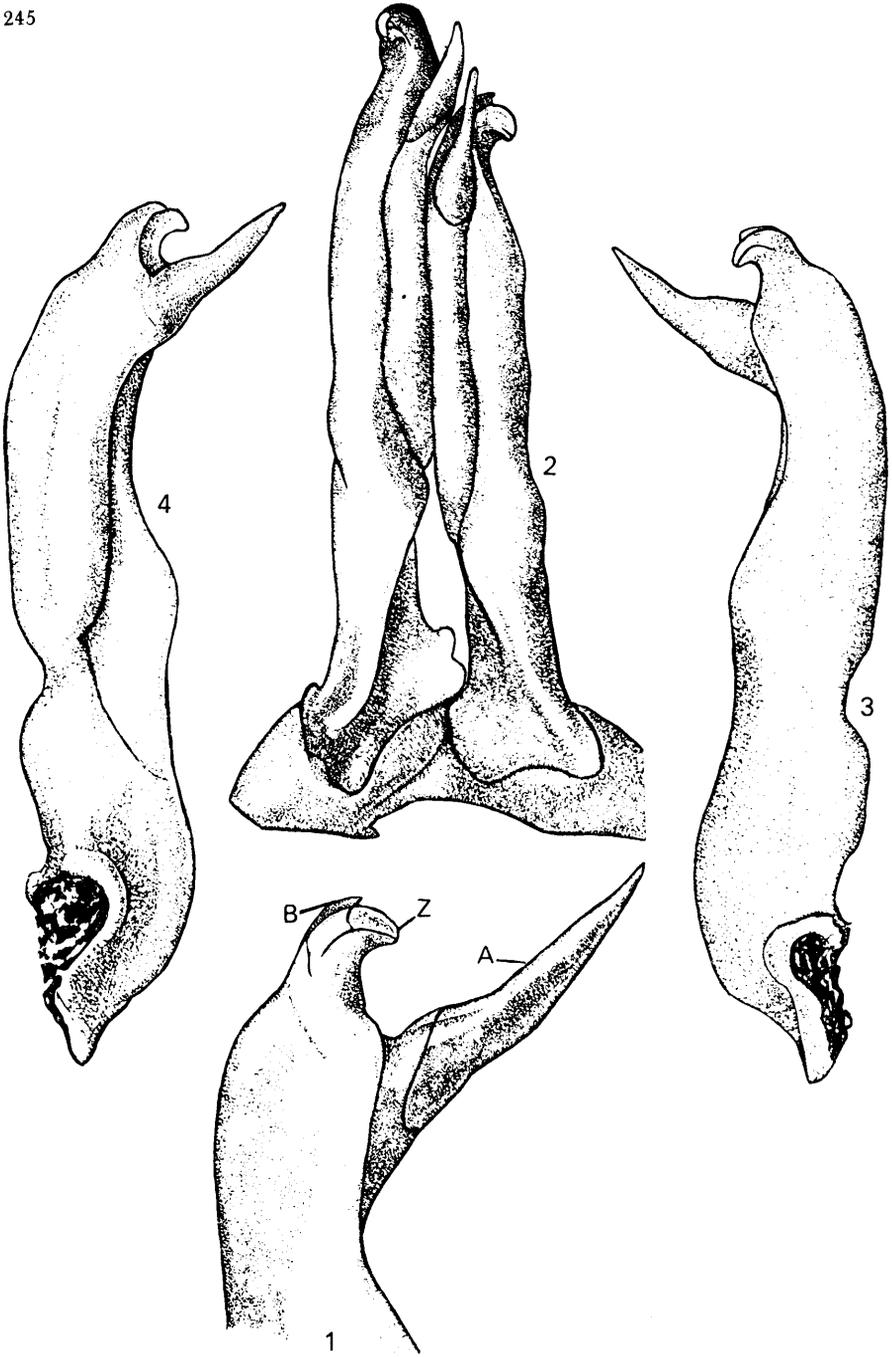
The coxopodites of the fifth pair of appendages exhibit a semi-circular plate with a smooth margin situated on the posterodistal part of the article (Plate 55, fig. 6).

246 The apical parts of the first pair of pereopods reach the middle section of the coxopodites of the third pair of pereopods; they are relatively short and robust, their distal portions extending clearly toward the caudal region and slightly laterally; they are unequal in size (that of the right is larger), which gives place to an asymmetry that is manifested mainly in the basal region of the appendages; the internal part of the right pleopod exhibits two prominences on its internal part that are located above the corresponding prominences of the left pleopod (Plate 56, fig. 2). The mesial process is large, strong, and chitinous; it is not straight; instead it is gently bent, permitting a slight deflection toward the distal region; at its insertion with the rest of the appendage, it forms an angle of approximately 135°; the extremity of this process overreaches the apical part of the appendage (Plate 56, figs. 3 and 4).

The cephalic process has an apical anterior position; its appearance

Plate 56. *Paracambarus paradoxus* (Ortmann). Male, Form I.

1, lateral view of the apical region of the first pleopod (A, mesial process; B, cephalic process; Z, central projection); 2, caudal view of the first pair of pleopods; 3, lateral view; 4, mesial view.



is that of a triangular plate, the vertex of which is directed distolaterally (Plate 56, fig. 1B).

The central projection is clearly chitinized, resembling in form the beak of a bird, and is curved caudolaterally; on it is a central line which starting from the vertex divides the structure into two portions that correspond to the centrocaudal process and the centrocephalic process (Plate 56, fig. 1Z).

Male, form II. The differences that may be noted with respect to the form I are principally in the hooks on the ischiopodites of the fourth pair of pereopods and in the appearance of the first pair of pleopods.

In the first case, we observe that the hooks on the ischiopodite of the fourth pair of pereopods vary according to the sexual stage which here seems to be less advanced. Correspondingly, the small process which appears so clearly on the ischiopodites of the third pair of pereopods is smaller and disappears completely in the younger males.

With regard to the first pair of pleopods, they exhibit little chitinization in the apical region. The difference in size between the appendages persists even in the very young forms. The mesial process is not chitinized, is conical in form, almost straight, but retains its caudal position. The platelike aspect of the cephalic process persists although it is thicker. With regard to the central projection, it exhibits a conspicuous difference from that of the form I; it resembles a very small conical tubercle and is partly covered by the cephalic process.

Female. The chelae of the first pair of pereopods are short; their length in respect to the rest of the articles reaches the proximal margin of the basipodite; both the immovable finger and the dactylopodite are slender and their cutting borders differ little from those of the chela of the male (Plate 55, fig. 5).

247 Anteriorly, the *annulus ventralis* has a semicircular contour. The groove begins in the anteromedian part very near the junction of the *annulus* with the body, describes two curves, and forms an S between the arcs of which arise prominences that are derived from the elevated margins that limit the groove (Plate 55, fig. 8).

The spiniform tubercle found between the fifth pereopods is well developed; it is conical at its base, and the apex is flattened laterally; the vertex touches the caudal part of the annulus.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	56.5	56.0	51.0
Length of carapace	27.5	28.0	26.2
Anterior part of carapace	18.0	18.0	17.5
Length of areola	9.5	10.0	9.3

Width of areola	3.0	2.5	3.0
Length of abdomen	31.0	30.5	26.5
Posterior width of rostrum	4.3	5.0	5.0
Length of rostrum	6.2	6.0	6.5
Length of chela	20.5	21.5	18.0
Length of palm	7.2	7.2	7.2
Length of movable finger	13.0	12.0	11.0

Locality. Tetela de Ocampo y La Cañada, 35 km N.E. of Zacapoaxtla, Puebla (type locality).

Relationships. The general considerations concerning the phylogenetic affinities are placed at the end of the description of *Paracambarus ortmannii*.

Paracambarus ortmannii Villalobos

1949 *Paracambarus ortmannii* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de Mexico, Vol. XX, pp. 332 – 339, pls. 1 and 2.

Diagnosis. Size rather small. Rostrum without lateral spines. Hooks only on ischiopodites of fourth pair of pereopods of male. First pair of pleopods unequal in length, with their apical regions turned toward caudal region; mesial process not overreaching apical part which formed only by central projection. Basal region of right pleopod with two processes very close together on internal part of appendage. *Annulus ventralis* with cleft in caudal region, laterally flattened spiniform process between fifth pereopods of female.

248 **Male, form I.** The body is small and narrow. The carapace is long and compressed; its surface is punctate and the larger punctations are located in the dorsal region, especially on the posterior part of the rostrum; the lateral regions have punctations, but these are small and provided with from two to five setae which adhere to the surface and which are disposed in a divergent manner; the hepatic regions have small subsquamous tubercles disposed in concentric semicircles. The areola is marked by punctations that have lost their circular contour and become elongated in the plane of the suprabranchial grooves which in this instance are not visible; the surface of the areola is covered with punctations.

The rostrum is rather short, triangular in form, and without lateral spines; its surface is slightly concave and covered with punctations; the acumen ends in a small conical chitinized spine, its apex elevated. The ventral keel of the rostrum exhibits a series of four dentiform processes on the proximal region of which the smallest occurs at the base of the rostrum.

The postorbital ridges are almost parallel; they lack spines on the anterior part.

The cephalic groove is deep without pronounced undulations; the part of the groove that limits the hepatic region posteriorly is less profound and almost circular except for a smooth undulation in the lower part; the groove ends in a small branchiostegal spine.

The proportions that exist between the different parts of the carapace are the following: the length of the areola goes into the length of the cephalic portion two and one-third times; the posterior width of the rostrum goes into the total length of the carapace a little more than six times; the length of the rostrum is almost four and one-half times shorter than the total length of the carapace (Plate 57, figs. 1 and 2).

The abdomen is narrower than the carapace; the surface of the somite is slightly punctate with the number of punctations increasing in the pleural regions; the two ultimate segments still retain the setae which are so characteristic of the punctations of this type that we described earlier. The telson appears decidedly pubescent; the posterolateral angles of the first section exhibit only two spines.

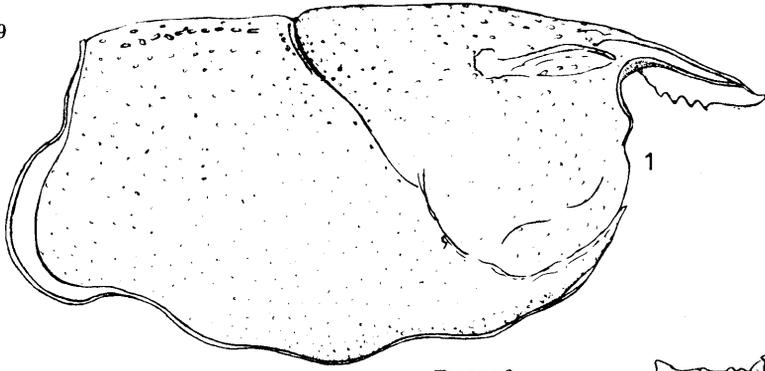
In the specimen that is described, the epistome is asymmetrical but in the other specimens tends to retain a heptagonal contour; the margins are elevated, terminating anteriorly in a central apex (Plate 57, fig. 3).

250 The antennal scale is short; the spine slightly overreaches the anterior extremity of the rostrum; the greatest width is exactly half the length (Plate 57, fig. 4).

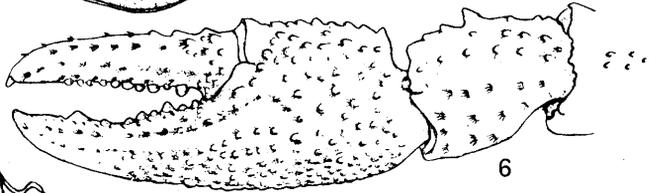
The first pair of pereopods are well developed; the meropodite exhibits subsquamous tubercles on the superior and anterior part, but are more prominent in those of the chela; on the inferior margin we find the conical spines so characteristic of this article in the crayfishes; the internal row consists of nine spines of which the smallest are the proximal ones; the external row has fewer of these structures, being larger but of unequal size; of this series first there are four small spines, then a large one followed by four other small ones; these latter are implanted on the articular border and the series converges with the spines of the internal row. The carpopodite is one and one-half times less than the length of the dactylopodite; the upper surface is scabrous and exhibits a somewhat deep groove which separates this surface into two portions, an external provided with punctations and an internal armed with subsquamous tubercles; the emargination of the articular border over that which flexes the chela is armed with four conical

Plate 57. *Paracambarus ortmanni* Villalobos. Male, Form I.

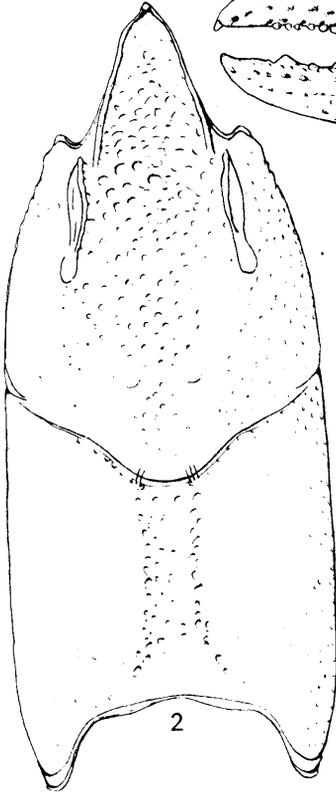
1, lateral view of the carapace; 2, dorsal view of the same; 3, epistome; 4, antennal scale; 5, chela; 6, chela of the female; 7, ischiopodites of pereopods III to V of the male, Form I.



1



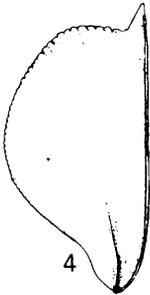
6



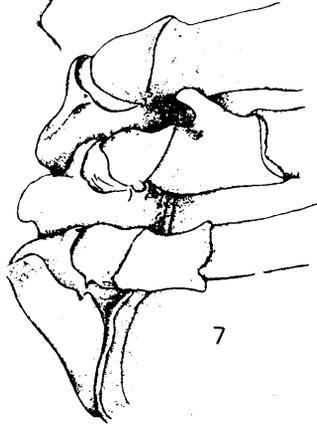
2



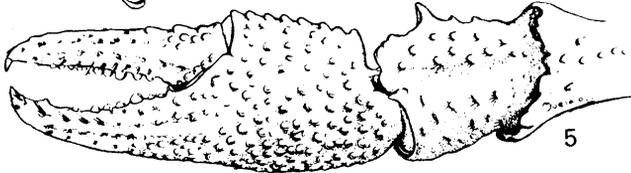
3



4



7



5

spines, two large ones, and between them two small ones; moreover, on the external side of the distal extremity there are two processes, one of them triangular in form and larger than the other.

In regard to the chela, we may say that the fingers are short and robust and the palm is ovate in outline. The internal border of the movable finger, or dactylopodite, exhibits two tubercles that stand out clearly very near the articular region; in the proximal and upper region of this same article, there is a series of prominences clustered in an irregular manner, but one row of four of the prominences is arranged along the length of the articular margin. The cutting border of the immovable finger is armed with small teeth which are disposed in the following manner: proximally first there are two slightly separated teeth, then a series of four teeth the size of which decreases distally; thereafter, there is a tooth somewhat separated from this group, and finally a series of three small teeth close together. The immovable finger is slightly shorter and more robust than the movable finger; the cutting border is concave and exhibits teeth similar in form to those of the opposite finger, but which are arranged in a different manner; in the same order as the former: there are first two small teeth, next a large one which stands out from all of them, followed by three small teeth more or
251 less close together, and finally another also small but slightly separated from the others. A little before the extremity there is a triangular spiniform process (Plate 57, fig. 5).

The third pair of pereopods lack tubercles on the ischiopodites.

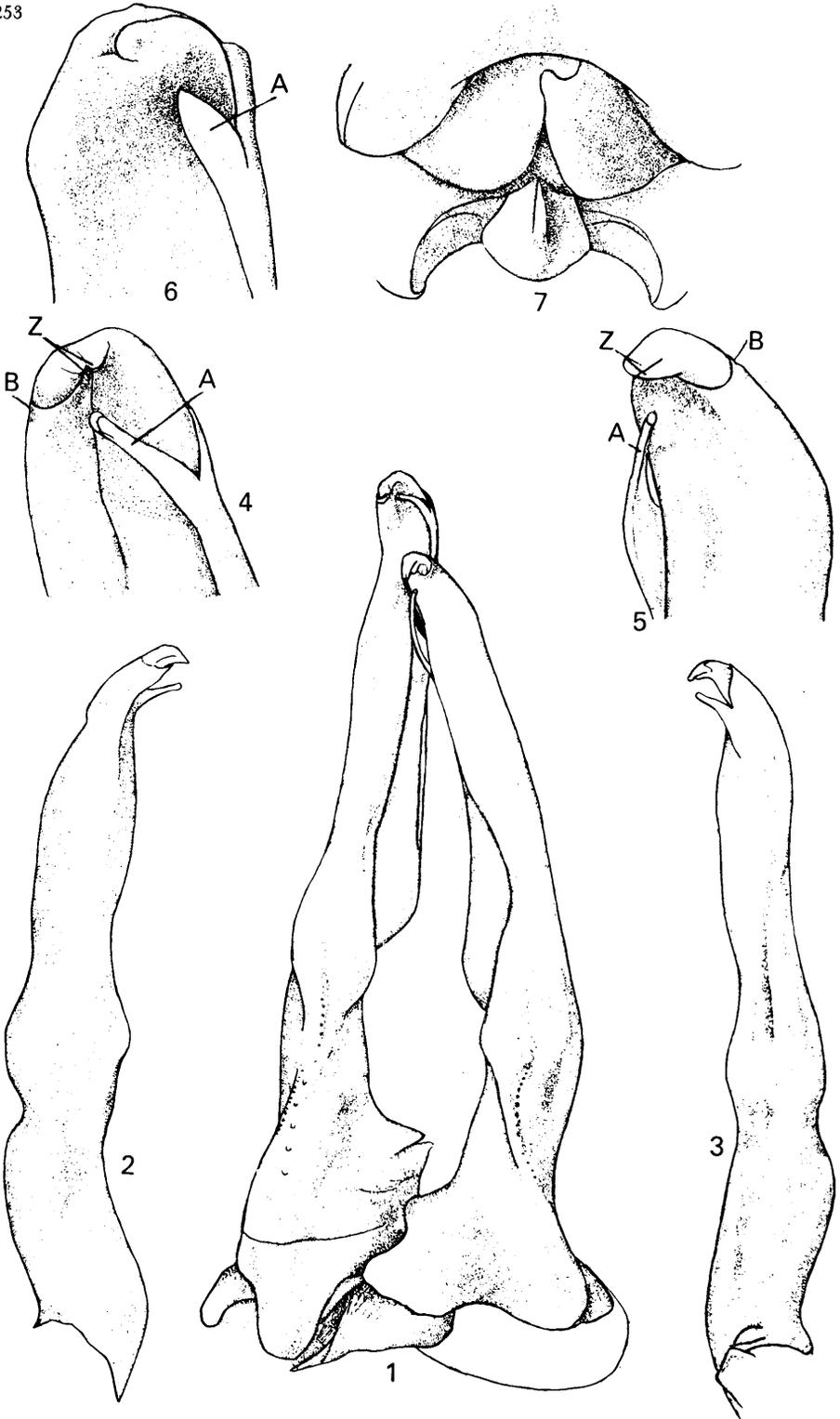
The coxopodites of the fourth pair of pereopods have a process similar to that described in *Paracambarus paradoxus*, but, in this case, the inferior extremity does not project freely. The hook on the ischiopodite is well developed and its terminal part has the form of a mitten; at its insertion, it occupies almost the entire length of the article (Plate 57, fig. 7).

The coxopodites of the fifth pair of pereopods have a small semicircular laminate process disposed perpendicular to the major axis of the body.

The apical regions of the first pair of pleopods touch the coxopodites of the third pair of pereopods; they are slender, convergent distally, and the apical parts are directed toward the caudal region. The right pleopod exhibits two more or less conical processes on the internal part of the basal region, their vertices very close together. The

Plate 58. *Paracambarus ortmanni* Villalobos. Male, Form I.

1, caudal view of first pair of pleopods; 2, lateral view; 3, mesial view; 4, caudal view of the apical region of the first right pleopod; 5, caudolateral view of the apical part of the first left pleopod (A, mesial process; B, cephalic process; Z, central projection); 6, caudal view of the apical part of the first pleopod of the male, Form II; 7, *annulus ventralis*.



left pleopod is smaller and is curved gently within (Plate 58, figs. 1, 2, and 3).

With respect to the elements that constitute the apical part, there are four the mesial process, the two processes of the central projection, and the cephalic process (Plate 58, figs. 4 and 5).

The mesial process is small and little chitinized, attenuated at its extremity, and flattened in the basal region; its extremity clearly shows an aperture which on the left pleopod is circular whereas that on the right exhibits two small lips (Plate 58, figs. 4. and 5A). The central projection is the most conspicuous part of the appendage; it is bent at an angle toward the caudal region, and the two structures that normally constitute it may be clearly distinguished (Plate 58, figs. 4 and 5Z).

The cephalic process is no more than a chitinized ridge which, like a collar, extends all along the external part of the base of the central projection (Plate 58, figs. 4 and 5B).

Male, form II. In this case, it is larger than the male, form I. The carapace is smoother, the rostrum wider and almost flat. The gastric region exhibits circular punctations that are more abundant in the median line; the branchial regions are also punctate, although not so densely as in the male, form I.

252 The third and fourth pairs of pereopods are very similar to those of the male, form I, but in this specimen the hook on the ischiopodite of fourth pair is very reduced in size.

The first pair of pleopods, except for the apical regions, are very similar to those of the form I, with the following exceptions: the tubercles of the internal basal region of the right pleopod are not sharp-pointed but rather blunt at their apices. In the basal region of the left pleopod, there is a small conical spiniform process situated exactly in the middle internal region of the pleopod. The apical parts are also slightly turned toward the caudal region; of the apical structures, only the mesial process is distinct; it is shorter, robust, and conical in form; it marks the beginning of a ridge which turns in a spiral and in the center of the ridge terminates in a prominence which represents the central projection (Plate 58, fig. 6).

Female. The specimen is also more robust than the male. The carapace is punctate over most of its surface; in the cephalic region these punctations are more visible.

The rostrum is subtriangular with a flat surface; the rostral margins do not have lateral spines, and they are more elevated in the apical region.

The postorbital ridges are elevated and lack spines on the anterior end.

The chelae are large, the entire surface covered with subsquamous tubercles. The fingers are slightly shorter and more robust than those of

the male. The carpopodite has four conical teeth on the articular emargination, one of which is very small. The two rows of teeth on the lower border of the meropodite appear very distinct from those that we described for the male, form I: the difference exists in that these rows are almost parallel in the female; the internal row comprises twelve teeth and the external, seven (Plate 57, fig. 6).

The *annulus ventralis* is typical of the genus *Paracambarus* and very similar to that of *P. paradoxus*; it is almost symmetrical, with an angular emargination in the caudal region. The groove is small and skewed to the left side (Plate 58, fig. 7).

Between the fifth pereopods, there is a spiniform, laterally flattened structure, the anterior border of which intrudes into the caudal margin of the *annulus ventralis* (Plate 58, fig. 7).

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	43.2	46.5	48.3
Length of carapace	20.8	22.9	23.5
Anterior part of carapace	14.2	15.2	16.0
Length of areola	6.6	7.7	7.5
Width of areola	2.1	2.3	2.4
Length of abdomen	22.4	23.6	24.8
Posterior width of rostrum	3.4	3.7	3.7
Length of rostrum	4.5	4.9	...
Total length of chela	15.5	16.4	15.9
Length of palm	7.4	7.2	8.0
Movable finger	8.9	9.3	9.4

Locality. Los Estajos, 6 km N.E. of Zihuateutla, Puebla. Collected in a small stream which runs along the right side on the way to the Rancho El Mirador. In the same locality, we found two other species, *Procambarus hoffmanni* and *P. erichsoni*.

Relationships. This species is similar to *P. paradoxus* in the following characteristics:

I. The apical parts of the first pair of pleopods of the male, form I, are turned toward the caudal region.

II. The mesial process is borne subdistally.

III. It has tuberculiform processes on the basal internal region of the first right pleopod.

IV. The apical region of the process between the fifth pereopods is flattened laterally.

The differences that we found for separating *Paracambarus ortmannii* are as follows:

I. The basal region of the right first pleopod of the male, form I, exhibits two tubercles that are very close together.

II. The cephalic process of the male, form I, has the form of a subapical ridge. The mesial process is very slender and little chitinized.

III. The caudal portion of the *annulus ventralis* bears an angular emargination.

IV. The ischiopodite of the third pair of pereopods lacks a trace of a tubercle.

The genus *Paracambarus* has close affinities with *Procambarus*; the characters of the two unique species clearly point out its possible phylogenetic ascendancy with those of the *blandingii* Subgroup; *Procambarus caballeroi* and *Procambarus tolteca* are intermediate species that exhibit strong similarities to members of the genus *Paracambarus*.

At one time, we considered that the unique existence of hooks on the fourth pair of pereopods should be the character for grouping all of those species that exhibit it in the genus *Paracambarus*. Later, we amended this taxonomic criterion and broadened the generic diagnosis of *Procambarus* in reference to the situation and number of hooks on the pereopods of the male. Consequently, the species of *Paracambarus* that possess hooks only on the ischiopodites of the fourth pair of pereopods should not be grouped with those *Procambarus* that possess this same character, instead with the species of the *blandingii* Subgroup, already mentioned, with which they share many other characters such as the features of the first pair of pleopods of the male, form I, and the coxopodites of the fourth pair of pereopods.

From a geographic point of view, *Paracambarus* is situated in the same general geographic territory in which the species of the *riojae* Section are distributed, but this is no more than the result of an invasion toward the south by the *blandingii* Subgroup, and if we consider that from this group the genus *Paracambarus* was derived, this logically results in the localization of *Paracambarus paradoxus* and *Paracambarus ortmannii* in the region.

Genus *Cambarellus* (Ortmann 1905a) S. Hobbs 1942b

Diagnosis. First pleopods of first form male terminating in three distinct parts, cephalic process always absent; terminal structures spiniform, somewhat truncate, spatulate, or grooved. In male, hooks present on ischiopodites of second and third pairs of pereopods. Very small crayfishes rarely attaining length of five centimeters. Third maxillipeds proportionately of normal size, with row of teeth along internal margin of ischiopodite.

Hobbs (1945b) has established three sections for this genus which he separated by the following key :

- 1 Terminal elements of first pleopods of first form male straight . . .
 *shufeldtii* Section
- 256 1' Terminal elements of first pleopod of first form male curved
 (directed caudadistally) 2
- 2(1') Mesial process of first pleopod of first form male grooved . . .
 *montezumae* Section
- 2' Mesial process of first pleopod of first form male not grooved but
 truncate or spiniform *schmitti* Section

MONTEZUMAE SECTION

[*Cambarellus montezumae montezumae* (Saussure)]

- 1857 a *Cambarus montezumae* Saussure, Rev. et Mag. Zool., 2nd Ser., Vol. IX, p. 102.
- 1858 *Cambarus montezumae* Saussure, Mém. Soc. Phys. Hist. Nat., Geneve, Vol. XIV, p. 459, fig. 22.
- 1870 *Cambarus mexicanus* (Erichson). Hagen, Mem. Mus. Comp. Zool., Harvard Coll., No. 3, p. 85.
- 1884 *Cambarus montezumae* (Saussure). Faxon, Proc. Amer. Acad. Arts and Sci., Vol. XX, p. 149.
- 1885 a *Cambarus montezumae* (Saussure). Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. X, No. 4, pp. 121 – 123, Pl. 2, fig. 6; Pl. 10, figs. 7, 7', 7a, 7a'.
- 1898 *Cambarus montezumae* (Saussure). Faxon, Proc. U.S. Nat. Mus., Vol. XX, p. 660.
- 1902 *Cambarus montezumae* (Saussure). Ortmann, Proc. Amer. Phil. Soc., Vol. XLI, p. 278.
- 1905 a *Cambarus (Cambarellus) montezumae* (Saussure). Ortmann, Proc. Amer. Phil. Soc., Vol. XLIV, pp. 97, 106, 127, Pl. 3.
- 1906 *Cambarus (Cambarellus) montezumae* (Saussure). Ortmann, Proc. Wash. Acad. Sci., Vol. VIII, pp. 19 – 20.
- 1914 *Cambarus montezumae* (Saussure). Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, pp. 371, 416.
- 1942 a *Cambarus (Cambarellus) montezumae* (Saussure). Hobbs, Proc. Fla. Acad. Sci., Vol. V, p. 57, Pl. 2, figs. 6, 7.
- 1942 b *Cambarellus montezumae* (Saussure). Hobbs, Amer. Midl. Nat., Vol. 34, No. 2, p. 340.
- 1943 *Cambarellus montezumae* (Saussure). Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XIV, No. 2, pp. 587 – 599, Pl. 1.
- 1945 b *Cambarellus montezumae* (Saussure). Hobbs, Amer. Midl. Nat., Vol. 34, No. 2, p. 467.

- 1950 *Cambarellus montezumae* (Saussure). Hobbs, Proc. Biol. Soc. Wash., Vol. LXIII, p. 89.
- 1952 *Cambarellus montezumae* (Saussure). Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXII, No. 2, p. 531.

257 **Diagnosis.** Small crayfishes. Male with carapace same width as abdomen; length of carapace projected over abdomen reaching sixth abdominal somite. Rostrum with lateral spines; acuminal spine slightly exceeding second article of antennular peduncle. Postorbital ridges terminating anteriorly in short, blunt process. Carapace without lateral spines. Areola broad (width six and one-half times less than length of carapace). Posterolateral angles of first section of telson with spine. Sexual dimorphism in chelae. Ischiopodites of second and third pairs of pereopods with hooks. First pair of pleopods of male, form I, subequal in length; mesial process membranous and excavate. *Annulus ventralis* in form of U, with articulation in either of its rami. Spiniform process between fifth pereopods of female.

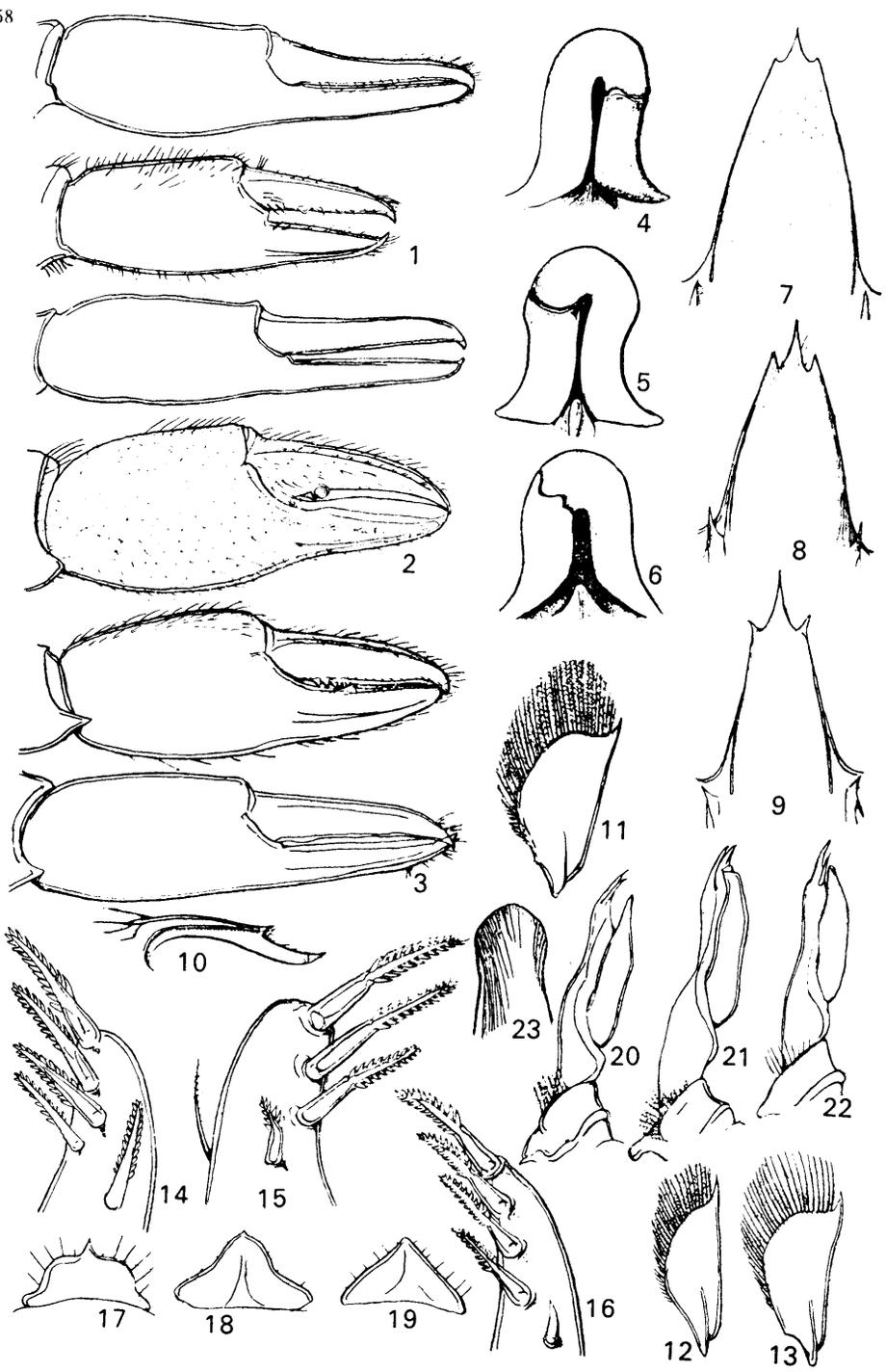
Cambarellus montezumae zempoalensis Villalobos

- 1943 *Cambarellus montezumae* Fma. *zempoalensis* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XIV, No. 2, pp. 601 – 603, Pl. 2, figs. 2, 4, 7, 13, 16, 17, 20.

Diagnosis. Areola moderately broad, three and one-half times shorter than length, with punctations dispersed on its surface. Rostrum broad at base, very narrow at apex; rostral margins convex and very convergent; lateral spines present, very close together; space between them equal to length of acumen; latter reaching distal articular border of second antennular article. Hooks on ischiopodites of second and third pairs of pereopods in male, neither bituberculate. Apices of first

Plate 59.

1, chelae of the male and of the female from Lago de Pátzcuaro; 2, chelae of the male and of the female from Lagunas de Zempoala; 3, chelae of the male and of the female from Río Lerma; 4, *annulus ventralis* of a female from Lagunas de Zempoala; 5, *annulus ventralis* of a female from Río Lerma; 6, *annulus ventralis* of a female from Lago de Pátzcuaro; 7, rostrum of a specimen from Lerma; 8, rostrum of a specimen from Zempoala; 9, rostrum of a specimen from Pátzcuaro; 10, lateral view of the rostrum of a specimen from Pátzcuaro; 11, antennal scale of a specimen from Lerma; 12, antennal scale of a specimen from Pátzcuaro; 13, antennal scale of a specimen from Zempoala; 14, maxillular endopodite of a specimen from Lerma; 15, maxillular endopodite of a specimen from Pátzcuaro; 16, maxillular endopodite of a specimen from Zempoala; 17, epistome of a specimen from Zempoala; 18, epistome of a specimen from Lerma; 19, epistome of a specimen from Pátzcuaro; 20, first pleopod of a specimen from Lerma; 21, first pleopod of a specimen from Pátzcuaro; 22, first pleopod of a specimen from Zempoala; 23, superior part of the mesial process of the first pleopod of a specimen from lago de Pátzcuaro.



pair of pleopods reaching posterior part of coxopodite of third pair [of pereopods], and terminating in three distinct parts; distal region of mesial process very narrow and excavate; central projection slightly recurved caudally; caudal process inclined caudally at angle of approximately 135° and shorter than central projection. *Annulus ventralis* slightly asymmetrical; suture on distal extremity of one of its rami disposed perpendicularly; cristiform process between fifth pereopods.

259 **Male, form I.** Generally it is smaller than the females. The carapace is slightly compressed, especially in the cephalic region since the branchial region is decidedly convex; the width of the carapace at the level of the caudal margin of the cephalic groove is less than the height; the greatest width is located at the level of the anterior part of the areola.

The areola is moderately broad and three and one-half times less than its length. The surface exhibits punctations located principally in the anterior half.

The postorbital ridges are subparallel and terminate anteriorly in a spine directed forward.

The surface of the carapace is provided with very few punctations of which the largest are located on the suprbranchial margins. The suborbital angle is approximately 90° and exhibits a rounded vertex.

The rostrum is broad at the base, narrow at the apex, and moreover gently flexed downward. The rostral margins are convex and convergent; the lateral spines are very short and are directed forward. The acumen is triangular and relatively short; its length is equal to the distance between the two lateral spines, whereas its apex reached the distal articulation of the second article on the antennular peduncle. The major part of the surface of the rostrum is flat, but slightly excavate at the level of the lateral spines (Plate 59, fig. 8).

The epistome is subtriangular or scutiform, with the anterolateral margins convex (Plate 59, fig. 17).

The abdomen is slightly longer than the carapace; the length of the latter reaches the posterior part of the cephalic section of the telson. In the posterolateral angles of the cephalic part of the telson there are one or two spines the length of which is less than that of the lateral spiniform process of that part of the telson.

The flagellum of the antennae reaches the first abdominal segment. The antennal scale is broad with the anterointernal margin almost perpendicular to the major axis of the body; the spine of the scale is long and sharp, the apex slightly overreaching the distal articular margin of the second article of the antennular peduncle (Plate 59, fig. 13).

The palm of the chela of the first pair of pereopods is almost cylindrical and very heavy in the proximal region, but compressed distally; the dactylar region is extremely slender. The surface of the chela

is completely smooth. The length of the dactylar region is greater than that of the palm, reaching the distal fourth of the carpopodite. The immovable finger, as well as the dactylopodite, is very slender and the cutting borders are devoid of teeth; the setiferous punctations of these margins are close together and the bundles of setae are short. The internal margin of the dactylopodite is almost straight (Plate 59, fig. 2).

The ischiopodites of the second and third pairs of pereiopods exhibit hooks; the hook of the second pair, which is implanted on the middle part of the margin of the article, is flattened and its apex rounded; the axilar margin is almost straight but slightly excavate in the proximal region; the hook of the third pair is implanted on the distal two-thirds of the margin of the article; it is sharp and its vertex is slightly recurved; the axilar margin is concave with a small prominence on the middle part.

The apical parts of the first pair of pleopods reach the coxopodites of the third pair of pereiopods. The apical processes are slightly inclined toward the caudal region. The mesial process is membranous, narrow, and rectangular in its terminal part, and moreover grooved; its extremity reaches the subapical region of the caudal process. The central projection is sharp apically and very wide at the base, and regularly curved in a caudal direction. The caudal process is spiniform, straight, and inclined at an angle of approximately 135° with respect to the appendage; its length is slightly less than that of the central projection (Plate 59, fig. 22).

Male, form II. The rostrum is subplane and the margins are very little elevated above the surface; moreover, they are decidedly convergent; the lateral spines of the rostrum appear as two short processes; the acumen is very broad and short, its apex overreaching the second third of the second article of the antennular peduncle. The postorbital ridges exhibit very small spines. The width of the areola has the same proportion with respect to the length as that mentioned for the male, form I.

The chelae are a little more compressed and the fingers broader and shorter than in the male, form I.

The distal extremity of the first pair of pleopods slightly overreach the anterior region of the coxopodites of the fourth pair of pereiopods. Their apical parts are short and flattened laterally. The mesial process is semicircular in contour, the central projection triangular, and the caudal process subcylindrical, slightly sharp at the apex.

Female. Reaches a size greater than that of the males. The rostrum is subplane, the lateral margins convergent and slightly convex; the lateral spines are very short, and the distance between them is greater than the length of the acumen; the latter is very broad at the base and very short, its apex reaching the first third of the third antennular

261 article. The postorbital margins are quite parallel and the anterior spine hardly evident. The areola is four and one-half times narrower than the length.

The chelae of the first pair of pereopods are very broad and compressed; their surfaces are totally covered with small setae. The dactylopodite is equal in length to the palmar region, and its cutting margin is provided with two dentiform tubercles that are very close together and situated at the end of the proximal third. The immovable finger has only one tooth, at midlength of the cutting border.

The *annulus ventralis* exhibits the form of an inverted U with its distal extremity asymmetrical, which coincides with the presence of the groove; the latter is situated at the extremity of one of the rami, is sinuous, its position perpendicular to the major axis of the ramus. Between the fifth pereopods, there is a cristiform process which is insinuated between the rami of the *annulus*.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	29.9	22.0	35.9
Carapace			
Height	7.3	4.6	8.4
Width	6.6	4.8	8.6
Length	13.6	10.2	12.1
Areola			
Length	4.6	3.5	6.1
Width	2.7	0.9	1.4
Rostrum			
Length	3.8	2.9	4.7
Width	2.0	1.6	2.4
Right chela			
Length of internal margin of palm	4.6	2.85	4.35
Greatest width of palm	2.8	1.85	3.5
Length of external margin of chela	10.4	11.7	9.2
Length of dactylopodite	5.1	3.6	4.6

Locality. Lagunas de Zempoala; these are contiguous reservoirs belonging to the same lacustrine basin, with probable communications between them, located in the mountains in the northern part of the State of Morelos at 2800 or 3000 meters above sea level. Surely these lakes had a volcanic origin. The vegetation is typically alpine.

262 **Relationships.** *Cambarellus montezumae zempoalensis* has close affinities with *C. montezumae lermensis* because possibly they have a common origin in *C. montezumae montezumae* and because of the Mio-Pliocene volcanism leaving them isolated and evolving independently.

Cambarellus montezumae lermensis Villalobos

1943 *Cambarellus montezumae* Fma. *lermensis* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de Mexico, Vol. XIV, No. 2, pp. 603 – 607, Pl. 2, figs. 3, 5, 11, 14, 18, 20.

Diagnosis. Areola narrow, its width almost one-fourth of its length, with punctations dispersed and two or three transverse folds on anterior surface. Postorbital ridges parallel and terminating anteriorly in two small spiniform processes. Rostrum with surface plane; rostral margins weakly convergent and almost straight, slightly elevated above surface; lateral spines small, short processes; acumen very broad at base, but extremely slender at apex, latter reaching distal articulation of second article of antennular peduncle. Hooks on ischiopodites of second and third pairs of pereiopods, neither bituberculate. Apical portions of first pair of pleopods of male, form I, reaching posterior part of coxopodites of third pair of pereiopods; distal processes directed caudodistally; mesial process membranous, excavate, and slightly recurved caudolaterally; caudal process spiniform, straight, and inclined caudally at angle of 135°; central projection very wide at base, whereas apex slender, flattened in cephalocaudal plane, and moreover slightly flexed caudally. *Annulus ventralis* of regular form with groove in distal region of one of its rami.

Male, form I. The size is little less than that of the female. The carapace is oval in contour and slightly compressed in the anterior part. Its width at the level of the caudodorsal margin of the cervical groove is equal to the height. The greatest width of the carapace is at the level of the middle part of the areola.

The width of the areola is four times less than the length. The surface is provided with widely dispersed punctations and moreover two or three thin transverse folds in the anterior half.

263 The rostrum is broad at the base and relatively narrow at the level of the lateral spines; the rostral surface is flat and the margins, which are straight and slightly convergent, are elevated a little over it, although at the anterior extremity the surface is deeper. The lateral spines are very small and the distance between them is slightly greater than the length of the acumen; the latter is broad at its base and very sharp at the apex, which reaches the distal articulation of the second antennular article (Plate 59, fig. 7).

The postorbital ridges are parallel and terminate anteriorly in a small spiniform tubercle.

The surface of the carapace is smooth and the suborbital angle obtuse with the apex relatively sharp.

The abdomen is longer than the carapace and its length projected over the latter reaches the middle part of the cephalic section of the

telson. The posterolateral angles of this section of the telson exhibit a single spine.

The epistome is subtriangular with its anterolateral margin distinctly concave (Plate 59, fig. 18).

The antennal flagellum reaches the fourth or fifth abdominal somite. The anterointernal margin of the antennal scale (Plate 59, fig. 11) is perpendicular to the external margin; the spine of the scale is long and acute; it is directed distally and its apex reaches the distolateral articular margin of the third article of the antennular peduncle.

The palm of the chela of the first pair of pleopods is subcylindrical, but more compressed in the distal region. The dactylar region is longer than the palm, reaching the anterior third of the carpopodite. The fingers are relatively robust and are devoid of dentiform tubercles on the cutting border. The internal margin of the dactylopodite is straight (Plate 59, fig. 3).

The ischiopodites of the second and third pairs of pereopods exhibit hooks. The hook of the second is small; it is implanted on the middle part of the margin of the article and is gently curved inward. The hook of the third pair is better developed, inserted between the second and proximal part of the distal third; its apex is sharp and slightly incurved; the axial margin is provided with a prominence in the form of a spur.

The apical region of the first pair of pleopods reaches the posterior margin of the coxopodite of the third pair of pereopods, and the distal extremity terminates in three parts: the mesial process, which is relatively broad and of membranous consistency, is slightly inclined in a caudolateral direction, its extremity reaching the subapical region of the caudal process; the central projection is very broad at the base, and its distal extremity is slightly flexed in a caudal direction; and the caudal process, which is straight, very slender, and sharp, slightly overreaches the mesial process and is inclined at an angle of approximately 135° (Plate 59, fig. 21).

Male, form II. The rostrum is short and the margins straight and convergent. The lateral spines are hardly perceptible. The base of the acumen is much wider and the acuminal spine is slightly longer and overreaches the distal articulation of the second article of the antennular peduncle. The areola is narrower. The postorbital ridges lack spines on the anterior part.

The chelae of the first pair of pereopods are more flattened, and the dactylar portion is robust and of the same length as the palmar part.

The first pair of pleopods are straight; only their apical processes are slightly turned caudally. The mesial process is of the same length as the other two processes.

Female. The size is slightly greater than that of the male, form I.

The rostrum is very broad and short; the rostral margins are convergent and convex. The lateral spines are very close together; as a result, the base of the acumen is narrower than in the males.

The postorbital ridges are slightly convergent forward, and the anterior spiniform process is very small.

The areola has the same width as that of the male.

The chelae of the first pair of pereopods are broad, compressed, and pubescent, mainly along the margins. The dactylar portion is slightly longer than the palm; the cutting border of the dactylopodite has two teeth that are very close together in the subarticular region; the cutting border of the dactylopodite exhibits a single tooth toward the middle portion (Plate 59, fig. 3).

The *annulus ventralis*, as in the previous species, has the form of an inverted U. In this case, this structure has a regular form and the groove is located in the distal region of one of its rami, but the proximal margin is heavier than the distal, and it seems that one of the rami of the arc penetrates the terminal portion of the corresponding ramus. Between the fifth pereopods, there is a cristiform tubercle.

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	26.5	20.2	30.5
Carapace			
Height	6.5	4.7	8.0
Width	6.5	4.2	7.2
Length	12.1	9.3	14.1
265 Areola			
Length	4.1	2.9	4.9
Width	1.0	0.8	1.2
Rostrum			
Length	3.1	2.3	3.5
Posterior width	1.9	1.5	2.1
Right Chela			
Length of inner margin of palm	4.1	2.4	3.9
Greatest width of palm	2.3	1.4	1.8
Length of outer margin of chela	9.1	5.5	7.3
Length of dactylopodite	4.9	3.0	4.3

Locality. Swamps, lakes, and canals that surround the town of Lerma, formed in the area by the Rio Lerma. Height above sea level 2,573 m.

Relationships. *Cambarellus montezumae lermensis* is an intermediate form between *C. montezumae* and *C. chapalanus*, although we are inclined to think that it is more closely related to the species of Lago de Chapala.

Cambarellus montezumae patzcuarensis Villalobos

1943 *Cambarellus montezumae patzcuarensis* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XIV, No. 2, pp. 607 – 611, Pl. II, figs. 1, 6, 9, 12, 15, 19, 21, 23.

Diagnosis. Areola broad, exactly two and one-half times narrower than long; areolar surface with punctations and transverse grooves, latter dispersed in anterior two-thirds. Postorbital ridges terminating anteriorly in long, sharp spines broadly diverging cephalically. Rostrum long and narrow with surface gently concave; lateral spines of rostrum long and slightly divergent; acumen very long, sharp, and conical, its apex reaching median portion of third article of antennular peduncle. Hooks on ischiopodites of second and third pairs of pereopods, neither of them bituberculate. Terminal region of first pair of pleopods of first form male reaching midlength of coxopodites of third pair of pereopods; apical structures gently inclined caudally (angle with body of appendage approximately 175°). Central projection slightly exceeding caudal process; in male, form II, this structure equal in length to caudal process and much more inclined caudally. *Annulus ventralis* with sinuous suture on distal extremity of one of its rami.

Male, form I. The general size is smaller than that of the females. The carapace is distinctly compressed; the width at the level of the caudodorsal margin of the cephalic groove is noticeably less than the height. The greatest width of the carapace occurs at midlength of the areola.

The width of the areola is two and one-half times less than the length; the surface is provided with punctations dispersed here and there; moreover, in the anteromedian part, a few transverse wrinkles of the chitin are present that disappear in front of the cephalic groove.

The rostrum is narrow, and the rostral margins are slightly convergent and a little convex at the level of the cornea of the eye; the lateral spines are long, very sharp, and project forward but very slightly to the side; the acumen is quite narrow at the base and sharp and conical at the apex, which reaches the middle part of the third article of the antennular peduncle. The rostral surface is slightly excavate and without setiferous punctations (Plate 59, fig. 9).

The postorbital ridges are subparallel; anteriorly they terminate in spiniform processes that are sharp and distinctly divergent, and which at times clearly overreach the anterior margin of the carapace.

The surface of the carapace is very finely punctate, but larger punctations may be observed in the dorsolateral parts of the gastric region and on the suprbranchial margins. The suborbital angle is 90° and its vertex slightly rounded.

The abdomen is longer than the carapace. The lateral borders of the

cephalic section of the telson are convergent behind, and its posterolateral angles exhibit a single spine, the length of which is less than half that of the spiniform angular process of the cephalic section of the telson.

The epistome is triangular with the anterolateral margins straight or slightly concave (Plate 59, fig. 19).

267 The flagella of the antennae are moderately long and reach the second or third abdominal somite; the antennal scale is narrow, and the anterointernal margin is distinctly inclined; the spine of the scale is very long and acute, and slightly overreaches the distal articulation of the third antennular article (Plate 59, fig. 12).

The palm of the chela of the first pair of pereopods is more robust and cylindrical in the proximal region, but slightly compressed in the distal; its surface is completely smooth. The dactylar region is almost equal in length to that of the palm; the fingers are very slender and cylindrical in section; they are completely devoid of dentiform tubercles, but on the sides of the cutting borders are series of setiferous punctations with tufts of long setae; moreover, other widely spaced long setae are located on the surface of the fingers. The internal margin of the dactylopodite is slightly concave from its articulation to the subterminal anterior part (Plate 59, fig. 1).

The ischiopodites of the second and third pairs of pereopods exhibit hooks; that of the second pair is implanted on the proximal part of the margin and is flattened in the same plane as the article; it is broad and blunt at the apex, and the axilar margin exhibits a small emargination; the hook of the third pair has the form of a spur; it is implanted on the middle part of the margin of the article and is also flattened; its apical portion is sharp and curved inward; the axilar margin exhibits a small angular prominence more or less at midlength which separates two undulating emarginations on this margin.

The apical parts of the first pair of pleopods reach the middle part of the coxopodites of the third pair of pereopods, and the distal extremity ends in three distinct parts. The mesial process is borne at the end of the second third of the appendage; it is broad at the base and narrow in the terminal part, which reaches the middle portion of the caudal process and is grooved; its consistency is membranous; the caudal process is distinctly chitinized; it is sharp and is slightly inclined toward the mesial region and in a caudal direction at an angle of approximately 145° with the principal body of the appendage; the apical extremity of this process hardly overreaches the central projection. The latter is broad at its base, its major part directed distally; only the apical region is slightly flexed caudally (Plate 59, fig. 21).

Male, form II. The male, form II, differs from the form I in the following characters: the margins of the rostrum are subparallel and the

lateral spines are more divergent; the rostral surface is subplane. Although the anterior spines of the postorbital ridges are divergent at the base, the apical portions project in a distal direction.

The chelae of the first pair of pereopods are less slender and the dactylar portions longer than the palm; the section of the palm is oval and the fingers are compressed and wide.

The apical region of the first pair of pleopods exhibits very short processes that are not chitinized and which are inclined caudally at an angle of approximately 120°; these processes terminate almost at the same level; the mesial process is very wide.

Female. The size is larger than that of the males. The rostral margins are more convergent, and consequently the lateral spines are closer together. The acumen is longer than in the males and reaches the distal articulation of the third article of the antennular peduncle. The spines of the postorbital region are shorter. The chela of the first pair of pleopods is shorter and broad; its palmar section is oval, and the surface is covered with setae which are more abundant on the external and internal margins; the fingers are straight, broad, and compressed; their length is greater than that of the palmar region; the cutting border of the dactylopodite exhibits a single tooth on the proximal third that is inclined forward; the cutting border of the immovable finger also exhibits a dentiform process which is smaller and located a little more forward than the tooth on the movable finger.

The *annulus ventralis* has the form of an inverted U and is almost regular in contour. The groove or suture is located on the distal part of one of its rami, in this case the right, but may be found also on the left ramus. Between the fifth pereopods, there is a pyramidal process, the vertex of which is applied between the two rami of the *annulus* (Plate 59, fig. 6).

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	27.7	22.3	35.5
Carapace			
Height	5.4	5.0	7.3
Width	6.1	4.8	7.2
Length	12.4	11.5	16.8
Areola			
Length	4.1	3.4	5.3
Width	2.7	1.3	1.8
Rostrum			
Length	3.9	4.0	5.8
Posterior width	2.85	1.5	2.2
Right chela			
Length of internal margin of palm	4.5	2.7	3.7

269	Greatest width of palm	2.0	1.3	1.8
	Length of external margin of chela	9.75	6.3	9.0
	Length of dactylopodite	5.1	3.3	4.7

Locality. Shoreline of Lago de Pátzcuaro, Michoacán.

Relationships. Among the localities that were cited by Faxon for this species, *Cambarellus chapalanus*, he included Lago de Pátzcuaro, but the crayfish from this locality which are described here show very clear differences that are pointed out following the description of *C. chapalanus*.

The differences between *C. montezumae patzcuarensis* and *C. montezumae montezumae* are pointed out in the comparative table that follows:

<i>Cambarellus montezumae montezumae</i>	<i>Cambarellus montezumae patzcuarensis</i>
I. Length of apical spine of rostrum less than distance between lateral spines.	I. Length of apical spines of rostrum greater than distance between marginal spines.
II. Width of antennal scale equal to [one-half] length of external border including spine.	II. Width of antennal scale almost one-third length of external border including spine.
III. Distal region of mesial process very broad.	III. Distal region of mesial process narrow.
IV. Epistome pentagonal.	IV. Epistome triangular.

SCHMITTI SECTION

Cambarellus alvarezi Villalobos

1952 *Cambarellus alvarezi* Villalobos, An. Inst. Biol. de la Univ. Nal. A. de México, Vol. XXII, pp. 525 – 531, pls. I and II.

Diagnosis. Areola broad, slightly less than half length; surface with few very fine and almost imperceptible punctations. Hooks on ischiopodites of second and third pairs of pereopods not bituberculate; hook of second pair curved toward caudal region. Palm of chela smooth. Postorbital ridges without spines. Carapace without lateral spines. First pair of pleopods of first form male with apical region reaching midlength of coxopodite of third pair of pereopods and exhibiting three spiniform processes directed caudally at angle of approximately 120°; central projection and caudal process equal in length and not exceeding length of mesial process. First pair of pleopods of second form male exhibiting in inclination of apical region little more open angle; central projection and mesial process of same length; caudal process shorter and conical.

Male, form I. The carapace is compressed laterally in the anterior region, subovate in the posterior; its surface is smooth with a few scattered setae. The cephalic groove is slightly angular in the dorsal region, shallow and discontinuous with the part that limits the hepatic region; it has neither lateral spines nor tuberculiform prominences where they are normally found. There are no branchiostegal spines; the postorbital ridges terminate in a straight angle and consequently lack terminal spines (Plate 60, figs. 1 and 2).

The rostrum is subplane, only slightly excavate in the anterior part; the rostral margins are convergent, little elevated, and end in two very short angular structures that correspond to the lateral rostral spines. The apical portion is short, forming an angle of more or less 45° and terminating in a short conical process which is equivalent to the apical spine; the rostrum reaches the distal internal margin of the second antennular article.

The areola is broad, marked by a transparency but not by supra-branchial grooves; in the posterior region its limits are imprecise. The areolar surface is smooth but very small punctations may be distinguished, each provided with a slender seta. The width of the areola is 44 percent of its length (Plate 60, figs. 1 and 2).

The epistome is broad and short, nearly symmetrical, and the anterior margins elevated (Plate 61, fig. 5).

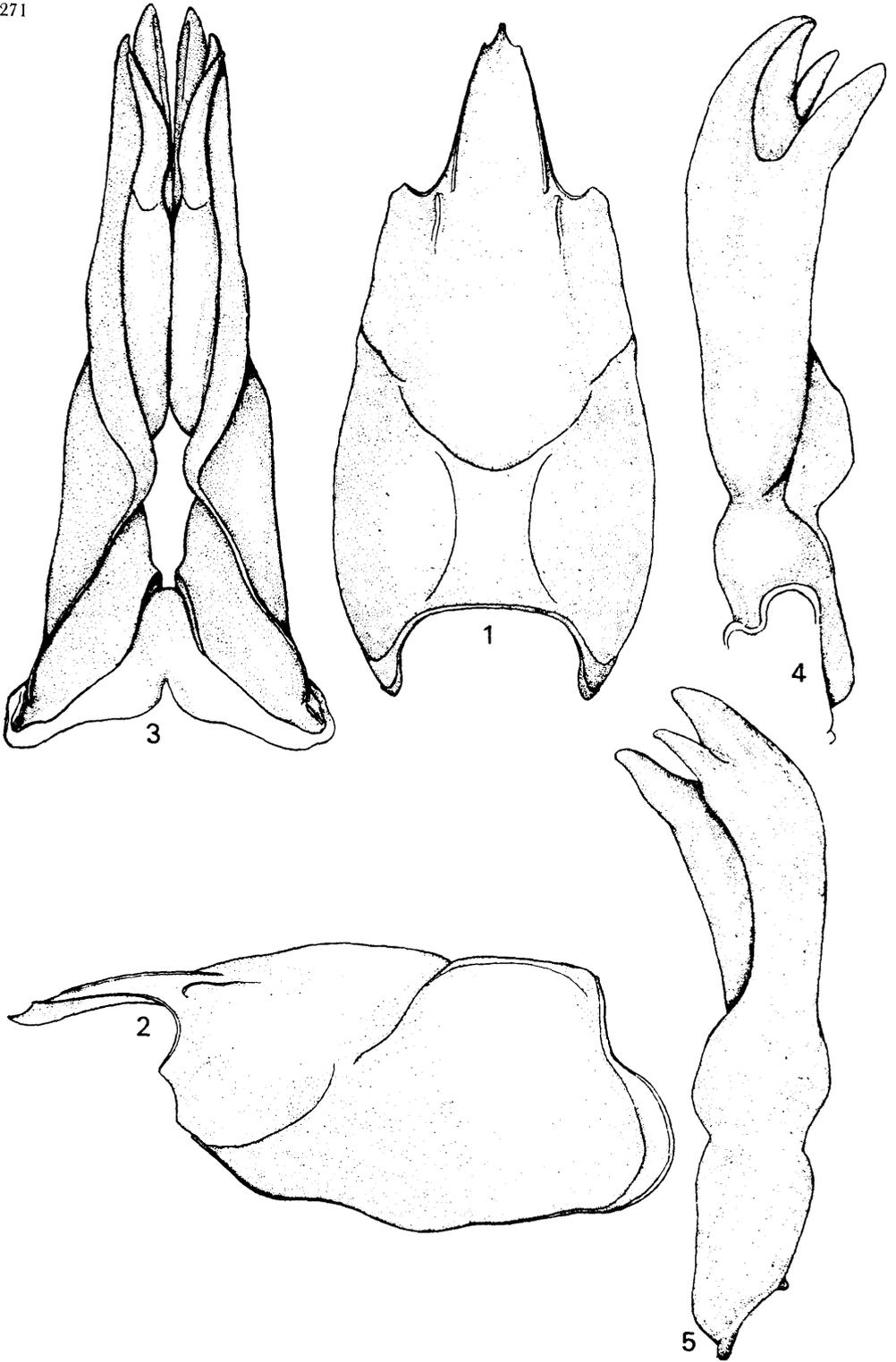
The abdomen is longer than the cephalothorax and its anterior portion exhibits a width equal to that of the branchial portion of the carapace. The anterior part of the telson exhibits two spines on each side of its distal margin, one of which corresponds to the spiniform process terminating the cephalic part of the telson.

The antennal flagellum, projected over the dorsal region of the body, reaches the middle of the fifth abdominal segment; the greatest width of the antennal scale is near its midlength. The spine of the scale is straight in relation to the external border, conical and sharp (Plate 61, fig. 6).

On the first pair of pereopods, we find that the meropodial article is smooth on the surface and its lower border does not exhibit spiniform tubercles, but only a ridge standing out clearly from the article and provided with setae. The carpopodite is smooth without a groove on the dorsal region, and its greatest length is three and one-half times shorter than the length of the propodus, including the dactylar portion; on the distal margin and on the lateral part, there is a broad angular plate.

Plate 60. *Cambarellus alvarezi* Villalobos.

1, dorsal view of the carapace of the male, Form I; 2, lateral view of the same; 3, caudal view of the first pair of pleopods of the male, Form II; 4, mesial view of a pleopod of the same pair; 5, lateral view of the same.



The chela is subcylindrical in the proximal part of the palmar region whereas it is flattened distolaterally; the surface is smooth, bearing very slender setae, the majority of which recline over the surface, but others are elevated almost perpendicularly; the immovable finger is straight, shorter than the movable one; its cutting border is convex and is devoid of teeth but on the sides exhibits groups of setae along its entire length; the terminal tooth is short and almost hemispherical; the dactylopodite, or movable finger, is equal in length to that of the palm; its cutting border is gently concave in the terminal portion, without teeth, and with groups of setae similar in form and disposition to those of the immovable finger; the terminal tooth is well developed and conical in form (Plate 61, fig. 7).

The ischiopodites of the second and third pairs of pereopods exhibit hooks. The hook on the ischiopodite of the second pair is more or less triangular, flattened anteroposteriorly, and curved toward the caudal region; it is implanted on the proximal region of the article, and the apex overreaches the articulation of the ischiopodite with the basipodite. The hook on the ischiopodite of the third pair is sharper than the former and the apex is bent toward the basipodite (Plate 61, fig. 4).

The coxopodite of the fourth pair of pereopods lacks a ventral prominence.

The apices of the first pair of pleopods in normal position reach the middle part of the coxopodite of the third pair [of pereopods]; the apical region is turned toward the caudal region and flattened laterally, terminating in three distinct, slender, long parts (Plate 61, fig. 1). The mesial process overreaches the other two structures; it is conical at its base and flattened at the apex; its consistency is membranous and forms an angle of approximately 120° with the principal body of the appendage (Plate 61, figs. 2 and 3A). The caudal process is spiniform, becoming abruptly narrower along the distal third and slightly curved (Plate 61, figs. 2 and 3D). The central projection is distinctly chitinous, sharp, and curved toward the caudal region, forming an angle of approximately 40° to the mesial process; its length slightly overreaches the caudal process (Plate 61, figs. 2 and 3Z). The centrocaudal process, a component of the central projection (Plate 61, figs. 2C and 3), is broad at the base and sharp at the apex; the centrocephalic process maintains more or less the same width throughout its length (Plate 61, figs. 2E and 3).

274 **Female.** Unknown; there are no individuals of this sex among the specimens at our disposal for this study.

Male, form II. The carapace is more compressed than the abdomen. The rostrum is broader than in the male, form I, and the rostral margins are almost parallel, slightly incurved in the distal part;

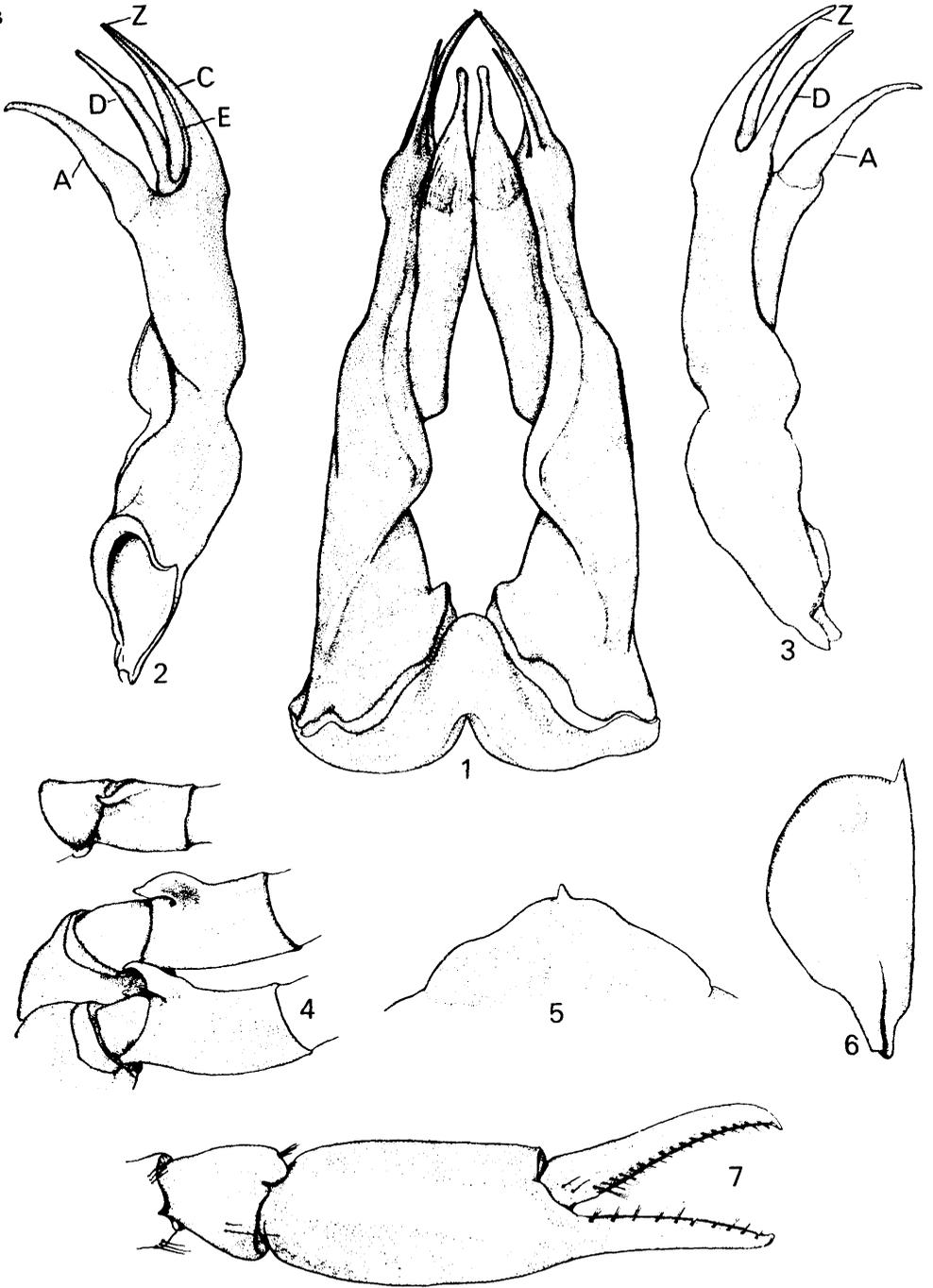


Plate 61. *Cambarellus alvarezii* Villalobos. Male, Form I.

1, caudal view of the first pair of pleopods; 2, mesial view; 3, lateral view; 4, ischiopodites of pereopods II and III; 5, ventral view of the hook on the ischiopodite of the second pereopod; 6, antennal scale; 7, chela.

the lateral spines are short and angular; the apical region is shorter than in the male, form I. The postorbital ridges lack spines; the areola is broader than in the male, form I.

The chelae of the first pair of pereopods are more slender.

The hooks on the ischiopodites of the second pair of pereopods are short and do not overreach the proximal ischiopodal articulation; the hooks on the ischiopodites of the third pair are also short, but in them the prominence of the dorsal or axilar border is more acute, and the apical region does not overreach the proximal articulation of the article.

The first pair of pleopods are distinctly flattened in the distal region, and the inclination toward the caudal region is less marked; the aspect of the mesial process is that of a broad plate at the base but not sharp at its end. The caudal process is shorter and conical in form. The central projection is broad and slightly curved; all of these structures are membranous (Plate 60, figs. 3, 4, and 5).

Measurements in millimeters

	Male, Form I	Male, Form II	Female
Total length	33.2	28.3	—
Carapace			
Length	15.0	8.8	—
Width	8.3	6.5	—
Height	8.2	7.0	—
Areola			
Length	4.5	3.7	—
Width	1.98	2.4	—
[?]	4.2	2.4	—
Chela			
Anterior width	0.8	0.9	—
Posterior width	2.8	2.0	—
Abdomen			
Length	19.7	17.0	—
Right chela			
Length of internal margin of palm	6.4	4.9	—
Width of palm	3.6	2.6	—
Length of external margin of palm [chela ?]	12.3	9.3	—
Length of dactylopodite	6.4	4.3	—

275 **Locality.** Potosí, Nuevo Leon, 23 km N.W. of Galeana. Collection obtained in body of water in a closed basin situated in the northern part of Valle Salado.

Relationships. Taking as a point of reference the classification of Hobbs (1945 b), *Cambarellus alvarezii* is placed within the *schmitti* Section

because we consider that the terminal part of the mesial process of our species, although slightly flattened, lacks the grooved form that we find in the same process of *Cambarellus montezumae montezumae* (Saussure). The hook on the ischiopodite of the third pair [of pereopods] is not double because the angular structure which it shows on the axial border has neither the characteristics nor the position of the accessory tubercle of *C. puer*, *C. diminutus*, or *C. ninae*.

The length of the mesial process, which in *C. alvarezii* overreaches the caudal process, and that of the central projection give us a unique combination of characters for our species.

The discovery of a new crayfish in the northern region of the Mexican Republic establishes another link in the chain with the fauna of the United States regarding the cited subfamily; *Cambarellus alvarezii* exhibits a clear affinity with the same genus of the neighboring country; in contrast, it stands completely apart from the species which exist in the central part of Mexico and which are related to *C. montezumae*.

Due to the shortage of time for presenting this work and the lack of adequate material, the various species and subspecies of the genus *Cambarellus* are left for a later study in which a careful revision will be necessary; consequently we confine ourselves to treating them in the following manner:

Cambarellus montezumae var. *tridens* (Von Martens)

1872 *Cambarus montezumae* var. *tridens* Von Martens, Archiv Für Naturgeschichte, Vol. XXXVIII, p. 130.

This form was described by Von Martens from crayfish material sent to the Berlin Museum from Puebla, Puebla. The principal characteristic is the presence of lateral spines on the rostrum, which as we know is a characteristic that Saussure did not mention in the original description of *C. montezumae*. Faxon and Ortmann considered it a synonym of Saussure's species.

276 *Cambarellus montezumae dugesii* (Faxon)

- 1890 *Cambarus montezumae* Faxon, Proc. U.S. Nat. Mus., Vol. XII, p. 633.
1898 *Cambarus montezumae dugesii* Faxon, Proc. U.S. Nat. Mus., Vol. XX, p. 660, Pl. XLVI, fig. 1.
1906 *Cambarus (Cambarellus) montezumae dugesii* (Faxon). Ortmann, Proc. Wash. Acad. Sci., Vol. VIII, p. 20.
1914 *Cambarus montezumae dugesii* Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, p. 416.

Diagnosis. Surface of rostrum plane; margins elevated, convergent;

acumen slightly longer than in *C. montezumae*; lateral spines on rostrum more strongly developed. Postorbital ridges with anterior spine. Chela broader and more hirsute than in *C. montezumae*; fingers pointed with claw more conspicuously yellow in color. Length 38 mm. (After Faxon.)

Locality. State of Guanajuato. Col. A. Dugés.

Types in the U.S.N.M. No. 16087.

Cambarellus montezumae areolatus (Faxon)

- 1885a *Cambarus montezumae* var. *areolata* Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. 10, p. 123.
1898 *Cambarus montezumae areolatus* Faxon, Proc. U.S. Nat. Mus., Vol. XX, p. 661, Pl. LXVI, fig. 2.
1906 *Cambarus* (*Cambarellus*) *montezumae areolatus* (Faxon). Ortmann, Proc. Wash. Acad. Sci., Vol. VIII, p. 23.
1914 *Caambarus* [sic] *montezumae areolatus* Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, p. 416.

Diagnosis. Form of rostrum similar to that of *C. m. dugesii*, but lateral margins not very elevated; lateral spines of rostrum and acuminal spine similar to those of *C. m. dugesii*. Areola very short but quite wide. (After Faxon.)

Locality. Parras, Coahuila.

Types in the Mus. Comp. Zool. No. 3650.

Cambarellus montezumae occidentalis (Faxon)

- 1898 *Cambarus montezumae occidentalis* Faxon, Proc. U.S. Nat. Mus., Vol. XX, p. 661, Pl. LXVI, figs. 3, 4.
1906 *Cambarus* (*Cambarellus*) *montezumae occidentalis* (Faxon). Ortmann, Proc. Wash. Acad. Sci., Vol. VIII, p. 23.
1914 *Cambarus montezumae occidentalis* Faxon, Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, p. 416.

277 **Diagnosis.** Surface of rostrum plane; margins slightly elevated above it, converging gradually from base to apex, without lateral spines clearly delimiting acumen, overreaching distal extremity of second antennular article. Postorbital ridges without spines. (After Faxon.)

Locality. Mazatlan, Sinaloa.

Types in the Mus. Comp. Zool. No. 3652.

Cambarellus chapalanus (Faxon)

- 1898 *Cambarus chapalanus* Faxon, Proc. U.S. Nat. Mus., Vol. XX, p. 661, Pl. LXVII, figs. 1, 2.

1914 *Cambarus montezumae chapalanus* (Faxon), Mem. Mus. Comp. Zool., Harvard Coll., Vol. XL, No. 8, p. 416.

Diagnosis. Similar to *C. montezumae*, but differing from it in following characters: body more slender and more cylindrical; rostrum longer and narrower, reaching extremity of antennular peduncle, somewhat hirsute, armed with pair of sharp and straight lateral spines; acumen long and spiniform. Postorbital ridges terminating anteriorly in strong spiniform tooth. Antennal scale much longer and narrower, armed with very long apical spine.

Surface of rostrum plane, with lateral margins slightly elevated. Sides of rostrum convex, distinctly convergent anteriorly before reaching lateral spines. Chelae and first pair of pleopods similar to those of typical form of *C. montezumae*.

In some respects, *C. montezumae dugesii* shows certain similarities to this species, but there should be no confusion between them if the slender form, the length of the rostral spines, etc., of *C. chapalanus* are taken into account. *Cambarellus shufeldtii* is distinguished from *C. chapalanus* by the presence of lateral spines on the carapace, the broader rostrum, and the different form of the first pair of pleopods of the male.

Locality. Chapala, Jalisco.

Types in the U. S. Nat. Mus., 1 male, No. 17698; topotypes, U. S. Nat. Mus., 3 males, No. 16294.

General Considerations Concerning the Present Distribution of the Crayfishes of Mexico

278 The geographical distribution of the currently known Mexican crayfishes and the natural groups that they comprise have many peculiarities. We should indicate that our collections have been made in the eastern part of Mexico, and for that reason the conclusions that are presented here will be modified as material is obtained from new localities, especially in the western region, in which for a lack of adequate explorations we cannot be sure of the non-existence of these crustaceans. Because of the ecological conditions that exist in western México, however, surely the crayfish fauna must be relatively poorer than that existing on the Atlantic slope.

In the present monograph, we have adopted a theory concerning the origin of the Mexican crayfish fauna, that in certain respects opposes the theory of Ortmann; "Are we right?"; this is something that the specialists of the group will decide.

It is admitted that the cambarines constitute a highly specialized group of the family Astacidae, and seem to have originated from a lower type very similar to the genus *Astacus*, from which they arose by the suppression of the only pleurobranch and by the advanced development of the first pair of pleopods in the male.

According to Ortmann and Marc André, the center of origin of the crayfishes should be in southeastern Mexico, and the immigration that carried the most primitive crayfishes to the United States could have originated on the Mexican plateau moving northeastward during the early Eocene to the eastern parts of North America.

According to Marc André, the cambarines originated early in the Cenozoic Era from a stock of *Astacus* that invaded the south through the western part of the Mexican Republic.

We think that if the primitive form of American *Astacus* had access to the western part of North America, using the intercontinental bridge that existed from early in the upper Cretaceous to late in the Tertiary, and that temporarily joined Alaska with Siberia, the separation of the stock of cambarines could have been effected in the upper Cretaceous,

279 precisely in the region of northwestern America. Immigrating to the southeast and occupying the eastern plateaus of the United States, where, sheltered by conditions of the environment which should have been very favorable, they evolved and became widely distributed. Concomitantly, the original stocks of *Astacus* continued their immigration to the south, following the route of migration between the Rocky Mountains and the west coast of North America.

We think that the Mexican cambarine fauna was derived from that of the United States, by emigrations in different geological periods, and, following two principal routes of invasion, they became established in regions suitable for them to exist.

Possibly the older route was across the central plains; concomitantly, the other, more modern, was progressing along the coastal plain of the Gulf, which, as a result of recent emersion, provided more favorable conditions, and explains why there is a greater variety of forms of cambarines in this zone.

A) Species that originated from the possible immigration across the central plain:

The geographic localization of the Mexican species of the *barbatus* Section and its discontinuous distribution, induces us to believe that it became established approximately during the Eocene. The following species are included in this section: *Procambarus digueti*, *P. bowvieri*, and a new subspecies of *P. simulans*, *P. simulans regiomontanus*.

Procambarus digueti, the primitive characteristics of which were pointed out by Ortmann, is located in the tributaries of the Río Santiago, near Chapala, Jalisco, and in Puruándiro and Jacona, Michoacán. It lives in localities where the currents are very slow, or even in standing water where there is an abundance of aquatic vegetation, at an altitude of 1400 to 1600 meters above sea level. These localities are situated in the western portion of the central part of Mexico (Plate 62, 1).

Procambarus bowvieri has been collected only in Uruapan, Michoacán, in creeks of slow currents or in standing water, the altitude of which is approximately 280 meters above sea level (Plate 62, 1').

None of the species previously mentioned has close affinities with the species of the east coast, and their isolation indicates that they were established long ago, representing remnants of the invading group that crossed the central plain. The only connection that we are able to establish, through morphological characteristics, is with *P. simulans regiomontanus*, located in Monterrey, Nuevo León, at an approximate
280 altitude of 500 meters above sea level (Plate 62, 1''). Another possible subspecies of *P. simulans* was found in Ciudad General Bravo, in the northern part of the State of Tamaulipas. The original species, *Procambarus simulans*, is located in Kansas and New Mexico in the United States, and all seem to indicate that probably this species extends

through Texas to the southeastern border with Mexico. According to Faxon this crayfish exhibits very primitive characteristics.

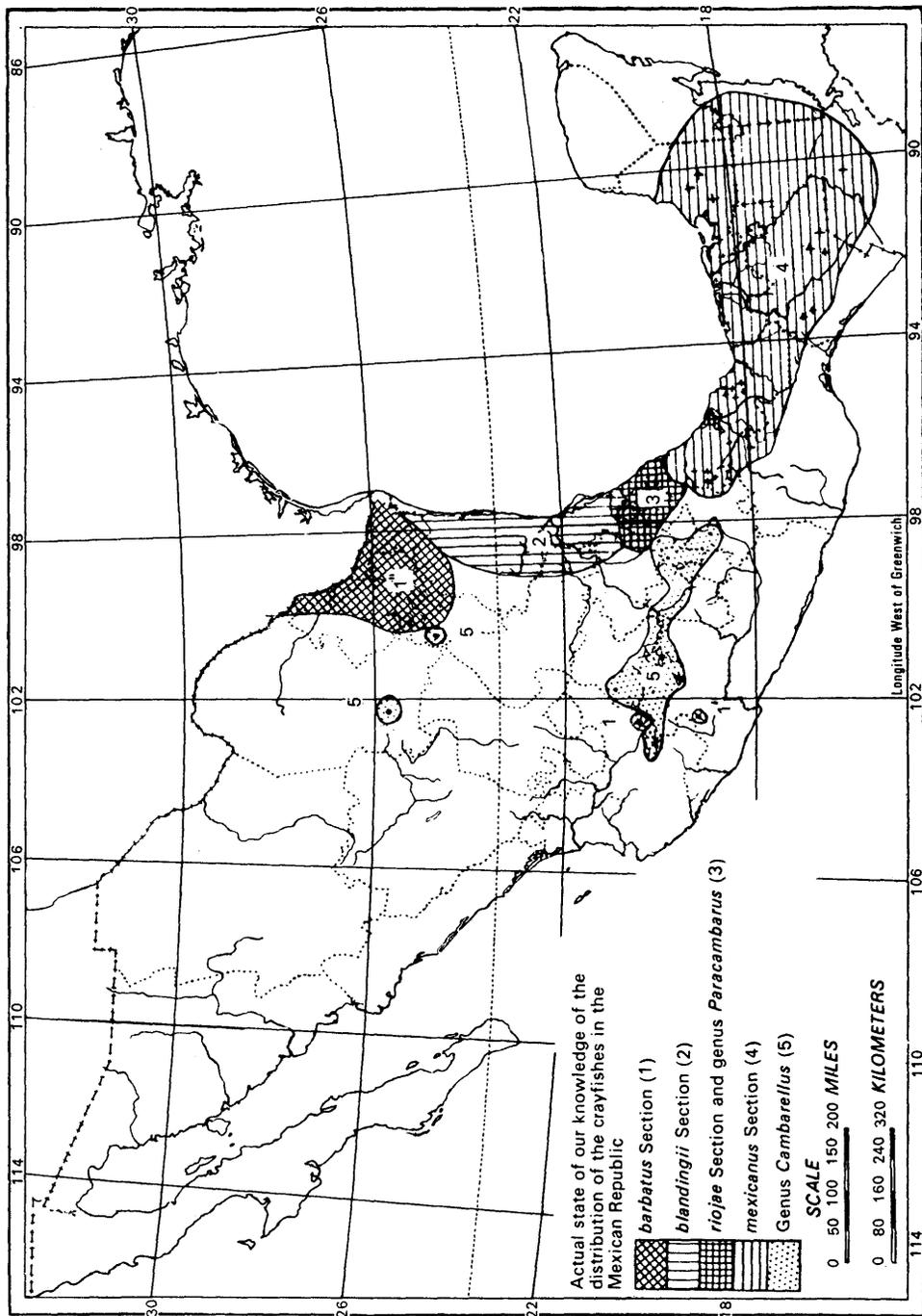
The genus *Cambarellus* is characterized also because its species exhibit a discontinuous geographic distribution, located principally in the closed basins in typical lotic habitats, and all of them are situated in the central plain; all of this seems to indicate that the route of invasion could be the same as that of the species of the *barbatus* Section, but possibly at a more modern time, that is in the Miocene, and they became established as far as the southern part of the central plain during the Pliocene; they were stopped in the northern part of the Sierra Volcánica Transversal (Plate 62, 5). In Parras, Coahuila, and in the State of Nuevo León, there are two species that have no connection with those of the south, but correspond in certain aspects with the species of the United States.

We must consider *Cambarellus chapalanus* as the representative stock from which the other species of the *montezumae* Section are derived. *Cambarellus patzcuarensis* and *Cambarellus montezumae dugesii* have closer geographic and morphological relations with *C. chapalanus* than with *C. montezumae*. The latter species, which we consider as typical of the genus *Cambarellus*, might have originated from the immigration of the ancient form of *C. chapalanus* that was moving to the southeast, across the Rio Santiago, becoming established in the Valley of Mexico; later it was isolated when the south end of the valley was closed by the volcanic upheavals of the Miocene-Pliocene. The subspecies *C. montezumae lermensis* and *C. montezumae zempoalensis* are forms isolated by the geographic accidents that brought about the closure of the Valley of Mexico; *C. montezumae lermensis* could be the representative of the invading form that populated the Valley of Mexico.

B) Species that originated from the possible emigration through the coastal plain of the Gulf of Mexico:

The retreating of the waters from the Atlantic coast probably began in the Pliocene, and should have produced very favorable ecological conditions for the emigration of the cambarines coming from the northeastern part of North America. This could have taken place toward the end of the Pliocene, and be correlated with the beginning of the Glacial period of the Quaternary, and we think that the decreasing temperature and other climatic changes influenced in this aspect the faunistic displacement, as has been shown in other animals.

The northeastern region of the Republic is populated by the species of the *blandingii* Section of the genus *Procambarus*, which are recognized as direct descendants of the cambarine fauna of the United States (Plate 62, 2). These species entered into the geographic range of the *riojae* Section (Plate 62, 3), which could have been derived from the *blandingii* Section.



The genus *Paracambarus* and the *riojae* Section occupy almost the same area, that situated between the 19° and 21° parallels on the Atlantic slope (Plate 62, 3).

The *mexicanus* Section occupies an extensive zone which extends from the south of the Volcánica Transversal to Guatemala and Cuba, but possibly there are other representatives in the southern part of Central America and northeastern South America (Plate 62, 4).

The Mexican forms of the *blandingii* Section are represented by *Procambarus blandingii cuevachicae*, *Procambarus caballeroi*, and *Procambarus toltecaae*.

Procambarus blandingii cuevachicae is distributed from Valles, San Luis Potosí, to the northern part of the State of Puebla, and in all of the localities we found the ecological conditions more or less similar. It lives in still or in very slowly flowing water at elevations between 60 and 300 m above sea level. The presence of this subspecies in a cavernicolous situation (Cueva Chica, San Luis Potosí, type locality) is only circumstantial, because in the specimens from this place there are no characteristics that denote an adaptation to cave life; consequently, we may consider them as troglonexes. The morphological study of the specimens collected in the northern part of Puebla resulted in the establishment of certain differential characteristics, but these are not considered to be of sufficient magnitude of variation to designate them subspecies.

Procambarus caballeroi is found in the southern part of Villa Juárez in places where the water is standing and at an altitude of 1000 m above sea level. This species is located in the geographic territory of the *riojae* Section; it is interesting that the localities in which *P. caballeroi* is found are sometimes separated from places where *Procambarus hoffmanni* lives by only a few meters, but never are they together. The relationships of *P. caballeroi* with *P. blandingii cuevachicae* are very close, not only in the form and disposition of the hooks on the third and fourth pairs of pereopods, but also by the appearance of the apical structures of the first pair of pleopods of the first form male. With reference to the *annulus ventralis*, it is a character that permits the establishment of the relationship between *P. blandingii cuevachicae* and *Procambarus toltecaae*.

Procambarus toltecaae is a very peculiar species in that the apical region of the first pair of pleopods is inclined in a caudal direction, a character that we see only slightly developed in *P. caballeroi* and that is typical of the species of the genus *Paracambarus*, with which we are able immediately to establish a connection. Also it is necessary to point out the form and disposition of the caudally inclined mesial process with which another similarity is established with *Paracambarus*. *Procambarus toltecaae* was collected near Tamazunchale, and the species most closely related

to it, although belonging to another genus, is *Paracambarus ortmanni* [sic] which is located in the geographic area of the *riojae* Section, providing additional proof that the *blandingii* Section migrated toward the south. The locality of *P. tolteca*, in Tamazunchale, is a stream of clear water that sometimes develops a swift current. Other collections of the same species from Xilitla, San Luis Potosí, indicate to us that its range is that part of the Atlantic slope of the Sierra Madre Oriental lying at an altitude of between 110 and 400 m above sea level.

The *riojae* Section is a complex of species which because of its quantity and restricted distribution presents interesting ecological and biological problems. The species united in this section have a common denominator, the presence of well developed hooks on the fourth pair of pereopods, whereas those of the third pair may be absent or reduced. Moreover, the first pair of pleopods in the first form male are straight and unequal in length; on the other hand, the apical structures of the pleopods vary within the range of a fixed type, but with a tendency to enlarge the mesial process, correlated with the reduction of the others.

Included in the *riojae* Section are the following species: *Procambarus riojae*, *P. hoffmanni*, *P. hortonhobbsi* [sic], *P. teziutlanensis*, *P. tlapacoyanensis*, which compose the *riojae* group *Procambarus erichsoni*, *P. contrerasi*, and *P. zihuateutlensis* which form the *erichsoni* group.

Procambarus riojae has been collected in Huachinango, Necaxa, Honey, and Zacatlán, in the State of Puebla, at altitudes that vary between 1500 and 2000 m above sea level. These localities are humid and relatively cold and located on the Atlantic slope of the Sierra Madre Oriental. They inhabit small brooks and streams that have more or less rapid currents and clear water. The characteristics of the terminal processes of the first pair of pleopods of the first form male agree almost completely with the scheme of the hypothetical pleopod given by Hobbs, exhibiting moreover a small adventitious process. There is an equal development of those processes, with the mesial and cephalic processes having the same length.

Procambarus hoffmanni is closely related to *P. riojae*, but the length of the cephalic process is reduced. This species has been found in Villa Juárez, Puebla, at approximately 1200 m above sea level, but its range extends from the Río Necaxa Basin to Coyutla and Papantla, Veracruz, where the altitude is approximately 30 to 40 m above sea level. It lives in clear brooks and streams with more or less rapid currents. Among the species of the *riojae* Section, this is one that exhibits a great adaptability.

Procambarus hortonhobbsi has been collected in a single locality, Arroyo El Coyular, 7 km N.E. of Zihuateutla, Puebla, in which there is a more or less rapid current and clear water; the height above sea level is approximately 400 m. This species is characterized by exhibiting a

platelike cephalic process while the mesial process remains more or less spiniform, considered a connecting link between the *riojae* and *erichsoni* groups.

Procambarus teziutlanensis and *P. tlapacoyanensis* are very closely allied but differ in the form of the mesial process of the first form male: in *P. teziutlanensis* it is conical and straight, whereas that of *P. tlapacoyanensis* is flattened and somewhat sinuous. These species are found in the southernmost part of the geographic range of the *riojae* Section, and possibly the *mexicanus* Section could have been derived from ancestral forms closely allied to them. These species frequent streams of clear water and have been collected in the Rio Nautla Basin. *Procambarus teziutlanensis* is found at an altitude of approximately 2000 m; *P. tlapacoyanensis* occupies a lower zone (500 m above sea level), which receives cold winds from the higher elevations, as a result of which the environment is very similar to that of Teziutlán, Puebla.

The species of the *erichsoni* Group differ from those of the *riojae* Group in the reduction of the mesial process, in that the caudal process is platelike and displaced centrally or cephalically, and moreover, the cephalic process is reduced and spiniform while the central projection is well developed.

285 *Procambarus erichsoni* now replaces *Procambarus weigmanni* [sic] (Ortmann); this change has resulted from a taxonomic adjustment. *Procambarus erichsoni* has been found in the region of Tenango de Doria, State of Hidalgo, at an altitude of 1400 m above sea level, which is the westernmost part of the range of the *riojae* Section. It inhabits clear streams in which the current is more or less rapid. The apical parts of the first pair of pleopods of the first form male exhibit certain similarities to those of *P. Hoffmanni* [sic].

Procambarus contrerasi has been found in the northern part of Puebla marking the northern limit of the geographic range of the *riojae* Section; there it is found in localities very near those occupied by *P. blandingii cuevachicae*, at altitudes between 300 and 50 m above sea level. The apical processes have certain resemblances to those of *P. erichsoni*, but it [*P. contrerasi*] seems to have a closer similarity to *P. zihuatlensis*.

Procambarus zihuatlensis is completely limited to the geographic range of the *riojae* Section. It was collected along with *Procambarus hoffmanni* and *Paracambarus ortmanni* [sic], surprisingly, because never before have we obtained three different species in the same place. This locality encompasses streams in the town of Zihuatl. It is related to *P. contrerasi* and *P. erichsoni* as is indicated by the similarity in the *annulus ventralis* and by certain homologies between the apical processes of the first pair of pleopods of the first form male.

The genus *Paracambarus* has been maintained in this study as a

taxonomic entity in spite of the fact that as the phylogenetic relationships have been more deeply investigated the species comprising it seem to belong in the genus *Procambarus*.

Paracambarus paradoxus and *P. ortmanni* [sic] occur within the range of the *riojae* Section and are related in certain respects to the *blandingii* Section of the genus *Procambarus*. The relationship of *Paracambarus ortmanni* [sic] to *Procambarus toltecaae* has already been mentioned.

Paracambarus paradoxus has been collected in Tetela de Ocampo, in the Siera de Zacapoaxtla, Puebla, at an altitude of approximately 1900 m above sea level, marking the southwestern limit of the range of the *riojae* Section, which coincides with the region of Teziutlán, Puebla, where *Procambarus teziutlanensis* occurs.

286 *Procambarus ortmanni* [sic] has been collected in a single locality: in Los Estajos, Municipality of Zihuateutla, in the eastern part of the State of Puebla, at an altitude of approximately 1200 m above sea level. In the same place where it was collected, *Procambarus hoffmanni* and *P. zihuateutlensis* were found.

The *mexicanus* Section is a natural group of species with very uniform characteristics; its range extends from northern Jalapa to Guatemala and Cuba, occupying all of the coastal plain and the lower parts of the Atlantic slope (Plate 62, 4). The number of currently described species, its ecology, and its special environmental adaptations indicate to us that it [the Section] is undergoing a full period of evolution.

The characteristics that are diagnostic of this section are as follows: shoulder present on the cephalic surface at some distance from the apical part of the first pair of pleopods of the first form male, which may be reduced but never absent; dispositions of the central projection and mesial process; and hooks present only on the ischiopodites of the third pair of pereopods of the male.

We have separated the species of the *mexicanus* Section into two groups:

The *mexicanus* group with eight species that do not have pubescent chelae, that have a single branchiostegal spine, and that exhibit a mesial process projecting distinctly beyond the apical region and directed distally or distolaterally.

The *pilosimanus* group, comprising three species, with the chelae partly or totally pubescent, with more than one branchiostegal spine and more than one lateral spine on the carapace; and finally, with the mesial process scarcely projecting beyond the apical region, almost always directed laterally.

The distribution of the *mexicanus* group embraces the area from Misantla, Veracruz, to the southern part of the same State, but possibly extends to the southern part of Chiapas, almost to the Guatemala

border, while that of the *pilosimanus* group has been found from southern Veracruz, Tabasco, Campeche, Quintana Roo, part of Yucatán, and Guatemala.

The data that we present will be completed with the study of the material in our collection, obtained from the southern part of the Republic.

The accumulation of a large number of forms in the geographic region 3 (Plate 62), between the 19° and 21° parallels, presents an important ecological and biological problem.

From an ecological point of view, it is possible that an important natural barrier, possibly the Sierra Volcánica Transversal, arrested the immigration of the crayfishes toward the south; [the crayfish stock] without losing its evolutionary potential, unfolded into the species of the *riojae* Section and those of the genus *Paracambarus*; those groups possibly were derived from the *blandingii* Section with which they share certain corresponding characteristics. However, only one stock of the *riojae* Section, near *P. teziutlanensis* and *P. tlapacoyanensis*, could have crossed the natural barrier already mentioned to give rise to the species of the *mexicanus* Section which were broadly distributed in the southeastern part of the Republic, Guatemala, and possibly all Central America. The bridge that united Central America with the Antilles could have been the route of invasion of these crayfishes of the *mexicanus* Section to the Island of Cuba.

From the purely biological point of view, the large variety of forms of the *riojae* Section may be explained by a series of mutations arising in a very short time; but in a broad view, in this case, we must not overlook the possibility that the geographic conditions forced those new and multiple forms to remain in a very restricted area. The same explanation could be given for the *mexicanus* Section, but in this case without some natural barrier, the species acquired a very broad range in relation to the distribution of the other sections. It is important to note that no species other than those belonging to the *mexicanus* Section has been found in the southern part of the Republic.

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