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Two new species of *Hemicyclops* (Copepoda: Poecilostomatoida: Clausidiidae) associated with mud shrimps of the genus *Callichirus* from Brazil

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Keywords: Taxonomy, associate copepods, Poecilostomatoida, Clausidiidae, *Hemicyclops*, *Callichirus*, Brazil

Abstract

Two new clausidiid copepods of the genus *Hemicyclops* (Poecilostomatoida: Clausidiidae) associated with mud shrimps are described from Brazil: *Hemicyclops caissarum* sp. n. associated with *Callichirus major* (Say, 1808) from a beach in Santos and *Hemicyclops sebastiani* sp. n., in burrows of *Callichirus guassutunga* (Rodrigues, 1971) in São Sebastião. *H. caissarum* is closest to *H. carinifer* Humes, 1965 from Madagascar and *H. sebastiani* can be easily distinguished from all its congeners by the presence of a thick, densely plumose seta on the antennule segment 2, and the greatly enlarged tergal plate of the 4th pediger. New records of *Hemicyclops subadhaerens* Gooding, 1960 and *Hemicyclops thalassius* Vervoort & Ramirez, 1966 from the Brazilian coast are also included.

Zusammenfassung

Zwei neue Arten von *Hemicyclops* (Poecilostomatoida: Clausidiidae), in Gemeinschaft mit Crustacea Thalassinidea lebend, sind zum ersten mal für Brasilien beschrieben worden. *H. caissarum* sp. n. ist in den Galerien von *Callichirus major* (Say, 1808) gefunden worden und *H. sebastiani* sp. n. in den von *C. guassutunga* (Rodrigues, 1971). *H. caissarum* ist *H. carinifer* Humes, 1965, aus Madagaskar, am nächsten, und *H. sebastiani* kann leicht durch das Vorkommen einer dicht befiederten Borste am 2. Segment der Antennula und durch eine sehr vergrößerte Tergalplatte am 5. Thoraxsegment von den anderen Arten des Genus unterschieden werden. Neue Vorkommnisse von *H. subadhaerens* Gooding, 1960 und *H. thalassius* Vervoort & Ramirez, 1966 an der Küste Brasiliens sind angegeben.

Introduction

Among the crustaceans listed by Humes (1984) as hosts of *Hemicyclops*, the mud shrimps of the

genus *Callianassa*, the closest relatives of *Callichirus*, were mentioned to harbor three species of *Hemicyclops*: *H. elongatus* Wilson, 1935 from Peru, *H. thysanotus* Wilson, 1935 from the Pacific coast of the United States, and *H. subadhaerens* Gooding, 1960 from California and Argentina.

Our knowledge of *Hemicyclops* from Brazil is scanty. Rodrigues (1971) mentioned the presence of *Hemicyclops* in galleries of *Callichirus major* (Say, 1808) and *C. mirim* (Rodrigues, 1971) in the intertidal zone of the State of São Paulo. One of us (C.E.F. da Rocha) identified *H. subadhaerens* Gooding, 1960 in samples taken from burrows of unknown origin in a beach in Rio Grande (State of Rio Grande do Sul) and *H. thalassius* Vervoort & Ramirez, 1966 in plankton samples from the estuary of the Rio Sergipe near Aracaju (N.E. of Brazil) and São Sebastião, State of São Paulo (unpublished data). In the present paper we report two new species of *Hemicyclops* recovered from the burrow water of mud shrimps (*Callichirus*) collected at Santos and São Sebastião.

Material and methods

The copepods were recovered from water drawn from the burrows of *Callichirus major* following the method developed by Hailstone & Stephenson (Rodrigues, 1971). Copepods were easily discerned by their reddish colour and relatively large size (S.A. Rodrigues, pers. comm.).

Whole specimens were examined in temporary lactic acid mounts. Chips of cover slip were used to support the cover glass of the preparation. After examination the materials were returned to and preserved in 70% ethanol.

Dissections were made in glycerine and the dissected parts were placed on slides and sealed with Glyceel.

A Leitz Laborlux D phase-contrast microscope was used for examination and the drawings were made with the use of a camera lucida.

Taxonomy

Hemicyclops caissarum sp. n.

(Figs. 1–25)

Material examined. – Santos, José Menino beach (23°58'11" S 46°20'56" W): 33 ♀ and 1 ♂, collected on 28 Oct. 1978; 7 ♀ ♀, collected on 25 Sep. 1984; 2 ♀ ♀, collected on 20 June 1966. All from water in burrows of *Callichirus major* (Say, 1818) in intertidal zone of the beach (Sérgio A. Rodrigues coll.). Cananéia: 1 ♀ caught free in a *Spartina* sp. salt marsh, 24 Apr. 1985 (A. Tararam coll.). The ♀ holotype, ♂ paratype, and 20 ♀ ♀ paratypes are deposited in the Museu de Zoologia, Universidade de São Paulo (MZUSP 11445 and 11446).

Description. – Female: Total length, excluding setae on caudal rami, 1.8–2.2 mm ($N = 8$). Prosome (Fig. 1) slightly shorter than urosome (0.93 : 1). Cephalosome sparsely covered with sensillae. Posterior borders of all urosomal somites smooth. Genital double somite (Fig. 1) as long as broad, with greatest width in its anterior third. Anal somite (Fig. 2) twice longer than preceding somite, with row of spines on ventral surface near anterior edge, another row on posterior edge extending from each side dorsally and ventrally, and four patches of minute spines on ventral surface.

Caudal ramus (Fig. 1) about 9 times longer than wide, and armed with 6 setae (Fig. 3). Lateral seta inserted in posterior quarter and not reaching tip of ramus. Inner apical seta twice as long as outer apical seta. Inner middle apical seta 1.6 times longer than outer middle seta; both plumose. Dorsal seta 1.5 times longer than outer apical seta.

Rostrum (Fig. 4) conspicuous only in ventral view, with rounded posterior margin.

Antennule (Fig. 5) 7-segmented; formula for armature: 5, 12, 6, 3, 4, 2 + aesthetasc, 6.

Antenna (Fig. 6) 4-segmented. Segments 1 and 2 with single seta each. Segment 3 with row of spines on inner edge, transverse row of spines on outer side, and 1 hook-like spine and 3 setae at inner dis-

tal corner. Segment 4 with 7 apical setae and 2 transverse rows of setules on outer side.

Labrum (Fig. 7, Lbr) triangular; free margin with row of setules medially, and row of spines on each side. Metastomal area armed as in Fig. 7.

Paragnaths (Fig. 7, Pr) protruded into denticulate narrow apical lobe, with setulose basal area continuing distally into line of setules on inner margin and row of minute setules on ventral surface.

Mandible (Fig. 8) with stout outer spine armed with teeth on inner edge and distal part of outer edge. Middle spine foliaceous, bearing spinules on each side. Inner spine also foliaceous but having spinules only on inner edge. Minute spine present at inner distal corner.

Maxillule (Fig. 9) bilobate. Apical lobe with 3 naked and 2 plumose setae. Smaller proximal lobe with 3 spines: outer spine serrate, middle spine with blunt pinnules on distal half of inner margin, and inner spine sparsely pinnate on both margins and bearing proximally group of 3 spinules.

Maxilla (Fig. 10) 2-segmented. First segment inflated, bearing 2 setae near distal end of inner surface; proximal seta stout, with spinule on enlarged base, and spinules and setules on both margins of distal half; distal seta slender and plumose. Second segment protruded into stout claw-like process, bearing basal seta and stout setulose apical claw.

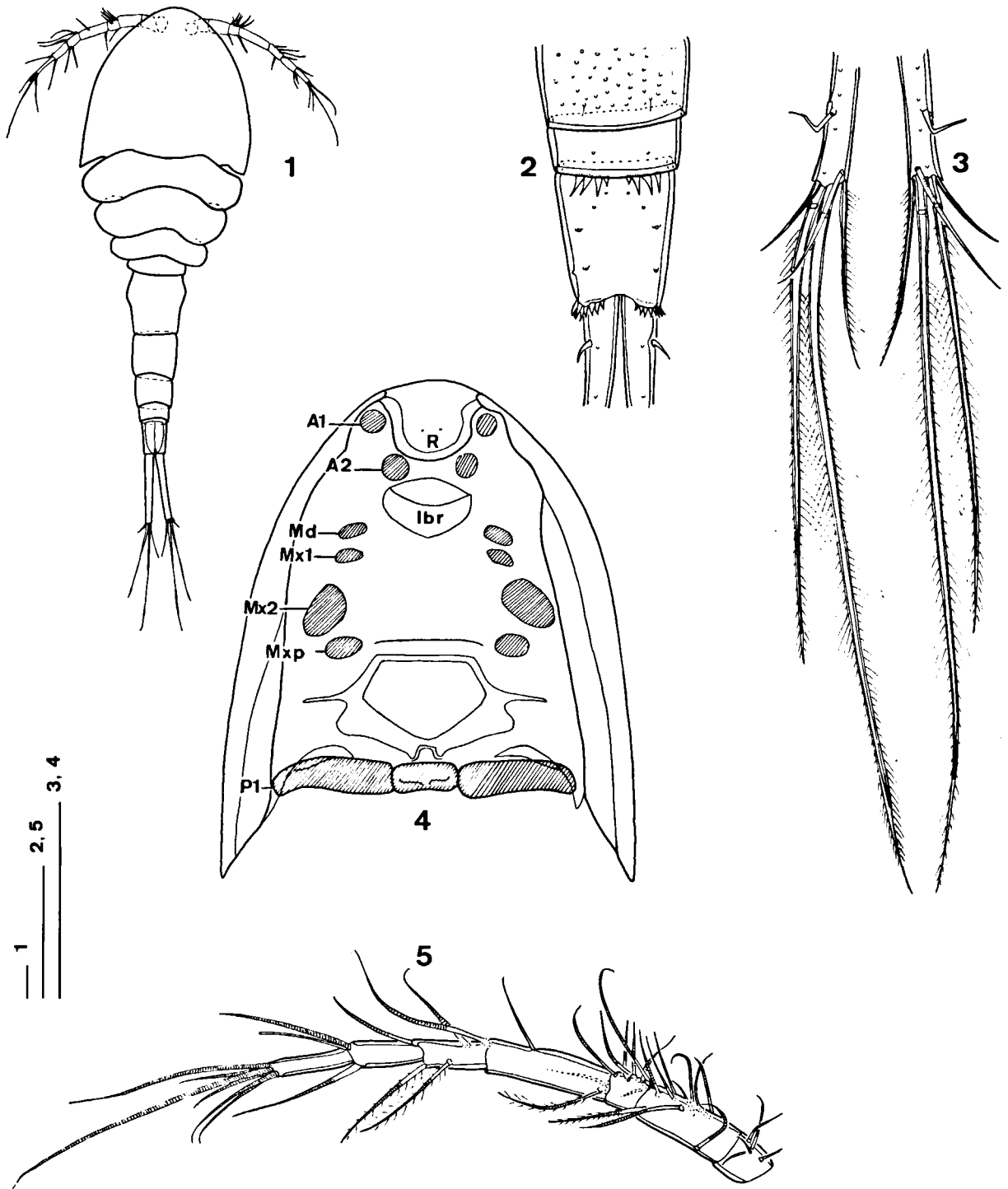
Maxilliped (Fig. 11) 4-segmented. Segment 1 with 2 inner setae. Segment 2 with 2 spinulose inner setae. Segment 3 naked. Segment 4 bearing 1 seta and 2 denticulate spines.

Area between maxillipeds and leg 1 (Fig. 4) with heavy sclerites protruding into a median longitudinal keel.

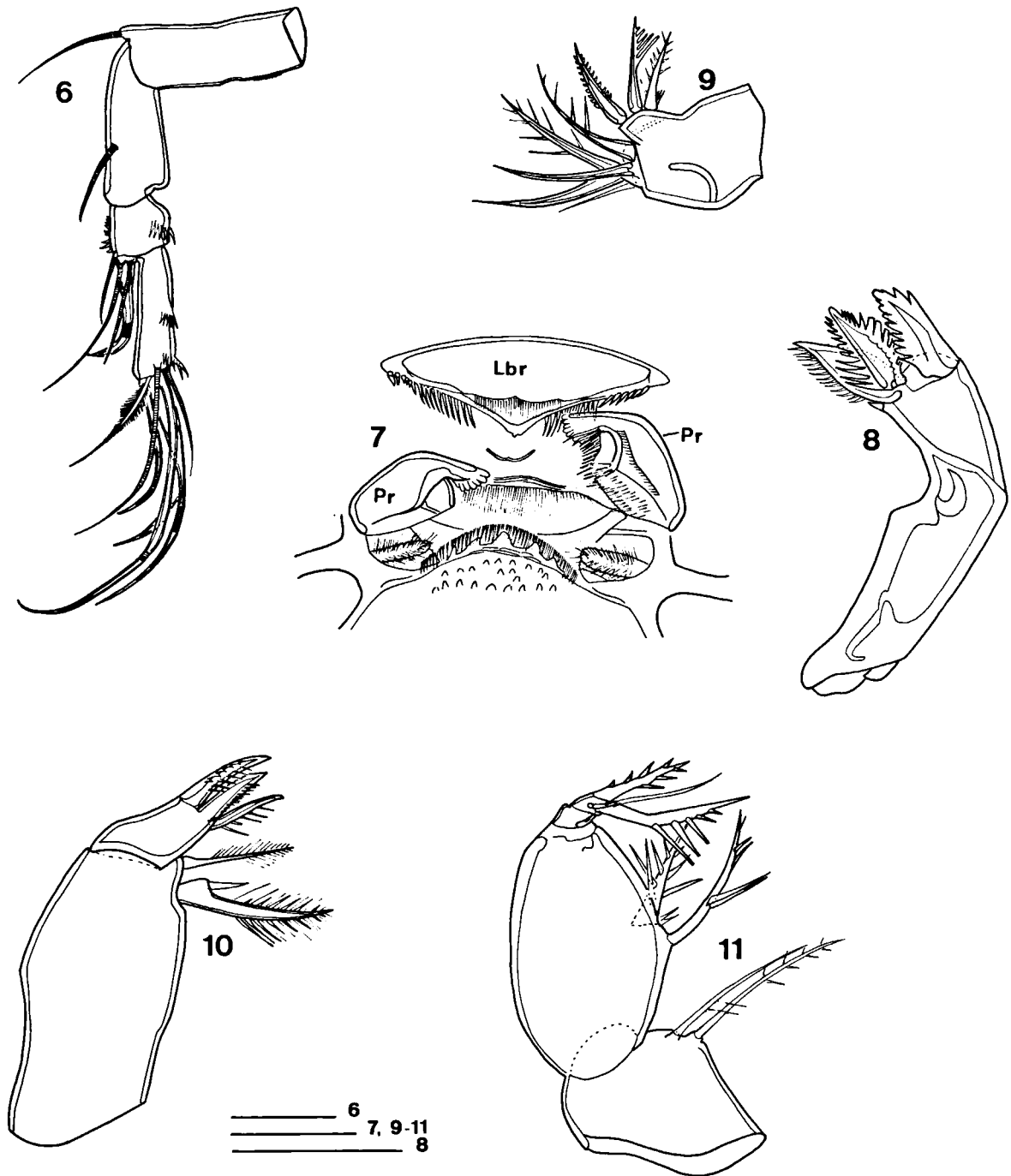
Armature of rami of legs 1–4 (Figs. 12–15) as follows (Roman numerals representing spines, Arabic numerals representing setae):

	Endopodite			Exopodite		
	1	2	3	1	2	3
Leg 1	0–1	0–1	I,5	I–0	I–1	III,1,4
Leg 2	0–1	0–2	II,1,3	I–0	I–1	III,1,5
Leg 3	0–1	0–2	I,III,2	I–0	I–1	II,1,5
Leg 4	0–1	0–1	I,III	I–0	I–1	II,1,5

Legs 1–3 (Figs. 12–14) with inner coxal seta. Only leg 1 armed with 1 inner spine on basis. Leg 4



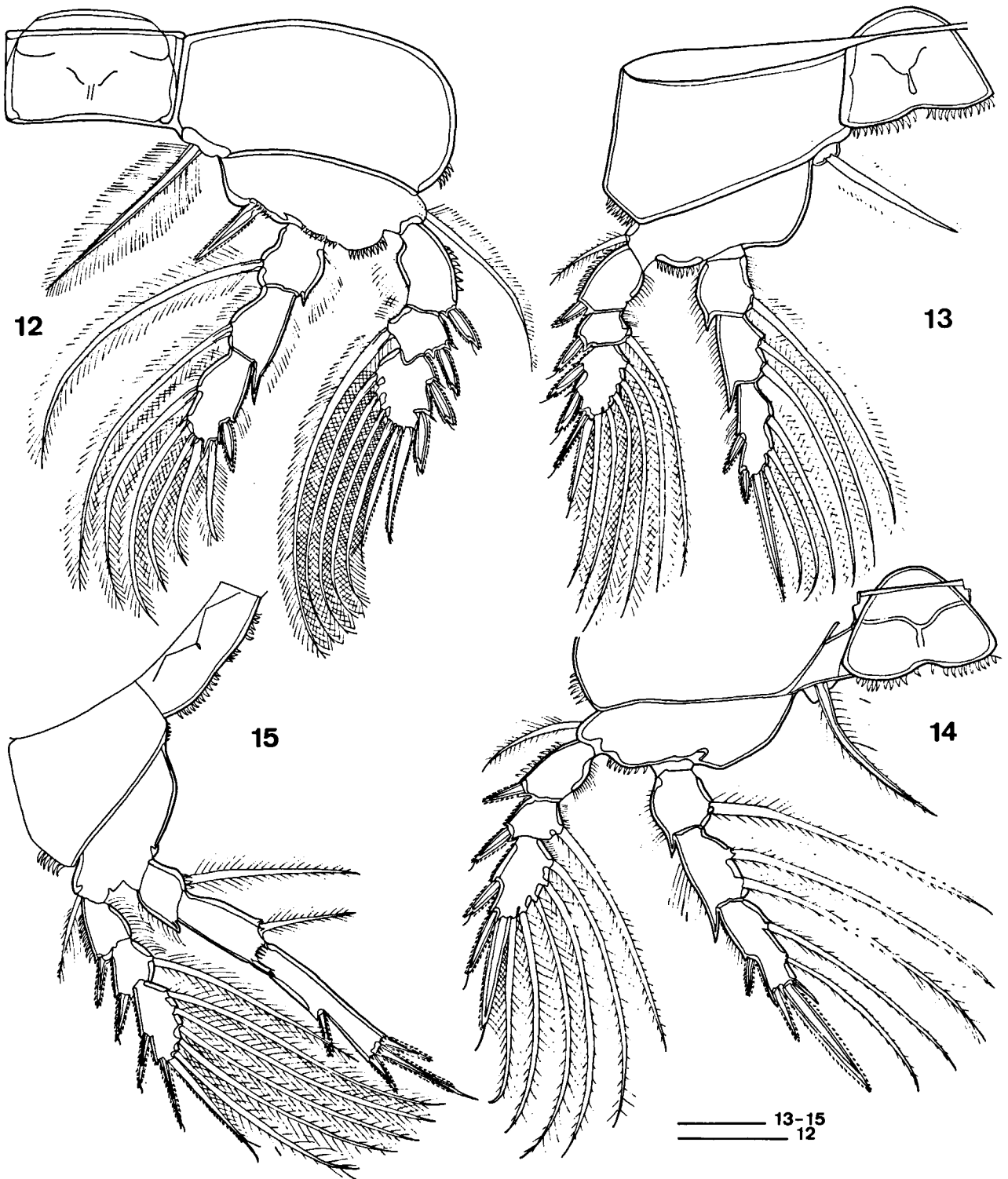
Figs. 1–5. *Hemicyclops caissarum* sp. n., ♀ holotype: 1, habitus, dorsal; 2, urosomite 5, anal somite, and proximal part of the caudal rami, ventral; 3, terminal part of the caudal rami with the set of setae, dorsal; 4, cephalosome, ventral, showing the rostrum (R), labrum (Lbr), area between maxillipeds (Mxp) and legs 1 (P1), and the insertion places of cephalic appendages (A1, antennule; A2, antenna; Md, mandible; Mx1, maxillule, Mx2, maxilla); 5, antennule. Scale bars 200 μ m.



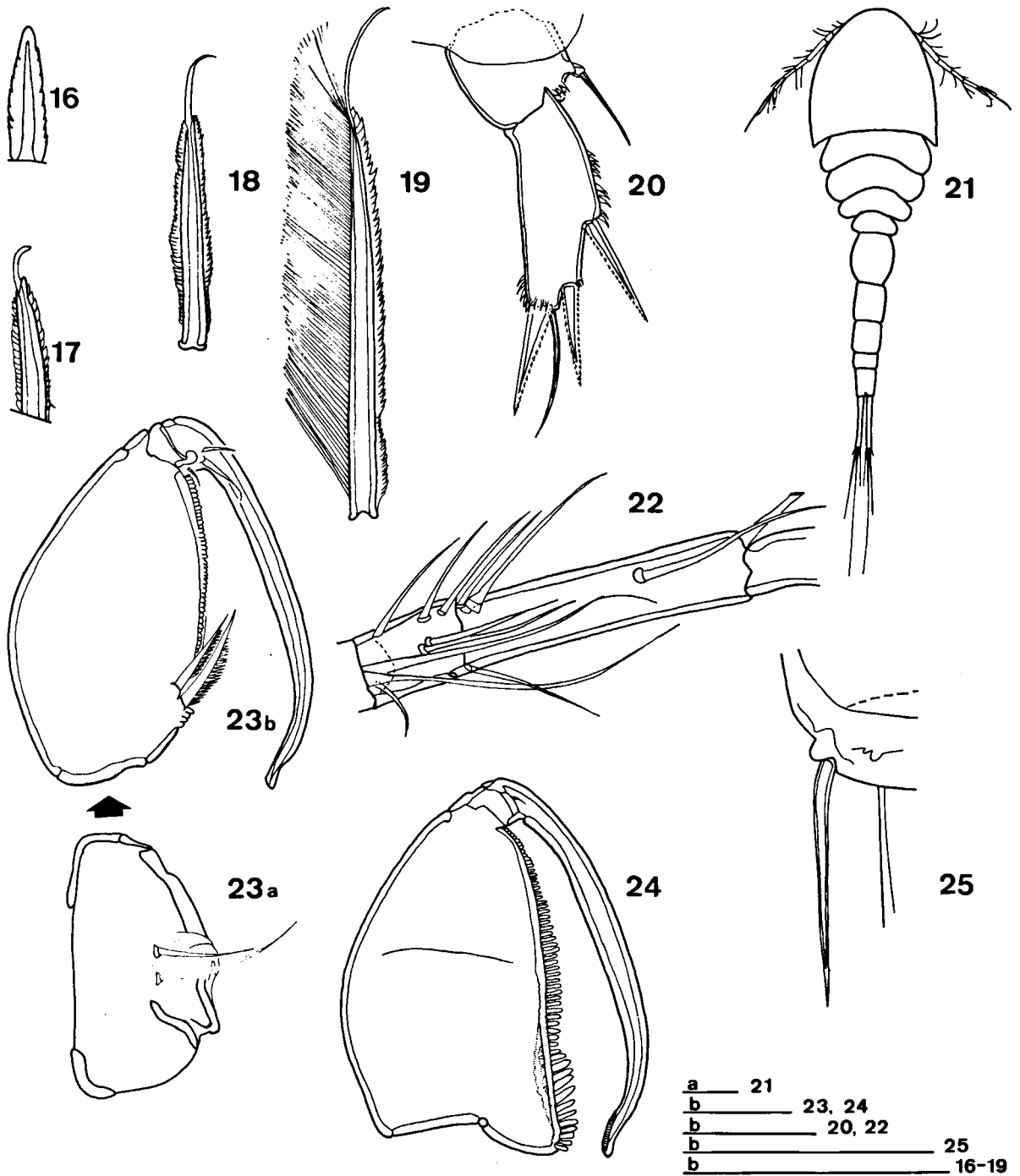
Figs. 6–11. *Hemicyclops caissarum* sp. n., ♀ holotype: 6, antenna; 7, oral area with labrum (Lbr) and paragnaths (Pr), ventral; 8, mandible; 9, maxillule; 10, maxilla; 11, maxilliped. Scale bars 100 μ m.

(Fig. 15) without inner coxal seta. Endopodite 1.3 times longer than exopodite; inner seta on proximal segment twice longer than that of middle segment;

distal segment twice as long as middle segment and 5 times longer than its width, naked on inner margin.



Figs. 12–15. *Hemicyclops caissarum* sp. n., ♀ holotype: 12, leg 1; 13, leg 2; 14, leg 3; 15, leg 4. Scale bars 100 μ m.



Figs. 16–25. Hemicyclops caissarum sp. n., 16–20, ♀ holotype; 21–25 ♂ paratype: 16, serrate spine (type a); 17, serrate spine with subterminal flagellum (type b); 18, serrate spine with terminal flagellum (type c); 19, serrate and plumose spine with terminal flagellum (type d); 20, leg 5; 21, habitus, dorsal; 22, antennule segments 3 and 4; 23, maxilliped, anterior face of segment 1 (a) and of rest of appendage (b); 24, maxilliped segments 2 to 4, posterior; 25, leg 6. Scale bars 200 μm (a) and 100 μm (b).

Spines on exopodites of legs 1–4 of 4 types: (a) serrate spines (Fig. 16) found on proximal segment of legs 2–4; (b) serrate spines with subterminal flagellum (Fig. 17) found on outer margin of 2nd and 3rd segments of legs 2–4 and all segments of leg 1; (c) serrate spines with terminal flagellum (Fig. 18) found on outer terminal margin of distal segment of all legs; and (d) spines with serrate outer margin, plumose inner margin, and terminating in a flagellum (Fig. 19), found on apex of distal segment of all four legs.

Leg 5 (Fig. 20) 2-segmented. Basal segment broad, with outer seta. Terminal segment thrice longer than wide, with 3 serrate spines about equal in length, all of them shorter than terminal segment; terminal seta naked and slightly longer than apical spine.

Male: Total length 1.45 mm. Prosome (Fig. 21) shorter than urosome (0.88 : 1). Genital somite oval. Proportions of abdominal somites as those of female. Caudal rami also as in female. Spermatozoa not seen.

Antennule (Fig. 22) differing from female in having segments 3 and 4 with 7 and 4 setae, respectively.

Mandible, maxillule, and maxilla resembling those of female.

Maxilliped (Figs. 23, 24) with 2 unequal naked setae on segment 1. Segment 2 broad, with 2 rows of teeth and 2 inner spinulose setae on inner margin; row of teeth on anterior surface interrupted by base of setae; row of teeth on posterior surface continued along entire inner margin, decreasing in size toward distal end of segment. Segment 3 short and unarmed. Segment 4 a claw slightly longer than segments 2 and 3 combined, with flexure near tip armed with striate lamella; basal portion of claw with 3 setae on anterior surface and 1 small seta on posterior surface.

Legs 1–5 as those in female in terms of types and arrangement of spines and setae.

Leg 6 (Fig. 25) represented by seta on posterior corner of genital somite.

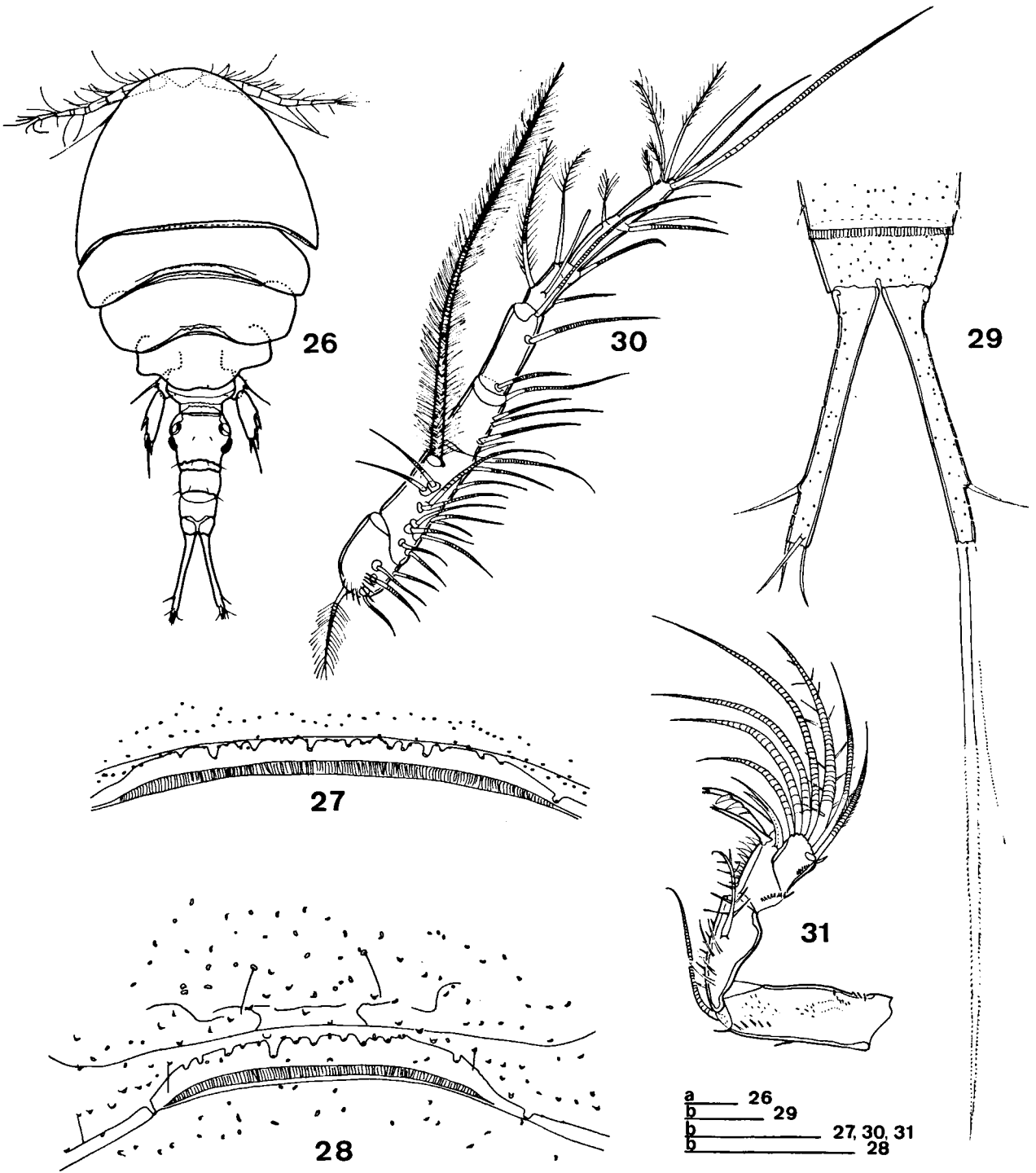
Etymology. – The specific name refers to the local name for coastal inhabitants of the State of São Paulo.

Remarks. – *Hemicyclops caissarum* sp. n. shares with *H. adhaerens* (Williams, 1907), *H. arenicolae* Gooding, 1960, *H. subadhaerens* Gooding, 1960, and *H. carinifer* Humes, 1965 a female urosome of 6 somites, the 4th antennal segment longer than the 3rd, 5 setae on the 1st segment of the antennule, elongate caudal rami, and the tip of the mandible armed with 3 elements. Among these species, it resembles *H. carinifer* described by Humes (1965) from Madagascar in having the same seta and spine formulae on legs 1 to 4, and a keel on the ventral surface between the maxilliped and the first pair of legs. Nevertheless, they differ (1) in the length/width ratios of the caudal rami, terminal segment of the antenna, second segment of the maxilliped in both sexes, and second and third endopodal segments of legs 1–4; (2) in the armature of the metastomal area, paragnath, labrum, and intercoxal sclerite of leg 1; (3) in the ornamentation of the mandibular spines, as well as the proximal seta on the basal segment and both setae on the second segment of the male maxilliped; and (4) in the relative lengths of the inner setae on the first two endopodal segments of leg 4.

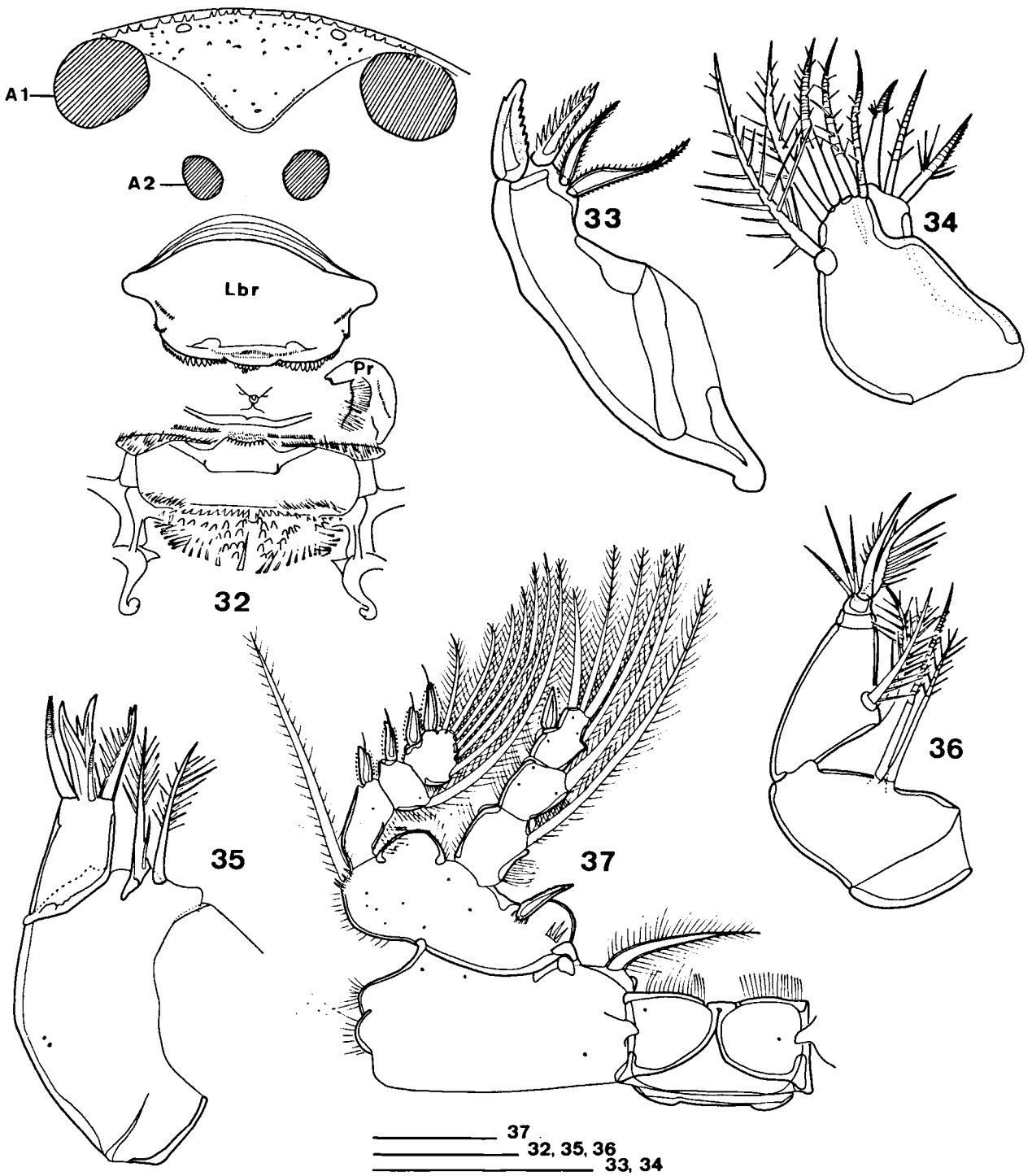
Hemicyclops sebastiani sp. n.
(Figs. 26–41)

Material examined. – São Sebastião, Araçá beach (23°43'06" S 45°24'36" W): 4 ♀♀ in burrow water of *Callichirus guassutinga* (Rodrigues, 1971), collected in the intertidal zone of the beach, 2 Oct. 1978, M.H.G. de C. Bjornberg coll. The ♀ holotype (MZUSP 11447) and 2 ♀♀ paratypes (MZUSP 11448) are deposited in the Museu de Zoologia, Universidade de São Paulo. One dissected specimen is kept in C.E.F. da Rocha's collection.

Description. – Female: Total length, excluding setae on caudal rami, 2.12–2.29 mm ($N = 3$). Prosome (Fig. 26) 1.38–1.52 times longer than urosome ($N = 3$). Tergal plates of prosome and entire surface of urosome ornamented with refractile points and sensillae. Posteromedian border of first two free somites of prosome ornamented as shown in Figs. 27 and 28, respectively. Last somite of prosome expanded posteriorly and covering part of 5th pediger (Fig. 26). Genital double somite (Fig. 26) as long as wide and expanded laterally in anterior



Figs. 26–31. *Hemicyclops sebastiani* sp. n., ♀ holotype: 26, habitus, dorsal; 27, median part of the border of 2nd free prosomal somite, showing ornamentation; 28, median part of 3rd free prosomal somite, showing ornamentation; 29, last two urosomites and caudal rami, dorsal; 30, antennule; 31, antenna. Scale bars 200 μm (a) and 100 μm (b).



Figs. 32–37. *Hemicyclops sebastiani* sp. n., ♀ holotype: 32, oral area (A1, antennule; A2, antenna; Lbr, labrum; Pr, paragnath); 33, mandible; 34, maxillule; 35, maxilla; 36, maxilliped; 37, leg 1. Scale bars 100 μ m.

third. Posterior border of two urosomites subsequent to genital double somite with membranous fringe (Fig. 29). Anal somite (Fig. 29) unarmed, 2.3 times wider than long and shorter than preceding somite.

Caudal rami (Fig. 29) wide at base, diverging from each other and about 12.5 times longer than wide. Lateral seta inserted in posterior quarter and reaching tip of ramus. Inner apical seta as long as lateral seta and slightly shorter than dorsal seta. Outer apical seta weak, attached to ramus ventrally and concealed by outer middle apical seta. Middle apical setae with minute barbs.

Antennule (Fig. 30) 7-segmented; formula for armature: 5 + row of spinules, 15, 5, 3, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc. Inner ventral seta of segment 2 densely plumose, much thicker than other setae, and reaching tip of antennule.

Antenna (Fig. 31) 4-segmented. Segment 1 with seta and several rows of spinules on surface. Segment 2 with seta and rows of spinules on inner side. Segment 3 bearing row of prominent spinules on inner edge, transverse row of spinules on outer side, and 4 setae on protruded inner corner. Distalmost seta recurved, bifid and armed with 3 spinules. Segment 4 subquadrate and armed with 7 terminal setae.

Labrum (Fig. 32) rectangular, curved anteriorly, expanded into lobe on each side, and with rows of spinules on ventral surface as shown in Fig. 32. Metastomal area with complex armature of spinules and teeth (Fig. 32).

Paragnaths (Fig. 32, Pr) consisting of apical lobe with minute teeth on edge, and swollen basal portion bearing inner setulose area and row of minute spinules on ventral surface.

Mandible (Fig. 33) bearing 2 stout serrate spines and 2 setulose setae.

Maxillule (Fig. 34) with 5 setae on larger lobe and 3 setae on smaller lobe. One seta of latter group slightly thicker than other two.

Maxilla (Fig. 35) 2-segmented. Segment 1 swollen, bearing 3 setae, one of them rather reduced. Segment 2 protruded into stout, trifid process bearing reduced basal seta, with a seta on outer corner and another bifid spinulose seta on inner corner.

Maxilliped (Fig. 36) 4-segmented. Segment 1 with

2 setae. Second segment bearing 2 setae at greatly expanded proximal inner surface. Segment 3 short and unarmed. Segment 4 with 2 thick setae (one of them with 6 long and slender spinules on inner margin) and 3 much slenderer setae.

Armature of rami of legs 1–4 (Figs. 37–40) as follows (Roman numerals representing spines, Arabic numerals representing setae):

	Endopodite			Exopodite		
	1	2	3	1	2	3
Leg 1	0–1	0–1	I,4	I–0	I–1	II,6
Leg 2	0–1	0–2	I,II,3	I–0	I–1	III,I,5
Leg 3	0–1	0–2	I,II,3	I–0	I–1	III,I,5
Leg 4	0–1	0–2	I,II,2	I–0	I–1	II,I,5

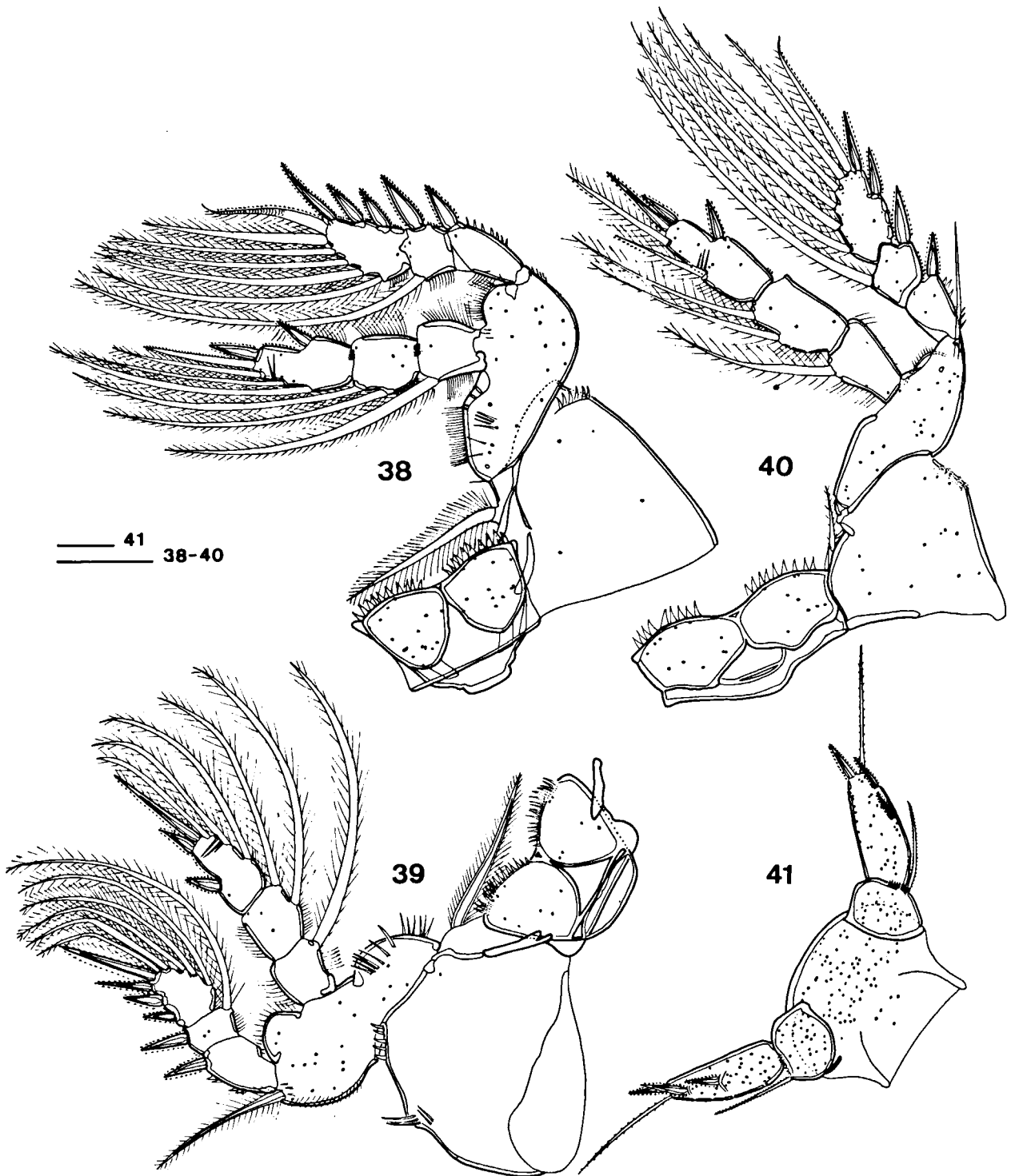
Inner coxal setae on legs 1–3 turned medially, but that of leg 4 short and positioned as usual in *Hemicyclops*. Basis of all legs protruded outward, reducing articulation area with coxa. Basis of leg 1 with short inner spine and stiff outer plumose seta distinctly longer than exopodite. Median seta on terminal segment of endopodite of legs 2–4 with 2 or 3 stiff basal setules on outer side. Exopodal segment 3 of leg 2 with characteristic terminal spine, being setiform with annulations in its distal half.

Leg 5 (Fig. 41) 2-segmented. Basal segment with outer seta. Terminal segment bearing 3 serrate spines similar in length, being one quarter of terminal segment. Apical seta ornamented with tiny spinules, about 4 times longer than apical spine.

Etymology. – The specific name is the name of the town where the new species was collected.

Remarks. – *Hemicyclops sebastiani* can be easily distinguished from its congeners by the presence of the following features: (1) 4th pediger expands posteriorly over the 5th pediger, and (2) ventral seta on antennular segment 2 is densely plumose and much thicker and longer than other setae, reaching the tip of the antennule.

Another unusual feature of the new species is the appearance of the terminal spine on the 3rd exopodal segment of leg 2.



Figs. 38–41. *Hemicyclops sebastiani* sp. n., ♀ holotype: 38, leg 2; 39, leg 3; 40, leg 4; 41, leg 5. Scale bars 100 μ m.

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