

Four new species of *Halicyclops* Norman, 1903 (Copepoda, Cyclopoida) from Brazil

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Abstract

Four new species of *Halicyclops* are described and figured from plankton samples of the brackish waters of Pomonga River, Sergipe State (NE Brazil). The ornamentation of the median apical setae of the furcal rami is proposed as useful diagnostic character for species distinction.

Introduction

The genus *Halicyclops* is poorly known in the Neotropical Region. Four species were reported from there until now: *H. exiguus* Kiefer, 1934 and *H. similis* Kiefer, 1935 from a brackish lake of Haiti, *H. venezuelaensis* Lindberg, 1954 from Venezuela (Lindberg, 1954) and the Amazonas River mouth (Cipólli & Carvalho, 1973) and *H. crassicornis* Herbst, 1955 from brackish water on the Brazilian coast (Lagoa Rodrigo de Freitas, Rio de Janeiro and Cananéia mangrove).

The plankton samples analysed here were obtained from the Pomonga River (Sergipe State, NE Brazil) during the course of a biological survey sponsored by the Sergipe State Government and Universidade Federal de Sergipe. River Pomonga meanders across a flat area. It is more of a canal running parallel to the coast in a direction NE-SE, connecting the rivers Sergipe and Japarutuba (Fig. 1). Thus, it is influenced by the tides of the both river estuaries, which meet near our station 3. The section under the influence of the Japarutuba River has depths around 1.0 m at high tide, water rich in suspension of particulated organic material, salinities ranging from 1.0 to 13.0 ‰ during the year, high temperatures (25.0–32.0 °C), and absence of mangrove trees on the margins, except near

the confluence of the waters. The other section is deeper (2.0–7.0 m) and wider, with more saline waters and extensive, marginal mangrove areas. Fresh water is provided by rain, some springs along the canal, principally near the confluence area, and influx of water from the Japarutuba River. During the rainy period (March–August) diluted waters occupy the canal from the confluence of the tides to the mouth in the Japarutuba. Sometimes the whole canal is under their influence (1.0 to 5.5‰ in July, 1978).

Materials and methods

The samples were collected using a conic-cylindrical net with nylon gauze Monyl Ny 120 HD, which was pulled horizontally at the surface during one minute. The material was fixed with formaline of 4%. Three collecting stations were situated in front of the boat-piers (1- Barreira d'água, 2- Papagaio and 3- Siriba) and the fourth was near Pedrinhas.

Specimens were measured in lateral position. The body lengths do not include the furcal setae.

The following abbreviations have been used in the descriptive text: MZUSP- Museu de Zoologia, Universidade de São Paulo, Brazil; Tx5- fifth thoracic segment; P1 . . . P6- first . . . sixth pair of legs;

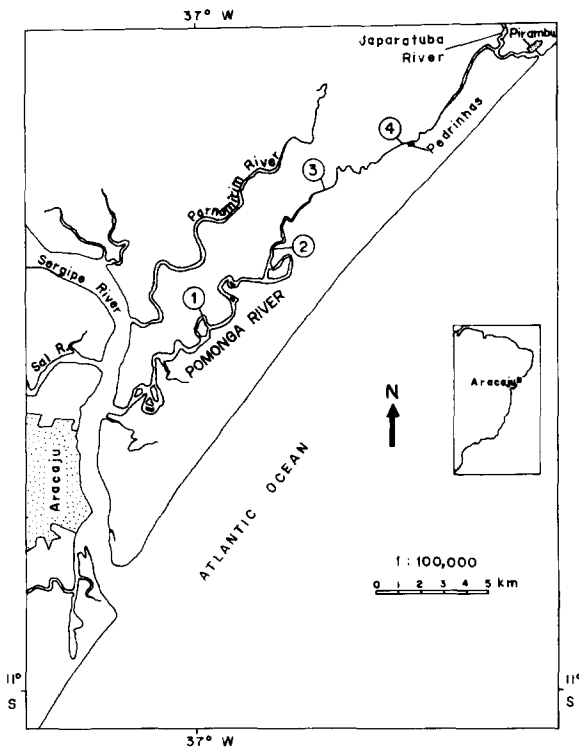


Fig. 1. Partial map of estuary of Sergipe River showing the sampling stations in Pomonga River.

B1-coxa; B2- base; En1 . . . En3- first . . . third endopodal joint; Ex1 . . . Ex3- first . . . third exopodal joint.

The terms 'basal portion' (bp) and 'terminal portion' (tp) (Fig. 19) of the median apical setae of furcal rami refer, the former, to the part between the joint on the ramus and the constriction near the middle of the seta and the latter to that between this constriction and the distal tip.

CYCLOPIDAE

Halicyclops Norman, 1903

Halicyclops pilosus sp. n.

(Figs. 2-22)

Type material. Holotype (1 female, MZUSP 5224) and allotype (1 male, MZUSP 5225) from station 4, Pomonga River, Sergipe State, NE Brazil, 1 June 1978, C.E.F. da Rocha coll. Paratypes: 2 females and 1 male from station 1, 2 females and

1 male from station 2, 2 females from station 3, 8 females and 5 males from station 4, same river, and date, 4 females and 3 males from station 4, same river, 30 June 1978, C.E.F. da Rocha coll. Six paratypes in MZUSP (ref. no. 5226).

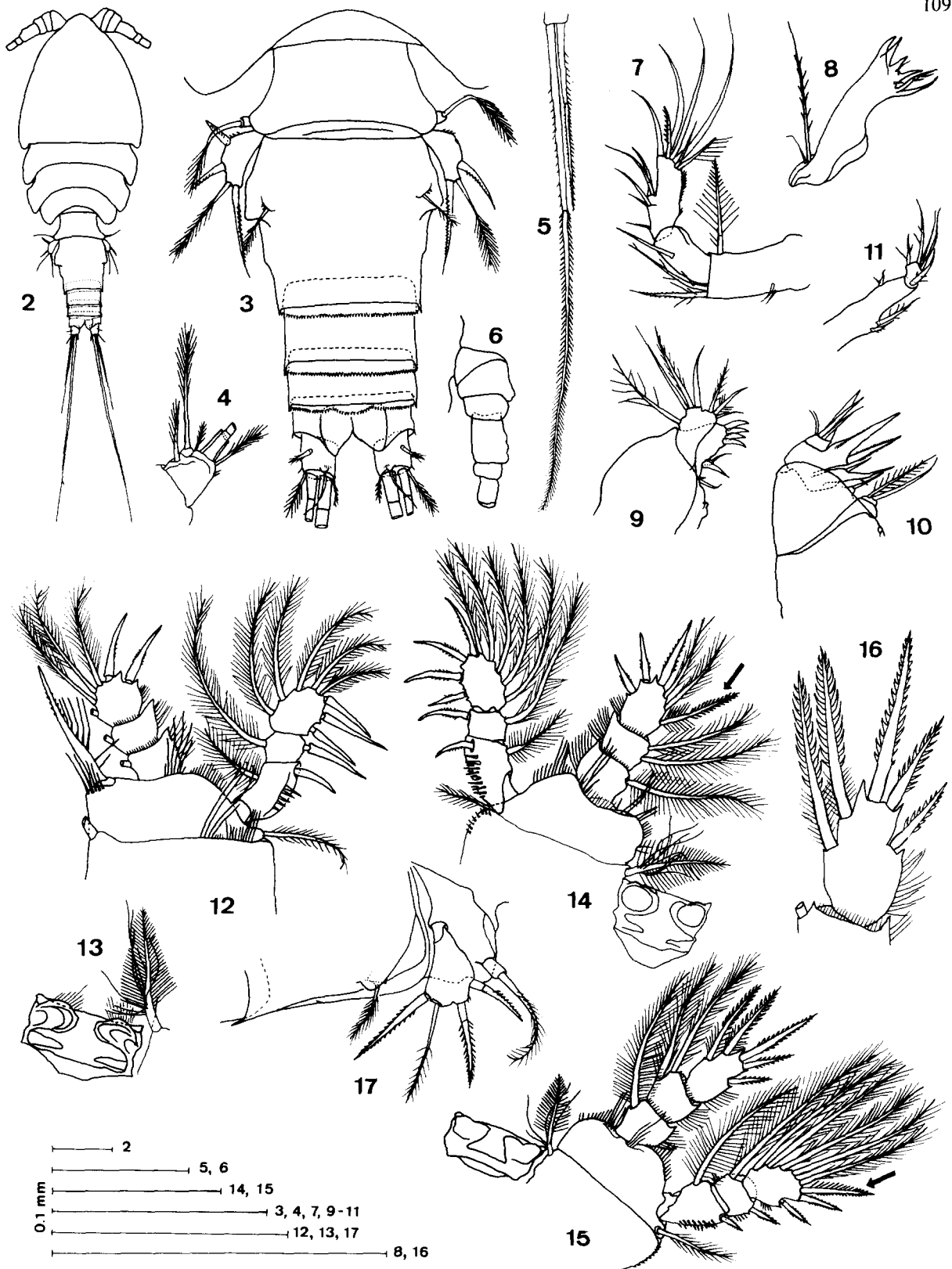
Description. Female. Total length 565-610 μm (N = 9), holotype 570 μm . Prosome:urosome ratio = 1.51-1.79:1 (N = 9). Cephalothorax (Fig. 2) anteriorly triangular in dorsal view, the greatest width in the posterior region. First urosomal segment (Tx5) protruding from prosome. Posterior borders of this segment and of all prosomal segments smooth.

Genital segment (Fig. 3) nearly as broad as long (100:90 μm) in the proximal third, where there are two lateral, triangular protuberances. P6 inserted dorso-laterally, constituted at an inner plumose seta and two reduced spines. Posterior border of this segment and of the two following urosomal segments denticulate; dorsal portion of the fourth urosomal segment slightly expanded. Anal segment with denticles only ventrally.

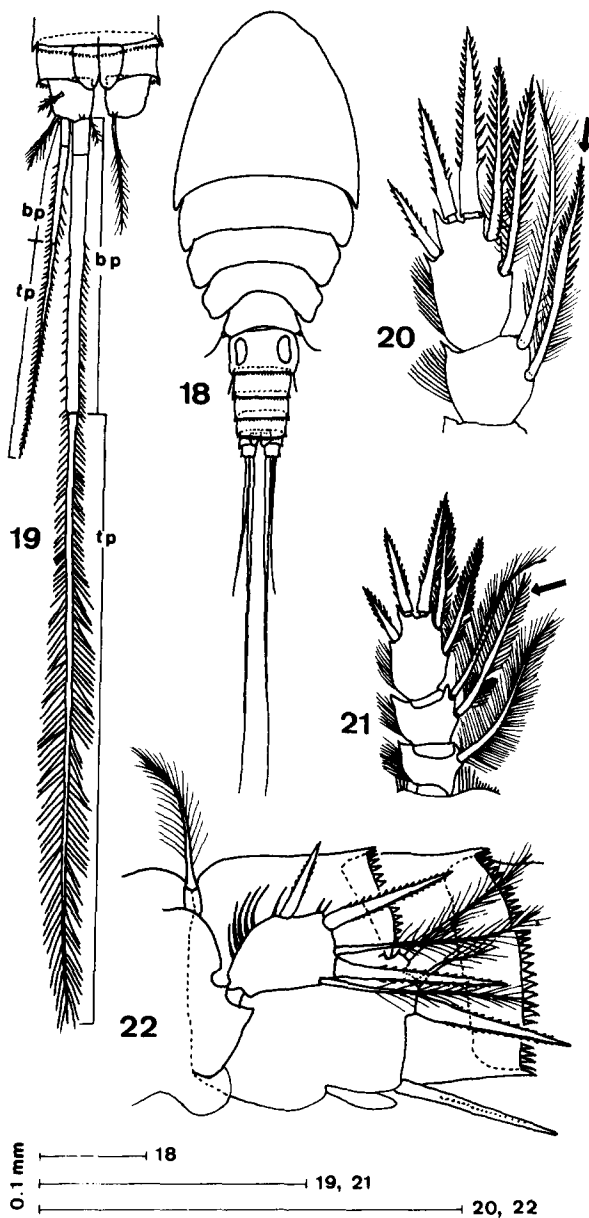
Furcal rami (Figs. 3, 4) long as wide (19 μm). Lateral seta plumose, about 1.4 times longer than furca. Dorsal seta plumose, arising from subterminal papilla and 2.7 times the length of ramus. Outer apical seta plumose, a little longer than ramus (25 μm). Inner apical seta shorter than ramus and outermost seta (0.8:1 and 0.6:1, respectively). Inner median apical seta (Fig. 5) with basal portion naked externally and with few setules on inner margin; terminal portion with setules progressively more slender towards the tip of the seta. Outer median apical seta (Fig. 5) about one third the length of inner median apical seta, setulose externally and with short setules internally on terminal portion.

Antennule (Fig. 6) six-jointed, reaching middle of cephalothorax. Fourth joint about 1.3 times as long as wide. Antenna and feeding appendages as on Figs. 7-11.

P1-P4 (Figs. 12-15) biramous; each ramus 3-jointed. P2 and P3 differing only in size. B1 with inner feather-like seta. B2 with outer seta and hairs on distal edge, some as long as or longer than the En1. B2 P1 bearing an inner spine, 1.22 times longer than endopod and ornamented as on Fig. 12. Ex1 with outer spine, inner seta and some external spinules. Ex2 with outer spine and inner seta. Ex3 P1-P4 with spinal formula 3.4.4.3 and setal formula 5.5.5.5. Exopodal spines of P1 and P2 long and



Figs. 2-17. *Halicyclops pilosus* sp. n. Female 2. habitus, dorsal; 3. urosome, dorsal; 4. furcal ramus, lateral; 5. median apical furcal setae, dorsal; 6. antennule; 7. antenna; 8. mandible; 9. maxillule; 10. maxilla; 11. maxilliped; 12. P1; 13. intercoxal plate and seta on B1 P1; 14. P2 and intercoxal plate; 15. P4 and intercoxal plate; 16. En3 P4; 17. P5.



Figs. 18–22. *Halicyclops pilosus* sp. n. Male 18. habitus, dorsal; 19. posterior end of urosome, dorsal (bp = basal portion and tp = terminal portion of median apical furcal setae); 20. En2 and En3 P4 (allotype); 21. Endopod of P4 (another exemplar); 22. anterior part of urosome showing P5 and P6, lateral.

slender. Innermost spine of Ex3 P3–P4 plumose internally and spinulose externally. En1 of all legs with inner seta; En2 with inner seta on P1 and 2 setae on P2–P4. En1 and En2 with short hairs on distal edges. En3 P1 with 2 spines and 4 setae; En3 P2–P3 with 3 spines and 3 setae, the proximal one

modified (plumose proximally and setulose terminally). En3 P4 (Fig. 16) 1.7 times as long as wide, with 3 spinulose spines and 2 spiniform setae. Inner apical spine 1.33 times the length of joint and 1.62 times that of outer apical spine. Inner setae equal in length, plumose proximally and spinulose terminally, both not reaching the tip of innermost spine. In all legs the normal setae are densely plumose. Protuberances of distal edge of intercoxal plate of P1 with hairs (Fig. 13).

Terminal joint of P5 (Fig. 17) twice longer than wide ($39:20 \mu\text{m}$), with 3 finely serrated spines and a plumose seta. Innermost spine slightly longer than terminal joint and outer apical spine (1.15:1).

Male. Total length 425–466 μm (N = 9), allotype 425 μm . Prosome:urosome ratio = 1.48–1.81:1 (N = 9).

Cephalothorax (Fig. 18) rounded anteriorly. Urosome with one more segment than in female; posterior borders of segments as in female.

Furcal rami (Fig. 19) slightly wider than long ($18:15 \mu\text{m}$). Setae similar in length to those in female. Outer apical seta about twice as long as the innermost one. Ornamentation of median apical setae with some differences relatively to those of female, mainly on its basal portions (Fig. 19).

Antennule prehensile and geniculate, 13-jointed. Antennae, feeding appendages and P1–P3 like those in female.

Endopod P4 (Fig. 20) with proximal seta on En2 and inner setae on En3 similarly modified; in one paratype, the seta on En2 was plumose, although a little shorter and thicker (Fig. 21). En3 1.5 times as long as wide ($30:20 \mu\text{m}$). Inner apical spine 1.5 times longer than En3 and outer spine.

Terminal joint of P5 (Fig. 22) 1.53 times as long as wide, with 3 serrated spines and 2 finely plumose setae. Measurements of spines (from inner to outer): 40, 33 and 19 μm .

P6 (Fig. 22) with an inner serrate spine, as long as outer seta (39 μm), both reaching beyond the posterior border of third urosomal segment. Median seta slender, measuring a half the length of the outer one.

Etymology. The specific name (from the Latin 'pilosus', hairy) refers to the abundance of hairs on swimming legs.

Habitat. This species occurred all along the Pomonga River. Salinity and temperature ranges were 1.0–7.4 ‰ and 27.5–29.0 °C, respectively.

Differential diagnosis. *H. pilosus* resembles *H. pilifer* Lindberg, 1949 from India in the morphology of P5, En3 P4 and in the ornamentation of the median apical setae of the furcal rami. The main differences are in the length width ratio of the furcal rami, the shape of the genital segment and in the length ratio between the inner and the outer apical furcal setae.

The abundance of hairs on the swimming legs is only comparable to that observed by Burckhardt (1913) in *H. sinensis* Kiefer, 1928.

The spine on B2 P1 of *H. pilosus* is the longest one known for the genus. Three other species (*H. blachei* Lindberg, 1952; *H. coulli* Herbst, 1977 and *H. fosteri* Wilson, 1958) have long spines on their B2 P1, but not reaching beyond length of the endopod.

Halicyclops ovatus sp. n.
(Figs. 23–40)

Type Material. Holotype (1 female, MZUSP 5227) and allotype (1 male, MZUSP 5228) and 9 paratypes from station 3, Pomonga River, Sergipe State, NE Brazil, 1 June 1978, C.E.F. da Rocha coll.

Description. Female. Total length 390–490 μm ($N = 5$), holotype 435 μm . Prosome:urosome ratio = 1.88–2.25:1 ($N = 5$). Cephalothorax (Fig. 23) rounded anteriorly. First urosomal segment (Tx5) slightly broader than genital segment and not protruding much from prosome. Posterior edges of all body segments smooth.

Genital segment (Fig. 24) cylindric, slightly wider than long (70–63 μm) and without lateral protrusions. P6 (Fig. 25) with an inner plumose seta (smaller than the half of inner spine of P5) and two outer spinules.

Anal segment (Fig. 26) medially almost divided into two parts, each one with a row of subterminal spinules on the ventral surface; the outer spinules smaller than the inner ones.

Furcal rami (Fig. 26) short, longer than wide (20:16 μm), with a ventral row of subterminal spinules. Lateral seta plumose, inserted dorso-laterally on the middle of ramus, and as long as this. Dorsal seta plumose too, arising from subterminal papilla and twice the length of ramus. Outer apical seta plumose, a little longer than ramus (25 μm), subterminally placed. Inner apical seta slender and

smooth, its length about one-half that of ramus and 0.4 times that of outer apical seta. Inner median apical seta (Fig. 27) about 2.3 times as long as outer one; its basal portion naked; the terminal one is proximally spinulose on both sides, and plumose apically. Outer median apical seta (Fig. 27) with basal portion with external edge sparsely spinulose and terminal portion setulose in both sides.

Antennule (Fig. 28) 6-jointed, reaching beyond middle of cephalothorax when bent backwards; its fourth joint about 2.9 times as long as wide. Antenna and feeding appendages as on Figs. 29–33.

P1–P4 (Figs. 34–36) biramous; each ramus 3-jointed. P2 and P3 differing only in size. B1 with inner seta. B2 with outer seta. B2 P1 bearing an inner spine extending beyond En1 and ornamented as in Figure 34. Ex3 P1–P4 with spinal formula 3.4.4.3 and setal formula 5.5.5.5. En3 P2–P3 (Fig. 35) with 3 spines and 3 setae, the proximal one modified (plumose on the base and serrate on terminal half). En3 P4 (Fig. 36) about 1.5 times as long as broad with 2 inner modified setae and 3 spines. Inner apical spine little longer than respective joint (1.12:1) and at least twice the length of the outer one (28:12 μm). Setae smooth on basal portion and serrate on terminal half; distal seta longer and stronger than proximal one, reaching beyond the apex of inner apical spine. Free edge of intercoxal plate of P1 with 2 naked protuberances; in P4 it is convex in its median portion.

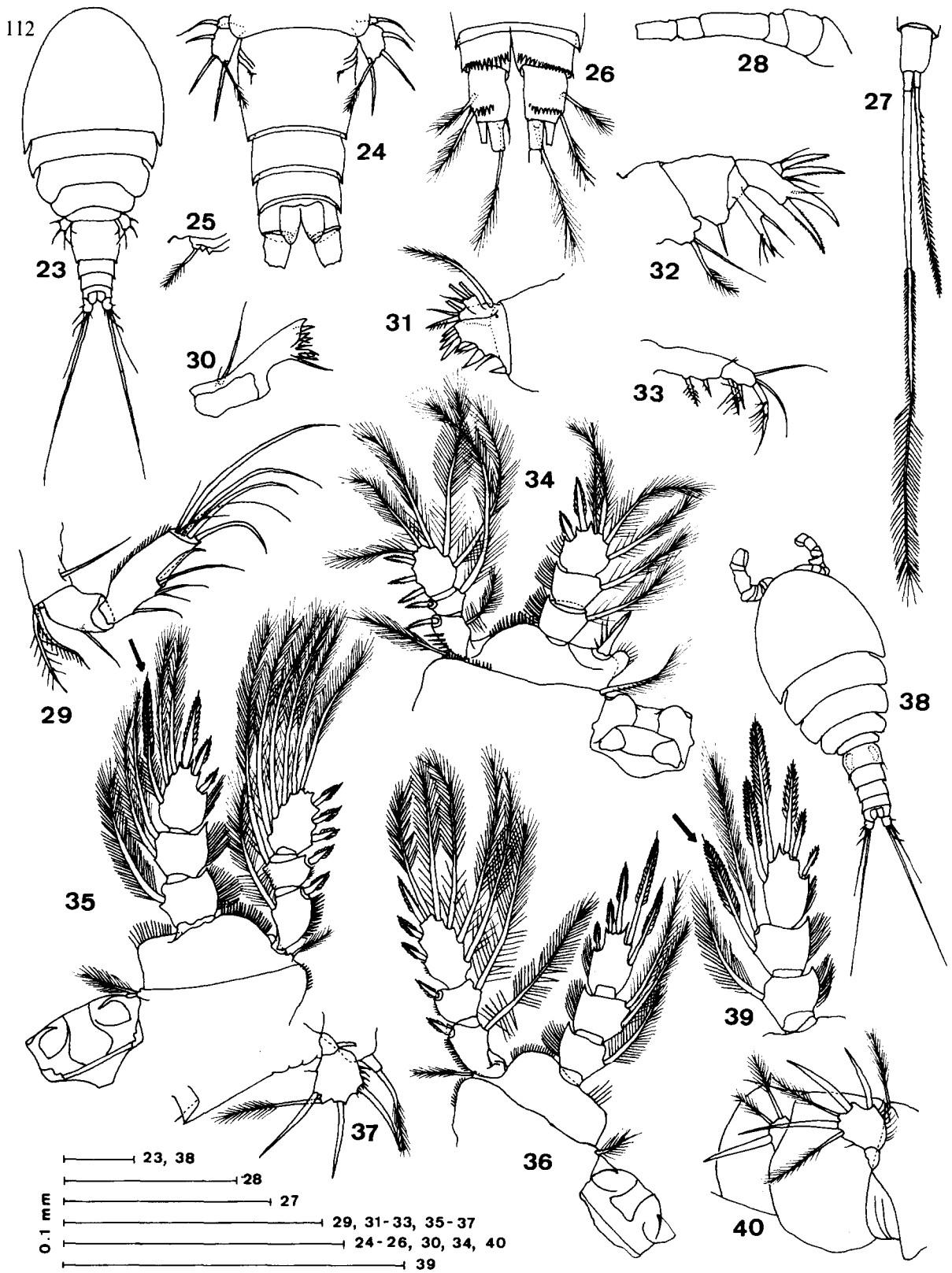
Terminal segment of P5 (Fig. 37) almost square, as long as wide (20 μm), with 3 slender, naked spines and a seta, similar in thickness to the spines. Measurements of spines (from inner to outer): 35, 30 and 30 μm .

Male. Body shape (Fig. 38) similar to that of female. Total length 390–435 μm ($N = 6$), allotype 395 μm . Prosome:urosome ratio = 1.75–2.29:1 ($N = 6$).

Furcal rami as long as wide. Setae similar in length and ornamentation to those in female. Outer apical seta about 3 times as long as inner one.

Antennule prehensile and geniculate, with thirteen joints. The other cephalothoracic appendages and swimming legs as in female, except the En2 P4 (Fig. 39), whose proximal inner seta is modified as the setae of En3 P4 of female.

Terminal joint of P5 (Fig. 40) as long as wide, with 2 plumose setae and 3 naked spines. The inner apical spine is longer than other spines and setae



Figs. 23-40. *Halicyclops ovatus* sp. n. Female 23. habitus, dorsal; 24. urosome, dorsal; 25. P6; 26. posterior end of urosome, ventral; 27. furcal ramus with only the median apical setae; 28. antennule; 29. antenna; 30. mandibule; 31. maxillule; 32. maxilla; 33. maxilliped; 34. P1 and intercoxal plate; 35. P3 and intercoxal plate; 36. P4 and intercoxal plate; 37. P5. Male 38. habitus, dorsal; 39. endopod of P4; 40. anterior part of urosome with P5 and P6, ventro-lateral.

and about twice the length of the joint. Measurements of spines (from inner to outer): 36, 29 and 22 μm .

P6 (Fig. 40) with a naked spine and two plumose setae, the outermost 1.5 times the length of median one.

Etymology. The specific name (from the Latin 'ovatus', oval) refers to the shape of prosome of these animals.

Habitat. *H. ovatus* is known only from the type-locality. It was found in brown-coloured water, with 2.2 ‰ salinity and 29.0 °C temperature.

Differential diagnosis. *H. ovatus* resembles *H. incognitus* Herbst, 1962 from the coast of Bretagne, France, in the general shape of body, size of genital segment and posterior edges of urosomal segments. It differs from this and other species of the genus by the structure of En3 P4, mainly in the length of distal inner seta, the P5, the shape of the free edge of the intercoxal plate of the P4 and the ornamentation of the median apical setae of the furcal rami.

Halicyclops verae sp. n.
(Figs. 41–55)

Type material. Holotype (1 female, MZUSP 5229) from station 2, Pomonga River, Sergipe State, NE Brazil, 1 June 1978 and a paratype (1 female) from station 1, same river and date, C.E.F. da Rocha coll.

Description. Female. Total length 643 μm , paratype 672 μm . Cephalothorax (Fig. 41) flattened frontally. First segment of urosome (Tx5) as wide as the genital one, and protruding from the prosome. Posterior edges of prosomal segments smooth.

Genital segment (Fig. 42) with two anterior bilobed bulges; measured here, the segment is as long as wide. Posterior border of urosomal segments ventrally denticulate; fourth urosomal segment with denticles also on dorsal side. P6 as on Fig. 43.

Furcal rami (Fig. 42) as long as wide (20 μm). Lateral seta plumose, about 1.5 times longer than ramus. Dorsal seta 4.3 times the length of ramus, plumose and inserted on a subterminal papilla protruding beyond the apex of ramus. Outer apical seta longer than innermost (50:10 μm); this is naked and spiniform. Inner median apical seta (Fig. 44) with basal portion naked proximally and sparsely spinulose distally; terminal portion with numerous spin-

ules proximally and plumose apically. Outer median apical seta (Fig. 44) with few external spinules on basal portion and numerous external spinules on terminal portion; the apex of the seta is plumose on its internal margin.

Antennule (Fig. 45) 6-jointed, reaching beyond half of cephalothorax; length of fourth joint 2.4 times the width. Antenna and feeding appendages as on Figures 46 to 50.

P1–P4 (Figs. 51–53) biramous; each ramus with 3 joints. P2 and P3 differing only in size. B1 with inner seta. B2 with outer seta; only on P1 with an inner spine ornamented near the base and reaching the second-half of En2. Ex3 P1–P4 with spinal formula 3.4.4.3. En3 P2–P3 with proximal seta spiniform and spinulose. En3 P4 (Fig. 54) 1.67 times as long as wide (42:28 μm), with the inner setae similar to the spines. Distal seta extending beyond innermost spine apex. Inner apical spine (59 μm) about 1.4 times the length of segment and 1.3 times that of outer apical spine.

P5 (Fig. 55) with terminal segment nearly as long as wide (30:27 μm), bearing three finely serrate subequal spines and one long seta (68 μm), about twice the length of innermost spine.

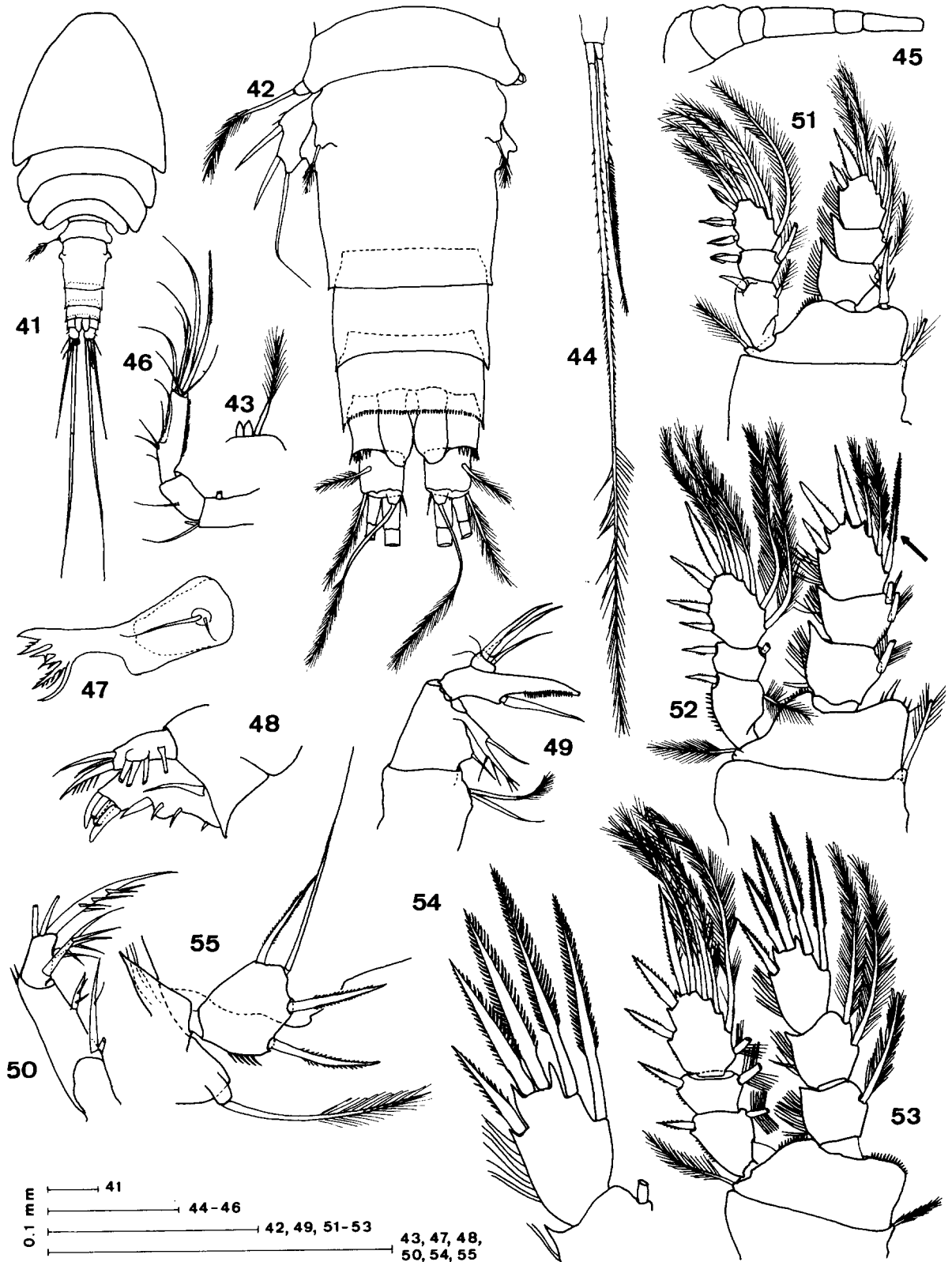
Ovigerous female (paratype) with 5 eggs in each sac.

Male. Unknown.

Etymology. The specific name is in memory of Vera Lúcia da Souza Cruz, a friend and collaborator at Universidade Federal de Sergipe.

Habitat. This species was found in the part influenced by Sergipe River tidal current, at 7.4 and 3.8 ‰ salinities and at a temperature of 28.0 °C. Both margins with adjacent extensive mangrove areas.

Differential diagnosis. *H. verae* differs from all the species in the genus by the ornamentation of the median apical setae of the furcal rami and the armature of En3 P4, with its two inner setae similar to the spines. Until now only species with one modified seta were known. In *H. japonicus* Ito, 1956, *H. sinensis* Kiefer, 1928 (*apud* Burckhardt, 1913) and *H. oraeeburnensis* Lindberg, 1957 this is the distal seta, while in *H. higoensis* Ito, 1957 this is the proximal one. The new species resembles *H. pondoensis* Wooldridge, 1977 in the length ratio of the spines and seta of P5, however it differs in the form of the terminal joint of P5 and in the shape of the frontal regions of the cephalothorax.



Figs. 41-55. *Halicyclops verae* sp. n. Female 41. habitus, dorsal; 42. urosome, dorsal; 43. P6; 44. median apical furcal setae, dorsal; 45. antennule; 46. antenna; 47. mandibule; 48. maxillule; 49. maxilla; 50. maxilliped; 51. P1; 52. P2; 53. P4; 54. En3 P4; 55. P5.

Halicyclops paradenticulatus sp. n.
(Figs. 56-60)

Type material. Holotype (1 female, MZUSP 5230) from station 3, Pomonga River, Sergipe State, NE Brazil, 1 June 1978, C.E.F. da Rocha coll.

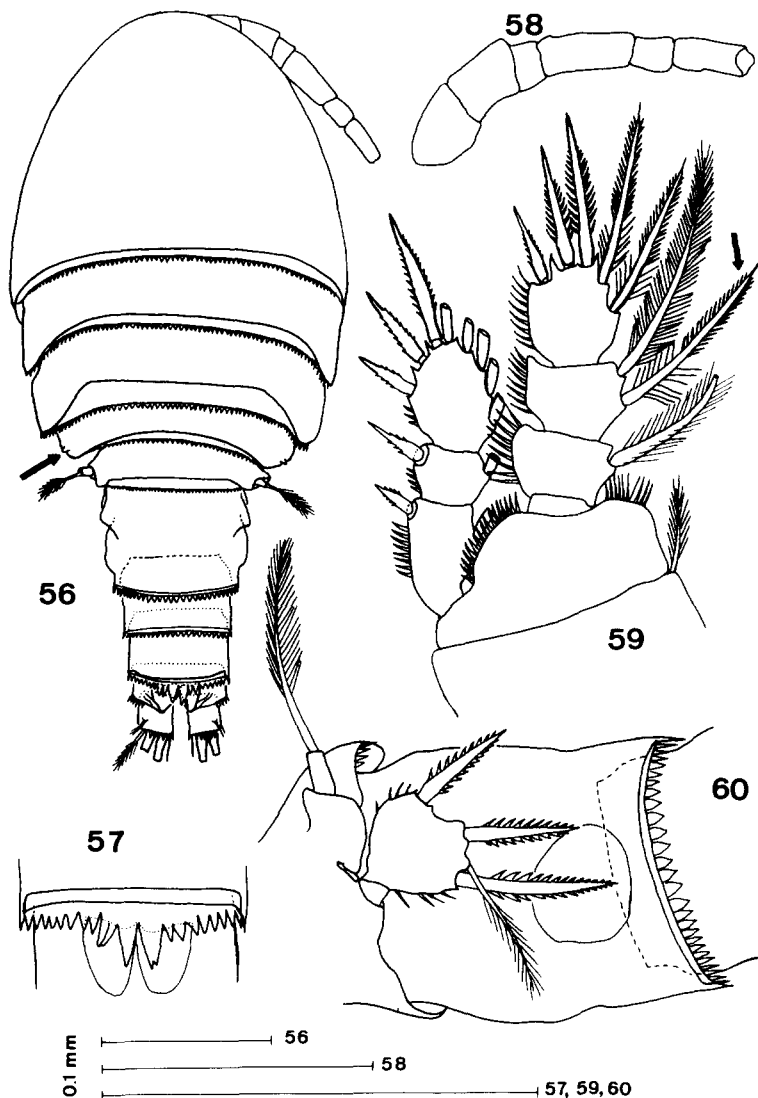
Description. Female. Total length 415 μm . Prosome (Fig. 56) rounded anteriorly, with major width in the posterior region of the cephalothorax. Third metasomal segment with a stout spinule at the middle of each lateral margin. Posterior border of all body segments with denticules. Dorsal margin

of the third abdominal segment (Fig. 57) with coalescent denticules partially hiding the anal operculum.

Genital segment (Fig. 56) wider than long (83:70 μm) with two slightly blunt dorso-lateral protuberances in the proximal portion.

Furcal rami (Fig. 56) as long as wide (18 μm). Lateral seta plumose and nearly equal in length to the ramus. Outermost apical seta plumose, about twice the length of the ramus and 2.8 times longer than innermost seta. Median apical and dorsal setae were broken in the specimen.

Antennule (Fig. 58) with six joints, the fourth one



Figs. 56-60. *Halicyclops paradenticulatus* sp. n. Female 56. habitus, dorsal; 57. anal area, dorsal; 58. antennule; 59. P4 (exopodal setae removed); 60. anterior part of urosome with P5, lateral.

the longest, being 2.7 times longer than wide. The distal tip of the antennule reaches beyond the middle of the cephalothorax.

P1–P4 biramous; each ramus 3-jointed. Ex3 with spinal formula 3.4.4.3. En3 P4 (Fig. 59) nearly as long as wide (23:21 μm), with 3 spinulose spines in the median portion, and two inner spiniform setae. Inner apical spine little longer than the outer one 38:30 μm = 1.27:1) and 1.65 times the length of segment. Setae plumose on basal third and setulose distally, with a sharp, smooth point. Distal seta extending little beyond the apex of innermost spine. Inner proximal setae of En2 P4 (Fig. 59) and En3 P2–P3 like setae of En3 P4.

P5 (Fig. 60) with terminal segment slightly shorter than wide (25:28 μm), bearing some spinules on the lateral margins. Innermost spine the longest (40 μm) and about 1.5 times the length of segment. Other spines equal in length (28 μm). Seta plumose and shorter than innermost spine.

Male. Unknown.

Etymology. The specific name 'paradenticulatus' refers to the similarity of this species with *H. denticulatus* Kiefer, 1960.

Habitat. *H. paradenticulatus* occurred in the same area as *H. ovatus* sp. n.

Differential diagnosis. *H. paradenticulatus* is very closely related to *H. denticulatus* by its dorsal median hyaline denticules of the posterior border of the fourth urosomal segment, the shape of the terminal joint of P5 and the ornamentation of its spines. The main differences are in the length ratios between the spines of En3 P4 and P5, the length width ratio of the furcal rami (2:1 to *H. denticulatus* and 1:1 to *H. paradenticulatus*) and the morphology of the genital segment.

The presence of denticules on the posterior edges of the prosomal segments has been reported in *H. denticulatus* and *H. stocki* Herbst, 1962. However, only *H. paradenticulatus* has such structures on the border of all segments. In *H. denticulatus* they are lacking on the cephalothorax border and in *H. stocki* on the last prosomal and first urosomal segments.

Taxonomic remarks

Wilson (1958) emphasized the necessity of more complete descriptions for the better identification

of the *Halicyclops* species, suggesting that features not mentioned in the lists of diagnostic characteristics organized by Kiefer (1936) and Lindberg (1949) should be included in the descriptions.

Here I call attention to the importance of the apical median setae of the furcal rami. Their ornamentation is peculiar in three of the species studied here, and can be similar in males and females of the same species (*H. ovatus*) or slightly different (*H. pilosus*). In the known species, these setae have been satisfactorily described only in *H. pondoensis*, *H. sinensis*, *H. pilifer* and *H. fosteri*. Thus, I suggest that they be examined with more detail in future descriptions.

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