

A new species of *Halicyclops* (Copepoda, Cyclopidae) from California, and a revision of some *Halicyclops* material in the collections of the US Museum of Natural History

Carlos Eduardo Falavigna da Rocha

Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Caixa Postal 20520, 01498 São Paulo, Brazil

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Abstract

Halicyclops hurlberti, a new species of cyclopoid copepod, is described from San Diego, California. Specimens identified by C.D. Marsh as *H. aequoreus* kept in the US Museum of Natural History were checked and placed in the species *H. cf. clarkei* Herbst and *H. fosteri* M.S. Wilson. The description of these two species is being emended.

The new species proposed in this paper, *Halicyclops hurlberti*, from San Diego is the second species registered along the entire Pacific Coast of the Americas. Marsh (1913) identified some specimens taken near the city of Panama as being *H. aequoreus* (Fisher), and Comita (1951) ascribed his material from a lagoon located about 5 km from Acapulco, Mexico, to *H. aequoreus propinquus* Sars, 1905. Unfortunately, Comita provided no reason justifying his identification, and the material analysed by him could not be located for examination to check the identification.

The great contrast between both coasts of the New World concerning the number of known species of *Halicyclops* remains evident, since 18 species have been described or recorded from several kinds of brackish water bodies and interstitial habitats in sandy beaches along the Atlantic Coast. More intensive studies in such habitats on Pacific side are needed in order to make the

knowledge of the species composition of *Halicyclops* more complete in this area.

Methods

Whole specimens were examined in temporary lactic acid mounts. Fragments of cover glass were used to give support to the cover glass of the preparation. Moving the cover glass slowly and carefully by hands or instrument, the animal as a whole or an appendage in particular was placed in different positions without damage, making possible the observation of the morphological details without dissections. After examination the specimens were returned and preserved in alcohol 70%.

The dissections were made in glycerine and the animals placed in slide preparations sealed with Glyceel. The figures were prepared using a camera

lucida on a Leitz Laborlux D phase-contrast microscope.

The following abbreviations are used in the text: A1 = antennule, A2 = antenna; ae = aesthetasc, B2 = 2nd basipodite, Enp1-2 = 1st and 2nd segments of the endopodite, Exp1-3 = 1st to 3rd segments of the exopodite, P1-P6 = 1st to 6th pair of legs, Pr = prosome, sp = spine, Ur = urosome.

Taxonomy

Family Cyclopidae Dana Subfamily Halicyclopinæ Kiefer

Halicyclops hurlberti sp. n.

(Figs. 1-9)

Material examined

U.S.A., California, San Diego: 16 females, 15 males and 7 copepodids. Female holotype and 17 paratypes including females, males and copepodids in the National Museum of Natural History, Smithsonian Institution, Washington (USNM 250903 and 250904, respectively). 8 male and female paratypes in Museu de Zoologia, São Paulo (MZUSP 10741).

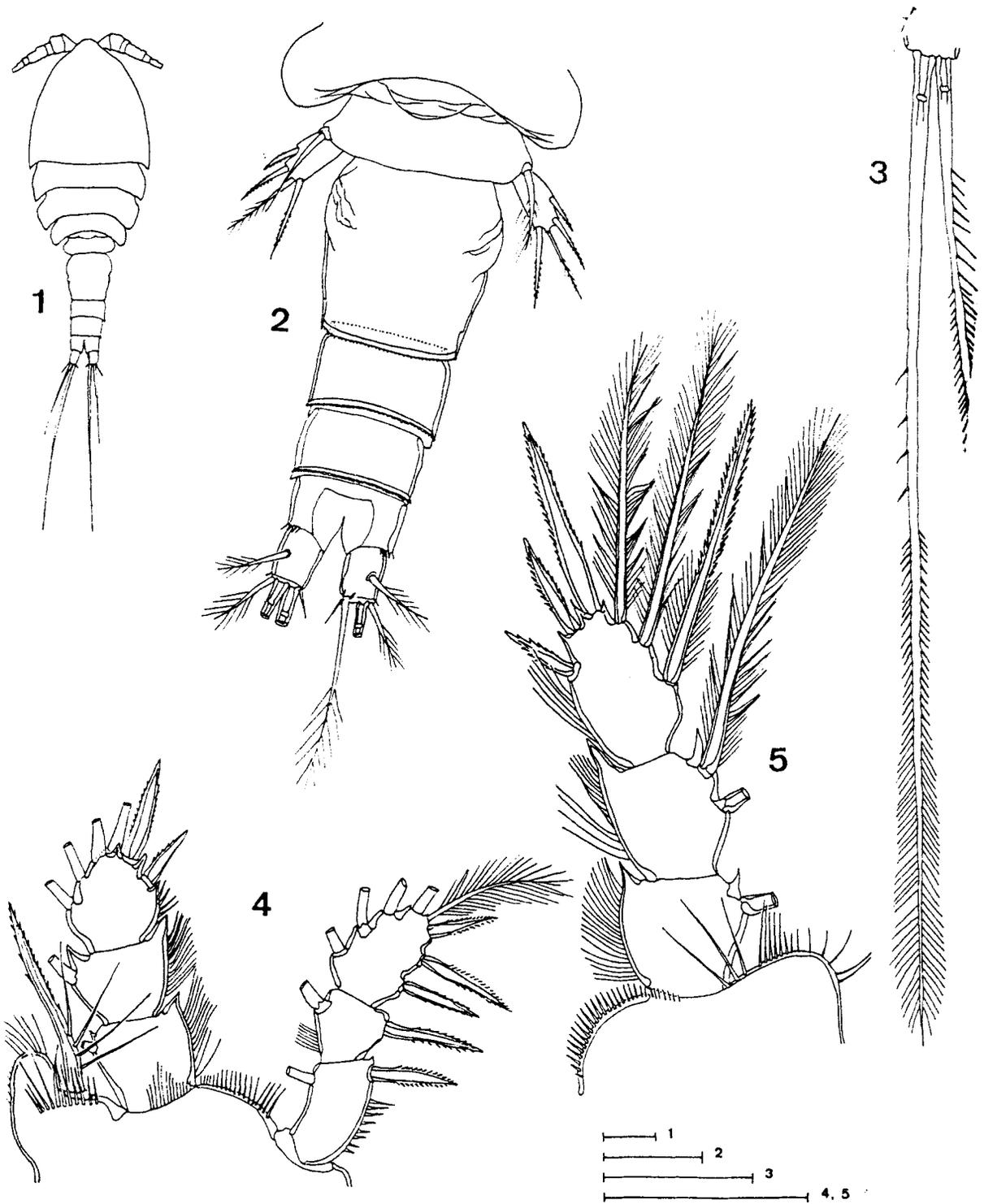
Female

Body length range 620-650 μm ($N = 5$). Pr:Ur = 1.5-1.7:1. Hyaline frills of all prosomites smooth (Fig. 1). Genital segment (Fig. 2) as long as wide and slightly enlarged anteriorly; posterior border of this segment and two subsequent somites serrate. Caudal ramus (Fig. 2) about 1.2 times as long as wide. Lateral seta and outermost apical seta similar in length. Innermost apical seta reaching midlength of outermost apical seta. Middle apical setae (Fig. 3) homogeneously ornamented; outer seta sparsely setulose on outer margin and smooth on inner margin of proximal half, and densely setulose on distal half; inner seta smooth on outer margin and sparsely setulose on distal half of inner margin of its proximal half; distal half of inner seta densely setulose, with setules gradually increasing in length towards tip of seta.

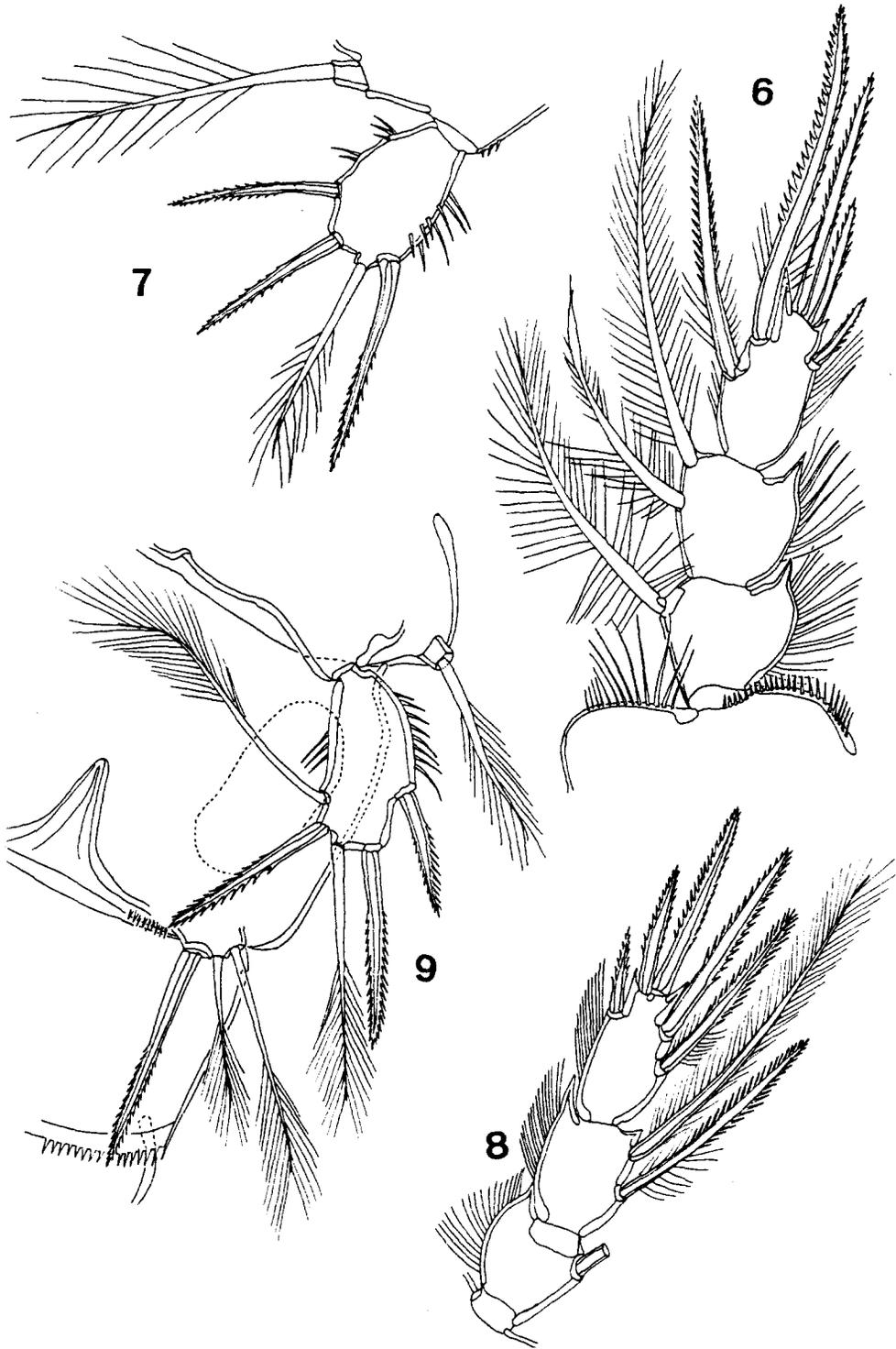
A1 6-segmented and armed as follows (Roman numerals indicating segments, Arabic numerals representing setae): I = 8, II = 12, III = 5 + sp, IV = 6 + ae, V = 2, VI = 10 + ae. Segment 4 of A1 about 1.6 times longer than wide. Mouthparts as those of *Halicyclops glaber* Rocha, 1983.

Formula of spines on Exp3 P1-P4: 3,4,4,3. Inner corner of B2P1 (Fig. 4) produced, with 2 rows of hairs, and long spine reaching level of insertion of inner proximal seta of Enp3 P1. Spines on Exp P1 quite long, especially spine of Exp2 and middle spine of Exp3. P2 and P3 similar, Enp3 of each (Fig. 5) with proximalmost inner seta plumose proximally and serrate distally. Enp2 P4 (Fig. 6) with proximal seta shorter and enlarged distally; distal seta longer, plumose. Enp3 P4 (Fig. 6) 1.75 times longer than wide; inner apical spine about 1.5 times length of segment and twice as long as outer apical spine; inner distal seta stouter than apical spines, heavily serrate distally, plumose proximally, and 1.5 times longer than inner apical spine; inner proximal seta little longer than inner apical spine, serrate distally and plumose proximally. Outer spine of Enp3 P4 spiniform, serrate, shorter than outer apical spine.

Free terminal segment of P5 (Fig. 7) 1.5 times as long as wide; outer spines similar in length and little longer than segment; inner spine about 1.3 times length of 2 outer spines. Apical seta equal in length to inner spine. *Male*. Body length range 520-595 μm ($N = 7$). Pr:Ur = 1.3-1.9:1. Enp3 P4 (Fig. 8) about 1.6 times as long as wide; inner apical spine about 1.5 times longer than segment; inner distal seta spiniform, almost reaching tip of inner apical spine; inner proximal seta as in female and similar to proximal setae of Enp2 P4 and Enp3 P2-P3. Terminal segment of P5 (Fig. 9) 1.6-1.7 times longer than wide and bearing 3 spines and 2 setae, apical spine and inner subterminal spine similar in length and little longer than segment. Outer marginal spine 0.75 times length of segment and about 0.6 times length of apical spine. P6 (Fig. 9) represented by inner spine longer than any spine of P5 and as long as outer seta. Median seta 0.6 times length of outer seta.



Figs. 1–5. *Halicyclops hurlberti* sp. n. Female 1. habitus, dorsal; 2. urosome, dorsal; 3. middle apical setae of the caudal ramus; 4. P1; 5. End P3. Scale bars = 50 μ m.



Figs. 6-9. *Halicyclops hurlberti* sp. n. Female 6. Enp P4; 7. P5. Male 8. Enp P4; 9. part of the urosome showing the P5 and P6, ventral. Scale bars = 50 μ m.

Etymology

The species is named after Dr. Stuart H.K. Hurlbert, San Diego State University.

Habitat

The specimens were collected in experimental tanks at San Diego State University, San Diego. The water of the tanks was brought from Tihuana Estuary.

Differential diagnosis

H. hurlberti sp. n. is included in a group of *Halicyclops* species sharing the following similarities: middle apical setae of the caudal rami homogeneously ornamented (only setules), the fourth segment of the A1 of the female from almost as long as wide to less than twice as long as wide, and the inner spine of the B2 P1 reaching at least midlength of the Enp3 P1. It is distinguished from all other species of the group (*H. blachei* Lindberg, 1952; *H. canui* Lindberg, 1941; *H. crassicornis* Herbst, 1955; *H. glaber* Rocha, 1983; *H. pilifer* Lindberg, 1949; *H. pilosus* Rocha; 1984; *H. sinensis*, Kiefer, 1928; and; as nearly as can be ascertained from the published descriptions *H. coulli* Herbst, 1977 and *H. lamini-fer* Herbst, 1982) by the structure of the Enp3 P4, principally by the form of the inner distal seta. The shape of the free segment of the P5 as well as the length ratios of its spines to each other, and between each spine and the length of the segment is also diagnostic for *H. hurlberti* in the group. *H. hurlberti* shares with *H. blachei* the pattern of ornamentation of the middle apical setae of the caudal rami.

Revision of some Halicyclops material in the collections of the US Museum of Natural History

Specimens identified by C.D. Marsh as *H. aequoreus* (Fischer) kept in the US Museum of Natural History, Washington, has been revised in an attempt to verify the true identity of them. At the time Marsh worked on his specimens, *H. aequoreus* was considered a cosmopolitan species. The specimens from Panama were identi-

fied as *Halicyclops* cf. *clarkei* Herbst, and those from Lake Pontchartrain, Louisiana, were attributed to *Halicyclops fosteri* M.S. Wilson.

Halicyclops cf. *clarkei* Herbst, 1982

(Figs. 10–16)

Material examined

PANAMA, from savannas and a well near city of Panama: 1 whole adult female, 4 dissected adult females, and 1 copepodid, Marsh Collection slides No. 3865, 3863, 3867-3859 and 3866, respectively. U.S.A., Louisiana, Lake Peigneur (type locality): 7 whole adult females on slides, and 10 females and 4 copepodids in alcohol, 1978, D.R. Clark col. (USNM No. 250905).

Additional description (based on topotypes examined)

Female: Enp2 P4 (Fig. 10) with 2 plumose setae. Enp3 P2-P3 with proximalmost inner seta modified as proximal seta of Enp3 P4 (Fig. 10). Middle apical setae of caudal rami (Fig. 11) heterogeneously ornamented; inner seta with proximal part smooth on outer margin and sparsely spinulose on inner margin; and distal part densely spinulose proximally and plumose terminally on both margins; outer seta with spinules on outer margin and plumose on inner margin of distal half.

Concerning the original description, there is another problem to consider. Herbst (1982: Fig. 26) illustrated the P5 of the male as bearing a spine on the inner corner of the terminal segment twice as long as the proximal lateral spine, which disagrees with the measurements given in the text, which show little difference in length of those spines (33 and 26 μm , respectively). Herbst (in litt.) confirms this difference and informs that the measurements were taken from one of his specimens while the Fig. 26 was made on the other specimen of the lot. According to him, there is the possibility that each male represents a different species. The measurements (in μm) presented below were taken by Dr. H.V. Herbst from his material (male 1 = male measured in the original description; male 2 = male illustrated):

	Male 1	Male 2
Enp3 P4		
length : width	29 : 19	29 : 19
outer spine	19	15
outer apical spine	23	22
inner apical spine	36	34
inner distal seta	44	40
inner proximal seta	47	40
P5		
length : width	28 : 17	28 : 19
outer proximal spine	26	21
outer distal spine	28	26
apical seta	33	48
inner spine	33	49
inner seta	37	52
P6		
inner spine	26	26
middle seta	23	21
outer seta	33	37

Remarks

The specimens from Panama were similar to the topotypes examined in all taxonomically important respects, except for the length ratios of the spines of the P5 to each other as well as between the spines and the length of the free terminal segment of the P5. In the specimens from L. Peigneur (Fig. 12), the outermost and the innermost spines are similar in length, longer than the middle spine and little shorter than the terminal segment; in all specimens from Panama (Fig. 13) the outermost spine was slightly shorter than the innermost and both were longer than the terminal segment. It must be pointed out that the specimens from Panama are mounted on slides and that their P5's are slightly inclined.

Variation in the ornamentation of the proximal part of the inner middle apical seta was also noted. The undissected female on Marsh's slide No. 3865 had that seta on its right caudal ramus (Fig. 14) with the proximal half smooth on both margins, as did all other animals from Panama examined, but the seta on its left ramus (Fig. 15) had 3 spinules on the inner margin of the proximal half, being identical to that seta of the specimens from L. Peigneur (Fig. 11). It is possible that the

differences between the P5 of the two lots of specimens here analyzed indicate the existence of two allied species. Differences in the P5 structure lead Kiefer (1935) to separate *H. rotundipes* from *H. neglactus*. Different spinal formulas on P1-P4 were considered by Herbst (1952, 1953) as a sufficiently important difference to distinguish two subspecies of *H. brevispinosus* representing geographically isolated populations, *H. b. brevispinosus* in the North Sea and *H. b. meridionalis* in the Mediterranean Sea. The presently available material can only suggest the existence of the problem. Additional material, including both sexes, collected between both points of occurrence of the species is imperative to interpret the true meaning of these subtle differences.

Halicyclops fosteri M.S. Wilson, 1958 (Figs. 17-20)

H. fosteri M.S. Wilson, 1958: p. 178-187, Figs. 1-20; *H. aequoreus* (Fischer) (misidentification) Marsh, 1910: p. 1106; 1913: p. 18, Fig. 6 (part); 1918: p. 780, Fig. 1230 (key).

Material examined

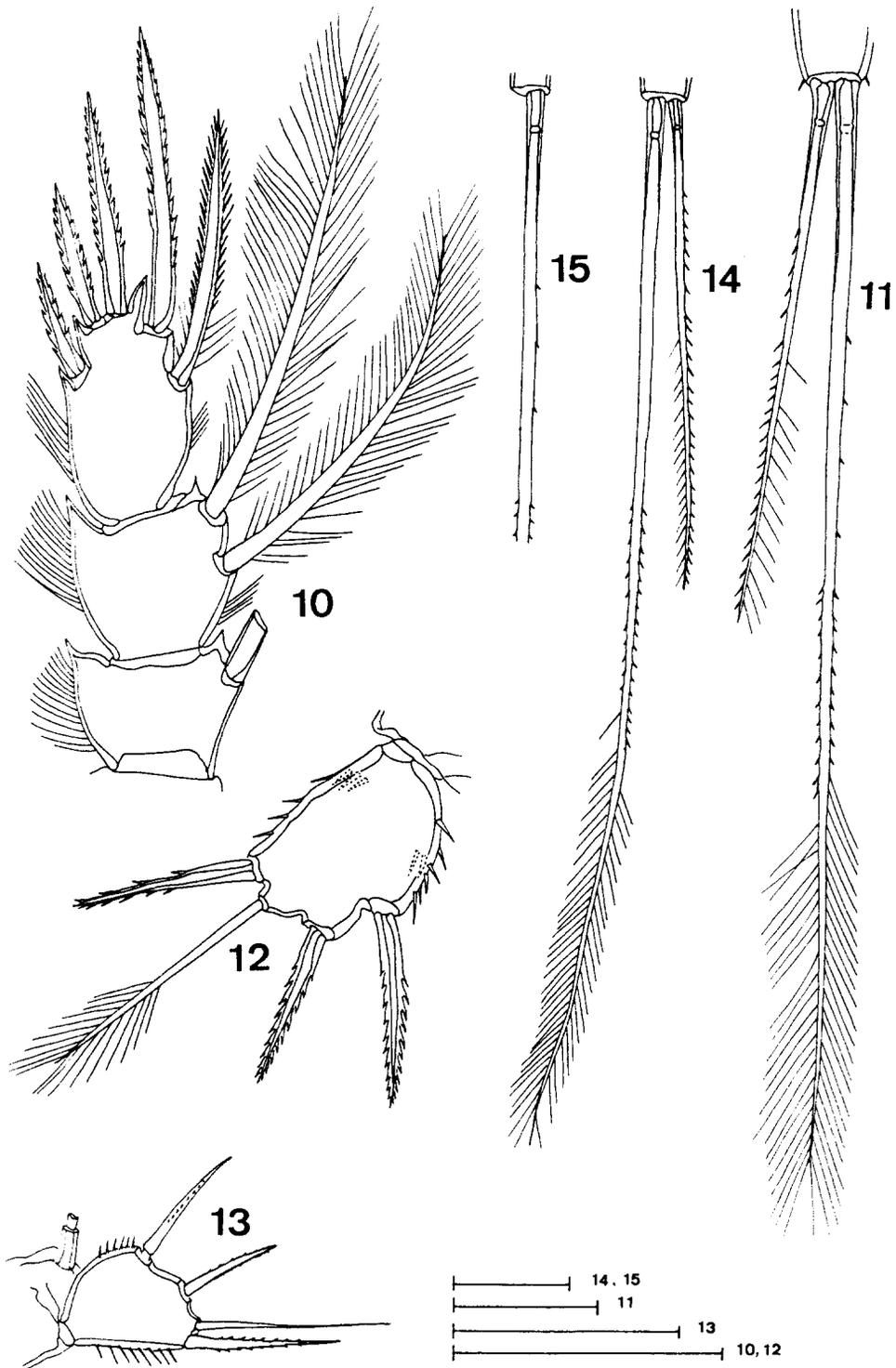
U.S.A., Louisiana: Lake Pontchartrain, 4 whole females and 6 dissected females, all on slides (Marsh Collection Nos. 3830-3838); Lake Peigneur, 10 whole females, 1 whole male and 2 copepodids, all on slides, 1978, D.R. Clark col. (USNM No. 250906).

Additional description (based on material examined)

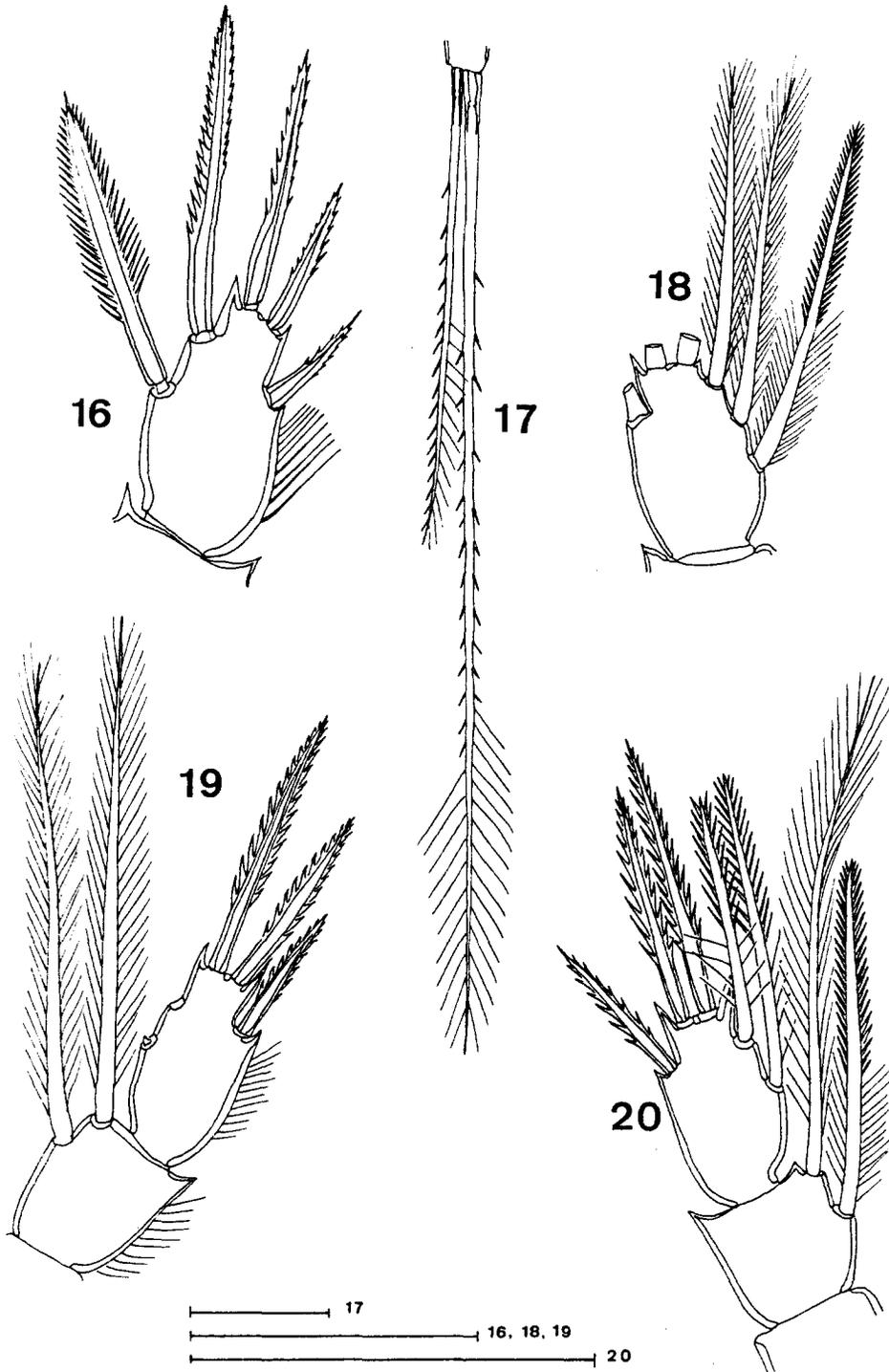
Female: outer middle apical seta of caudal ramus (Fig. 17) plumose on distal half of inner margin; Enp3 P2-P3 (Fig. 18) with proximalmost inner seta modified; Enp2 P4 (Fig. 19) with both inner setae plumose; in 2 specimens, Enp3 P4 presenting small blunt hyaline spinule implanted on proximal indentation of inner margin of segment. *Male*. Enp2 P4 (Fig. 20) as well as Enp3 P2-P3 with proximalmost seta modified as inner setae of Enp3 P4.

Remarks

The specimens from Marsh collection could be readily identified as *Halicyclops fosteri* based on the



Figs. 10–15. *Halicyclops* cf. *clarkei* Herbst. Female 10. Enp P4; 11. middle apical setae of the caudal rami (specimen for L. Peigneur); 12. terminal segment of the P5 (specimen from L. Peigneur); 13. P5 (specimen from Panama); 14. middle apical setae of the right caudal ramus of a specimen from Panama; 15. proximal half of the inner middle apical seta of the left caudal ramus of the same specimen of the Fig. 14. Scale bars = 50 μ m.



Figs. 16–20. *Halicyclops cf. clarkei* Herbst. Female 16. Enp3 P4 (specimen from Panama). *Halicyclops fosteri* Wilson. Female 17. middle apical setae of the caudal rami; 18. Enp3 P3; 19. Enp3 P4. Male 20. Enp2-3 P4. Scale bars = 50 μ m.

structure of the P4, P5 and caudal rami of the females. Marsh never mentioned having examined the material from Lake Pontchartrain. He apparently obtained it after publication of his 1910 revision of the North American species of *Cyclops* because he stated in that paper '*Cyclops aequoreus* never appeared in any of my collections, but Mr. E. Foster tells me that he has collected it in Lake Pontchartrain and connecting waters.' However, Marsh had it at the time of writing his article on the freshwater copepods from Panama (Marsh, 1913). In the latter article, the figure of the urosome attributed to *Cyclops aequoreus* from Panama represents the urosome of one of the specimens from L. Pontchartrain which is part of Preparation No. 3834. The other figures in Marsh's 1913 article are of *H. cf. clarkei*.

H. fosteri was described from Lake Pontchartrain. It has been registered in Texas (Wilson, 1958) and Delaware Bay (Aurand & Daiber, 1979). Herbst (1982) found it in a sample from Lake Peigneur together with *H. clarkei* and *H. laminifer*.

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References

- Aurand, D. & C. Daiber, 1979. Occurrence of *Halicyclops fosteri* (Copepoda, Cyclopoida) in the Delaware Bay Region, USA. *Crustaceana* 36: 155–165.
- Comita, G. W., 1951. Studies in Mexican copepods. *Trans. am. micros. Soc.* 70: 367–379.
- Herbst, H. V., 1952. Neue Cyclopoida Gnathostoma (Crustacea Copepoda) des Küstengrundwassers. *Kieler Meeresforsch.* 9: 94–111.
- Herbst, H. V., 1953. Weitere Cyclopoida Gnathostoma (Crustacea Copepoda) des Küstengrundwassers. *Kieler Meeresforsch.* 9: 257–270.
- Herbst, H. V., 1955. Cyclopoida Gnathostoma (Crustacea Copepoda) von der brasilianischen Atlantikküste. *Kieler Meeresforsch.* 11: 214–229.
- Herbst, H. V., 1977. A new species of *Halicyclops* from North America. *Gew. Abw.* 62/63: 121–126.
- Herbst, H. V., 1982. Drei neue marine Cyclopoida Gnathostoma (Crustacea: Copepoda) aus dem nord-amerikanischen Küstenbereich. *Gewäss. Abwäss.* 68/69: 107–124.
- Kiefer, F., 1928. Beiträge zur Copepodenkunde (VII). *Zool. Anz.* 75: 216–223.
- Kiefer, F., 1935. Zur Kenntnis des *Halicyclops* (Crustacea Copepoda). *Zool. Anz.* 110: 10–13.
- Lindberg, K., 1941. Cyclopidae (Crustacés Copépodes) de L'Indie. V. Contribution à l'étude du genre *Halicyclops* Norman. *Rec. Indian Mus.* 43: 1–7.
- Lindberg, K., 1949. Contributions à l'étude des Cyclopidés (Crustacés Copépodes). *K. fysiogr. Sällsk. Lund Förh.* 19: 98–121.
- Lindberg, K., 1952. Cyclopidés (Crustacés Copépodes) du Royaume du Cambodge. *Bull. Inst. r. Sci. nat. Belg.* 28: 1–16.
- Marsh, C. D., 1910. A revision of the North American species of *Cyclops*. *Trans. Wis. Acad. Sci. Arts. Lett.* 16: 1067–1135.
- Marsh, C. D., 1913. Report on fresh-water Copepoda from Panama, with description of new species. *Smithson misc. Colln* 61: 1–31.
- Marsh, C. D., 1918. Copepoda. In: Ward H. B. & G. C. Whipple, *Freshwater Biology*. New York, John Wiley and Sons, pp. 741–789.
- Rocha, C. E. F. da, 1983. *Halicyclops glaber*, a new cyclopoid copepod from the Pomonga River, Brazil, with comments on *Halicyclops korodiensis* Onabamiro, 1952. *Crustacean Biol.* 3: 636–643.
- Rocha, C. E. F. da, 1984. Four new species of *Halicyclops* Norman, 1903 (Copepoda, Cyclopoida) from Brazil. *Hydrobiologia* 119: 107–117.
- Sars, G. O., 1905. Pacificische Plankton-Crustaceen. *Zool. Jb. Syst. Geogr. Biol. Tiere* 21: 371–414.
- Wilson, M. S., 1958. The copepod genus *Halicyclops* in North America, with description of a new species from lake Pontchartrain, Louisiana, and the Texas coast. *Tulane Stud. Zool.* 6: 176–189.