THE COPEPOD GENUS *HALICYCLOPS* IN NORTH AMERICA, WITH DESCRIPTION OF A NEW SPECIES FROM LAKE PONTCHARTRAIN, LOUISIANA, AND THE TEXAS COAST

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A new species of the brackish and freshwater cyclopoid copepod genus *Halicyclops* has been found in plankton collections made in Lake Pontchartrain, Louisiana, during the course of a biological survey conducted by Tulane University and the State of Louisiana. Lake Pontchartrain is a large, brackish water lake in southeastern Louisiana, indirectly connected with the Gulf of Mexico through tidal channels and Lake Borgne. The new species is not endemic to Lake Pontchartrain, having also been found in a Texas collection. The specimens from the two localities vary from one another, and are described separately.

I am indebted to Dr. R. M. Darnell, Marquette University, for the collections of the new species, and for the opportunity to study the interesting copepods of Lake Pontchartrain. Grateful acknowledgment is also expressed to Dr. K. Lindberg, Lund, Sweden, who kindly assisted in a preliminary check list of species and with literature.

Halicyclops in North America

The few American records of *Halicyclops* show that the genus occurs on both the Atlantic and Pacific coasts of North America, in coastal water bodies of the Gulf of Mexico, and of the northern and eastern coasts of South America. Its presence in the Caribbean area is known through two south Haitian species (*H. exiguus* Kiefer, 1934; *H. similis* Kiefer, 1935), and one from the Venezuelan coast of South America (*H. venezuelaensis* Lindberg, 1954). Another species has been described from the Brazilian coast (*H. crassicornis* Herbst, 1955).

North American continental records of *Halicyclops* are listed under either *aequoreus* or *magniceps*, names of geographically separated European forms that have been much confused in literature. Because of this, the species records are questionable. *Kiefer* (1936) and Lindberg (1949) consider *aequoreus* (Fischer), 1860, from the Madeira Islands, as an inadequately known species not presently identifiable with the better known north European form to which Sars (1913) and Lindberg (1949) have restored the name *magniceps* (Lilljeborg), 1853. Lindberg has reexamined the literature and presented seemingly valid evidence for the preference of the name *magniceps* over *christianensis* (Boeck), 1873, as suggested by Kiefer (1936). In the light of growing knowledge of the broad distribution and diverse structure within the genus, it seems reasonable to me that the species *aequoreus* should be considered in need of redefinition from topotypic material and comparison with the north European form before coidentity can be established.

The first notice of *Halicyclops* in North America is, interestingly, from Lake Pontchartrain where it was reportedly found by Edward Foster, whose publication (1904) is one of the pioneer studies on Gulf of Mexico copepods. No reference was made to *Halicyclops* in Foster's paper, nor in his manuscript records published by Penn (1947). The Lake Pontchartrain record first appeared in Marsh (1910) under the name *Cyclops aequoreus*. In this and other papers, Marsh included several of Foster's Louisiana records, communicated to him either personally or through correspondence. Apparently, he never examined any of Foster's specimens. At the time of writing his 1910 revision of *Cyclops*, Marsh had not found *Halicyclops* in any of his American collections, but stated (p. 1106), "Mr. E. Foster tells me that he has collected it in Lake Pontchartrain and connecting waters." Since only one species has been found in the survey of Lake Pontchartrain, Foster's specimens may well have been the species described herein and named for him.

Marsh's statement (1910) that *Halicyclops* (as represented by the name *Cyclops aequoreus*) "was first recognized in our fauna by Herrick" is erroneous. In Herrick's two summaries (1884, 1895) the species is listed without reference to any North American occurrence. Herrick included diagnoses of many European species which he anticipated might be found on this Conti-

nent, and this has led at times to the interpretation that he was reporting a known occurrence of the species. In 1884 he commented in regard to *Cyclops aequoreus* that "those who have the opportunity to search the brackish pools along our coast would do science a service by looking for this interesting species." This indication that he had not found the species was omitted from the 1895 revision, in which he included a brief diagnosis and a habitus figure labeled "after Brady," and so presumably of an English form. Marsh (1913) again mentioned Herrick's reference as an established record stating that "Herrick found it in waters connected with the Gulf of Mexico," giving as reference Herrick, 1895, p. 122, and adding "in Mississippi Sound." There is no mention of such Gulf of Mexico records in Herrick's 1895 paper. Neither the Appendix of his 1884 paper in which he first listed Gulf species nor of his later enlarged study (1887) contain any reference to *Cyclops aequoreus*. These references of Marsh and his further statement (1918) as to the occurrence of the species "in waters connected with the Gulf of Mexico" are therefore valid only in so far as Foster's communication to him can be accepted.

Marsh's own record (1913) from the Pacific coast of Panama is actually the first substantiation of *Halicyclops* from the Continent. The figure labeled *Cyclops aequoreus* in his 1918 key was made from these Panama specimens. This has been unfortunate since these specimens were not referable to either the European species *aequoreus* or *magniceps*, as has been recognized by others. Gurney (1933) has incorrectly called them *aequoreus propinquus;* Kiefer (1936) and Lindberg (1957) have questioningly referred them to the Haitian species *similis*. Marsh's figure of the fourth leg shows that the Panama species was not the new species described herein, though some characters of the urosome and fifth leg are similar. The Panama material will have to be restudied to determine the identity.

There are two records of *Halicyclops* from Mexico. Whether the specimens in either of these Mexican collections were accurately assigned to the species listed cannot be judged from the brief accounts given. One, based on a single female from a saline pond at Progreso on the Yucatan Peninsula, was identified as *H. magniceps* by C. B. Wilson (1936); general comments on its occurrence and ecology are included in Pearse (1936). Lindberg (1955) considers this a questionable record. Another Mexican record is that of Comita (1951), who listed *H. aequoreus propinquus* from a brackish lagoon near Acapulco on the Pacific coast. Comita's identification is apparently based on Gurney's misapplication of the name *propinquus* given by Sars (1905) to specimens from the Chatham Islands, and should also be considered a questionable record.

H. magniceps has been reported from the Woods Hole, Massachusetts area by C. B. Wilson (1932) and Deevey (1948). Wilson's identification is apparently based on Sars's (1913) redescription of *magniceps,* and since it is stated that the caudal rami are longer than wide, at least some of the specimens may have been referable to this north European species. There is, however, some confusion in the account, particularly in that of the male, which is recorded as much smaller than the female, and as lacking the innermost seta on the fifth leg. This latter point suggests that Wilson may have either misidentified his material or may have had two species in his collections.

Both *H. exiguus* and *similis* were more completely described by Kiefer (1936). This paper gives a good basic revision of the genus, with illustrations of all the nine species recognized at that time. Growth of knowledge of the genus is illustrated by the fact that a key by Lindberg (1949) included seventeen species and subspecies, and a recent revision of the key (Lindberg, 1957) includes thirty-one. This key seems to refer to all named forms except *H. japonicus* Ito (1956) and *H. higoensis* Ito (1957). With inclusion of the new Gulf of Mexico species, the number is now increased to thirty-four.

In Lindberg's keys, the species names are given without author and date, or any other reference to the literature where descriptions may be found. This information has an obviously useful application and it would be well if authors and editors would always consider it an essential part of a key. A check list of named species and subspecies, following the categories recognized in Lindberg's key, with references to the original

and additional descriptions in the literature, is given here as a supplement to the key and Kiefer's (1936) revision. No attempt has been made to evaluate, and no implication is intended regarding the taxonomic status of any of these names.

Check List of Halicyclops Species Known to January 1958

H. magniceps (Lilljeborg), 1853; Sars, 1913; Gurney, 1933 (as *aequoreus*); Kiefer, 1936 (as *christianensis*); Schafer, 1936 (as *christianensis*); Plesa, 1956 (as *christianensis*).
H. propinquus Sars, 1905.
H. tenuispina Sewell, 1924; Kiefer, 1936.
H. sinensis Kiefer. 1928, 1936; Burckhardt, 1913 (as *aequoreus?*).
H. thermophilus Kiefer, 1929, 1936; Heberer and Kiefer, 1932; Lindberg, 1941 (as *t. spinifer*), 1952b.
H. spinifer Kiefer, 1935 and 1936 (as *thermophilus spinifer*).
H. neglectus septentrionalis Kiefer, 1935 and 1933 (as *aequoreus propinquus*); Margalef, 1951, 1953; Plesa, 1956 (as *rotundipes*).
H. neglectus septentrionalis Kiefer, 1935 and 1936 (as *thermophilus septentrionalis*).
H. rotundipes Kiefer, 1935, 1936, 1938a and b; Petkovski, 1955 (as *neglectus rotundipes*).
H. rotundipes putealis Kiefer, 1938b.
H. exiguus Kiefer, 1934, 1936.
H. similis Kiefer, 1935, 1936; ? Marsh, 1913, 1918 (as *Cyclops aequoreus*).
H. sarsi Akatova, 1935; Hemsen, 1952.
H. canui Lindberg, 1941.
H. electus Lindberg, 1943.
H. caridophilus Humes, 1947.
H. pilifer Lindberg, 1949.
H. konkanensis Lindberg, 1949.
H. setifer Lindberg, 1949 (in key), 1950, 1951.
H. robustus Lindberg, 1951.
H. oblongus Lindberg, 1951.
H. blachei Lindberg, 1952a.
H. korodiensis Onabamiro, 1952.
H. brevispinosus Herbst, 1952.
H. brevispinosus meridionalis Herbst, 1953.
H. venezuelaensis Lindberg, 1954.
H. pusillus Kiefer, 1954a.
H. troglodytes Kiefer, 1954b; Lindberg, 1956.
H. dalmatinus Petkovski, 1955.
H. crassicornis Herbst, 1955.
H. japonicus Ito, 1956.
H. oraeeburnensis Lindberg, 1957.
H. higoensis Ito, 1957.

COPEPODA, CYCLOPOIDA
Family CYCLOPIDAE
HALICYCLOPS Norman, 1903

HALICYCLOPS **FOSTERI**, sp. nov.

(Figures 1-20)

? Cyclops aequoreus. Marsh, 1910, p. 1106 (Lake Pontchartrain record).

Type lot.—96 females (61 ovigerous), 30 males; Lake Pontchartrain, Louisiana, August 6, 1953, R. M. Darnell, collector. Holotype ♀, United States National Museum catalog number 99413; allotype ♂, number 99414.

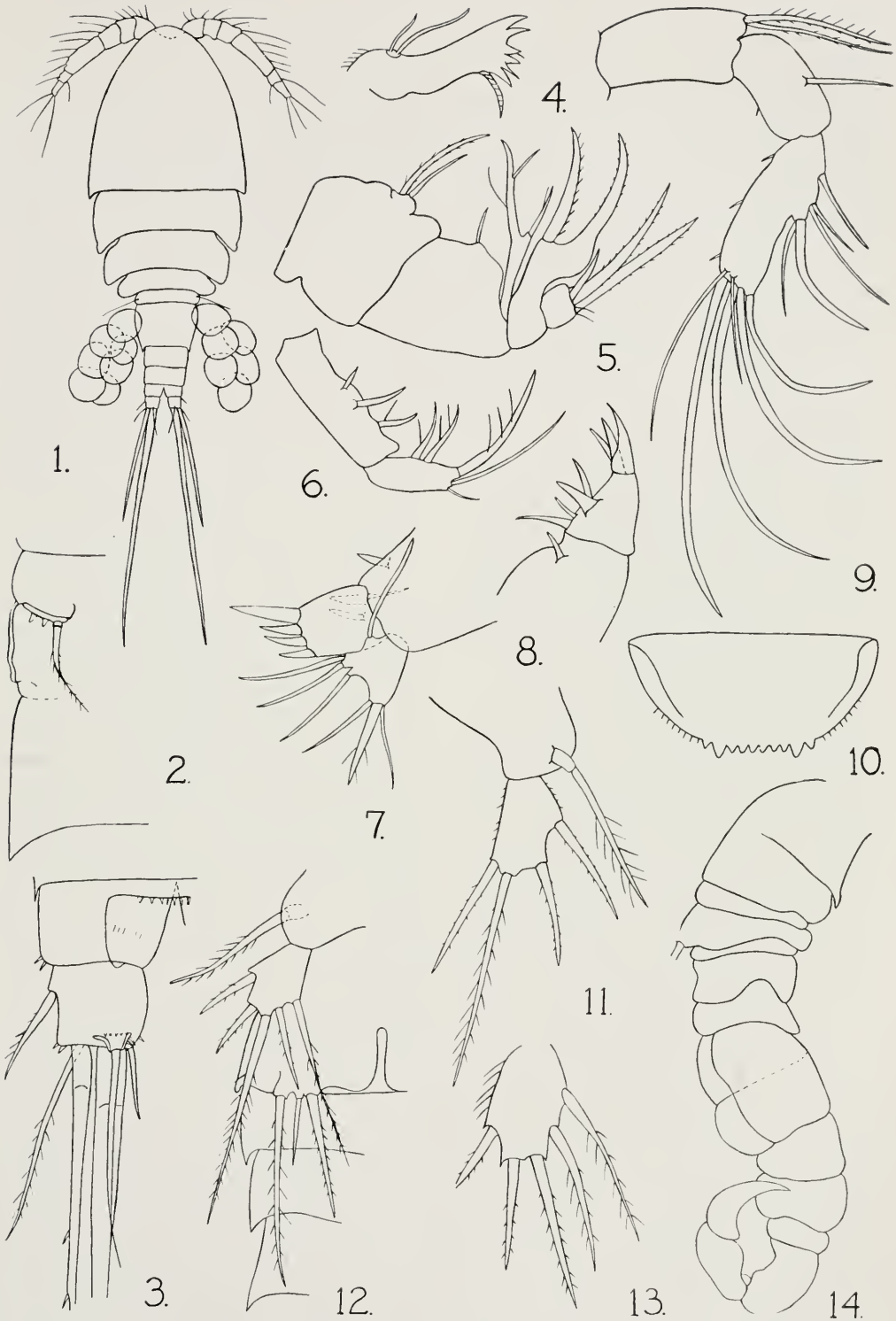
Diagnosis.—Genital segment female proximally with lateral protrusions armed with membranous flange, variously produced but not spiniform; urosomal segments, except anal, without ornamentation; area of anal operculum with minute serrations or denticles. Caudal rami about as long as broad; all apical setae present, the outer lateral seta placed marginally. Leg 4, exopod segment 3 with two spines in both sexes, between proximal and apical spines a somewhat eccentrically placed seta; endopod segment 3 lacking inner setae in female, with two setae in male. Leg 5 female, segment 2 with slender spines, their length subequal to or longer than that of segment; the inner spine the longest; the seta subequal to or longer than inner spine. Leg 5 male, segment 2 with three spines and two elongate setae.

DESCRIPTION OF LAKE PONTCHARTRAIN SPECIMENS

Complete dissections made of 10 females and 5 males. Habitus measurements based on 20 females and 10 males. Antenna examined in dissected and in 20 additional whole specimens. All undissected specimens of type lot examined individually for detection of noticeable variation in habitus characters and spines of legs.

Female

Total length, mid-dorsal line, 0.42-0.52 mm (Mean 0.47). Length of metasome about 2.25 times that of urosome (including somite of leg 5). Length of cephalic segment greater than width (range from 1.1-1.25 : 1); the greatest width in distal portion.



Figures 1-14. *Halicyclops fosteri*, sp. nov. (from Lake Pontchartrain specimens). FEMALE: **1.** Habitus, dorsal aspect; **2.** Lateral portion of genital segment, dorsal aspect, showing lateral flange and leg 6 (from little expanded specimen from which ovisacs were removed); **3.** Anal segment and caudal ramus, dorsal aspect; **4.** Mandible; **5.** Maxilla; **6.** Maxilliped; **7.** Maxillule (with palp); **8.** Profile view of maxillule (without palp); **9.** Antenna; **10.** Labrum; **11.** Leg. 5. MALE: **12.** Legs 5 and 6, *in situ*, ventral aspect; **13.** Leg 4, endopod segment 3; **14.** Antennule, dorsal outline (without setae). (All appendages except fig. 13 drawn to same scale).

Genital segment with variable lateral protrusions in proximal portion, the protrusions armed outwardly with a narrow, seemingly stiff, membranous (or sclerotized?) flange with laterally rounded margin (fig. 2); width of segment below protrusions equal to or a little less than length at midline (range 0.9-1.0 : 1), width of proximal area, including lateral protrusions, subequal to or greater than length (range 1.1-1.25 : 1); genital openings dorso-laterally placed, dorsal armature (leg 6) consisting of a narrow sclerotization armed with an inner plumose seta and two outer, much reduced spinelike points (fig. 2); ovisacs with 6-9 large ova (fig. 1). Urosomal segments posterior to genital decreasing regularly in length; only anal segment with ornamentation, consisting of small spinous serrations on edge of operculum, dorsal rows of medially placed hairs (fig. 3), and minute spinules overlying bases of caudal rami on ventral side. Medial incision of anal segment reaching to or nearly to distal margin of preceding segment.

Caudal rami appearing parallel to one another or slightly divergent as in figure 1; their length subequal to their width (measured just below insertion of lateral seta) and a little less or subequal to that of anal segment; ventrally, minute spinulose scales overlying bases of apical setae. All caudal setae usually found in genus present (fig. 3). Lateral seta plumose; set marginally at about proximal fourth of ramus and reaching beyond the apex; its length usually a little less than twice that of ramus (about 1.72 : 1). Dorsal seta about 3 times length of ramus, arising from enlarged surface papilla ornamented basally and inwardly with minute spinules. Second and third apical setae stout, both jointed basally; second sparsely spinulose on outer edge; third much stouter throughout than second, its proximal third naked, the middle third spinulose on both edges, the distal third thickly plumose. Second seta subequal to or a little longer than urosome and at least one-half of length of third seta; ratio of length of second to third seta, 1 : 2.02-2.27. Ratio of length of third seta to total body length, about 1 : 1.5-1.7. Innermost seta about as long as ramus, nonplumose. Pattern of comparative setal lengths determined from measurement of 10 specimens, and cursory examination of others. Very little range of variation was found except that between the two longest apical setae, as given above. Average ratio of setae and caudal ramus to outer apical seta expressed as 1 (as in Herbst, 1955):

Caudal ramus	Lateral seta	Dorsal seta	Apical setae (outer to inner)			
0.33	0.57	1.03	1	3.5	7.3	0.3

Antennule (fig. 20) 6-segmented, reaching to near or beyond middle of cephalic segment, its actual total length a little more than half that of segment (midline). Length of segment 4 from 2 to 2.25 times its greatest width. Relative length of segments (midline) and number of setae (s), spines (sp), and aesthetes (a):

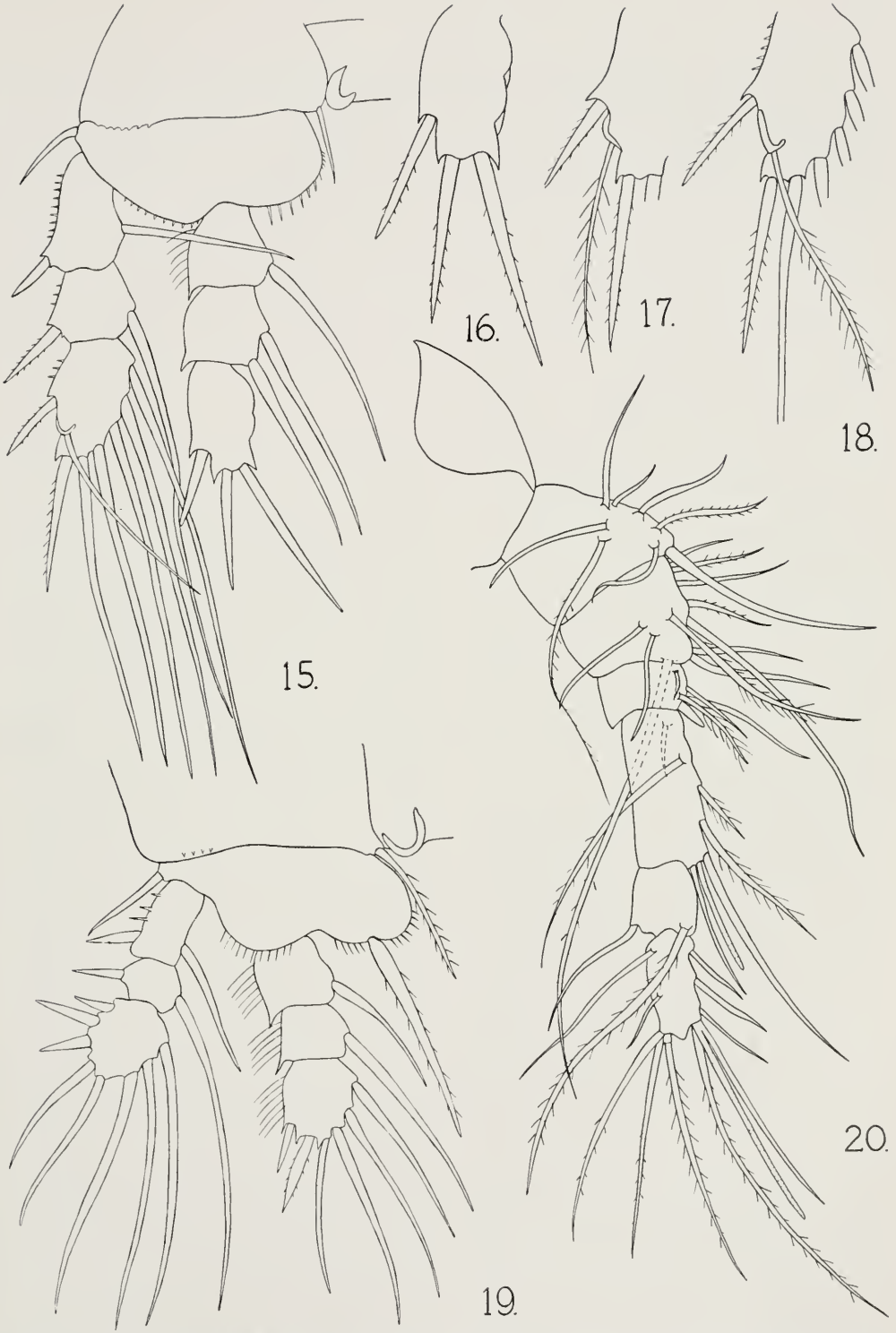
Segment	1	2	3	4	5	6
Length	20	15	10	31	14	20 μ
Armature	8s	11s	4s sp	6s a	2s	10s a

As shown in figure 20, a few of the setae inconspicuously plumose and their lengths ranging from considerably less than that of the segment to considerably more; the longest attached apically on segment 2, reaching to end of antennule or beyond.

Antenna (fig. 9) 3-segmented. Segment 1 with two apically placed setae on inner side, lacking the usual seta on outer side. Segment 2 with one seta. Segment 3 with five lateral setae; of these, the distal two borne on produced part of midportion of segment and one exceptionally stout and clawlike; apical group consisting of four stout and two slender, subterminally placed setae.

Labrum (fig. 10) broader than long; midposterior edge toothed as illustrated. Mandibular palp (fig. 4) consisting of two very unequal setae arising from depression in blade.

Maxillule (fig. 7) with broad basal segment to which is attached a slightly shorter apical segment and an unsegmented palp. Apical segment, viewed ventrally *in situ* and in dissection, little longer than broad; armed terminally with four stout clawlike spines of which the anterior is nearly twice as long as the others, and dorsally with a group of setae of irregular size (fig. 8). Setae of palp arranged in three groups; the anterior group consisting of a single seta attached on lateral side; the other two groups terminal in position and each composed of



Figures 15-20. *Halicyclops fosteri*, sp. nov. (from Lake Pontchartrain specimens). FEMALE: **15.** Leg 4; **16.** Leg 4, endopod segment 3; **17-18.** Leg 4, exopod segment 3, two different aspects; **19.** Leg 1; **20.** Antennule. (Note: plumose ornamentation omitted from setae in figs. 15 and 19.)

three setae borne on a slightly produced lobe.

Maxilla (fig. 5) largest of oral appendages, composed of two expanded and nearly equal basal segments and a modified, 2-segmented apical portion. First segment with indistinctly separated lobe bearing two setae; segment 2 with single medial seta. An attenuated lacinia intercalated between narrowed apex of segment 2 and apical portion, armed with a lateral branch bearing a seta and an apical portion drawn out to nearly same point as succeeding segment. Segment 3 modified, expanded and produced distally into stout inner claw and an articulated outer claw. Apical segment not produced, armed apically with a reduced spine, two hairlike setae and two long claws reaching to about the distal third of the claws of the expanded third segment.

Maxilliped (fig. 6) much reduced in size, its two segments together about as long as the two basal segments of the maxilla but exceedingly slender; basal not quite twice length of apical segment. Basal segment with three setae placed near the middle. Second segment with two stout clawlike setae at midpoint and apically with a stout, anteriorly placed claw longer than the segment, and two very slender, posteriorly placed setae of unequal length.

Legs 1-4: First basal segment of all legs with inner seta, and second segment with outer seta. Inner seta of second basal segment present only on leg 1; this seta exceptionally long, reaching at least to apex of endopod (fig. 19). Exopod segments 1 and 2 of all legs with outer spine and inner seta. Endopod segment 1 with one inner seta; segment 2 with one inner seta on leg 1, with two setae on legs 2-4. Exopod segment 3 with spinal formula, 3,4,4,2, and setal formula, 5,5,5,5. Endopod segment 3 with two spines and four setae on leg 1 (fig 19); with three spines and three setae on leg 2 and 3.

Leg 4 (figs. 15-18): Exopod segment 3 with an exceedingly slender, plumose seta somewhat eccentrically placed on a marginal sclerotization between outer marginal and apical spines; seta longer than apical spine. In most of the specimens observed, whether the appendage was still attached or dissected from the body, this seta was directed crosswise of the apical and inner setae as shown in figures 15 and 18, thus emphasizing its eccentric placement; in appendages turned a little laterad, the seta appeared marginal as in figure 17. Endopod segment 3 not quite twice as long as broad, ratio of length to width about 1.8 : 1; inner margin without setae but with cuticular expansions at the points of attachment of the two setae normally present in the genus, these expansions not resembling the marginal indentations or depressions of usual setal attachments (fig. 16); the outer and two apical spines normal, the apical longer than segment; average ratio of length of segment (expressed as 1) and spines (from outer to inner), 1 : 0.77 : 1.1 : 1.5.

Leg 5 (fig. 11): Segment 1 coalesced with thoracic segment, its lateral seta arising dorsally on stout basal joint. Length of segment 2 varying from 2 to 2.25 times its width; its inner margin straight and armed with inconspicuous, irregularly placed short hairs. First outer lateral spine set just above middle of segment; inner spine subterminal, being placed just above the slight apical production bearing the terminal seta. All three spines exceedingly slender, barely stouter than basal portion of apical seta; their edges minutely denticulate. The seta much longer than spines; inconspicuously plumose. The spines varying slightly in actual length from specimen to specimen, and from left to right side of an individual, but not departing from a pattern of relative length: inner spine always the longest, first outer spine a little longer than the second, and both of these spines as long as or longer than the segment; the shortest spine (second outer) a little shorter to a little longer than segment; the seta more than twice the length of segment, twice or more the length of second spine and less than twice the length of inner spine. This pattern determined from measurement of five pairs of legs from which no spines had been broken (Table 1).

Male

Total length, midline, 0.355-0.37 mm. Metasome more slender than that of female. Urosome lacking dorsal ornamentation except on anal segment as in female. Caudal rami and setae as in female.

Antennule (fig. 14) of fourteen segments; separation incomplete between segments 1 and 2, and between 8 and 9. Setae arising largely on ventral side; proximal

TABLE 1.

Length of segments, spines, and setae found in five pairs of fifth legs of the female of Halicyclops fosteri.

Segment (Length : width)	Outer spine 1	Outer spine 2	Seta	Inner spine
27.2 : 13.6	34	27.2	71.4	40.8 μ
27.2 : 17	37.4	30.6	68	40.8 μ
27.2 : 13.6	34	30.6	68	37.4
27.2 : 13.6	34	27.2	68	37.4
27.2 : 13.6	27.2	23.8	71.4	37.4
27.2 : 13.6	34	27.2	68	37.4
27.2 : 13.6	34	27.2	68	37.4
27.2 : 15.3	30.6	23.8	68	37.4
30.6 : 13.6	37.4	34	68	40.8
30.6 : 13.6	34	30.6	68	40.8

four segments with numerous, closely set setae of which one on segment 3 and one on segment 4 are exceptionally long, reaching to near end of antennule; the rest of antennule with few, short setae or aesthetes. Apical segment curved and somewhat clawlike, its proximal half with numerous setae. (Note: Fig. 14 erroneously shows fifteen segments in the antennule. The fourth segment from the apex is an artifact that appeared in the appendages from which the outline drawing was made. Inadvertently, this faulty drawing was inked and mounted rather than the corrected one, and the error unfortunately was not detected until the galley proof of the paper was seen. Study of several appendages shows that the antennule agrees closely with the superior figures of Gurney (1933). There are five segments beyond the somewhat swollen middle portion (segments 8 + 9); of these, three precede and two follow the point of geniculation which thus occurs between segments 12 and 13.) Other cephalic appendages as in female.

Legs 1-3 and exopod of leg 4 as in female. Endopod segment 3 of leg 4 differing from that of female in having two setae on the inner margin (fig. 13); these setae reaching to near end of apical spine.

Leg 5 (fig. 12) with the usual dorsally placed seta on thoracic segment. Segment 2 with two outer marginal spines shorter than segment; a long, apically placed seta more than twice the length of segment; an inner spine subequal to the segment and a longer seta; all spines very slender and minutely denticulate as in female.

Leg 6 (fig. 12) with outer seta nearly as long as apical seta of leg 5, and longer than its own middle seta and inner spine.

DESCRIPTION OF TEXAS SPECIMENS

Occurrence.—2 ovigerous females; Harbor Island (a tidal delta), Aransas Bay, Texas, March 24, 1948, J. W. Hedgpeth, collector; United States National Museum accession number 179561; occurring with brackish water harpacticoid copepods.

Description.—Total length, midline, 0.635 and 0.65 mm. Color dark brown. Cuticle and appendages stouter than Lake Pontchartrain specimens, but habitus outline and proportions of cephalic segment the same. Genital segment a little longer than broad (1.2 : 1), with pronounced lateral membranous flanges. Ovisac with 9-10 large ova. Urosome without ornamentation except as in Pontchartrain specimens. Length of caudal ramus subequal to width and to that of anal segment. Lateral seta placed marginally near middle of ramus, its length only a little more than that of ramus. Average ratio of length of setae and caudal ramus to outer caudal seta expressed as 1:

Caudal ramus	Lateral seta	Dorsal seta	Apical setae (outer to inner)		
0.5	0.7	1.2	1	5.7	12.7	0.4

Antennule reaching just beyond middle of cephalic segment. Relative segmental length and armature as in Pontchartrain specimens. Antenna differing from Pontchartrain specimens in the presence of the usual outer seta of first segment. Mandibular palp as in Pontchartrain specimens.

Legs 1-4: Armature of exopods differing in part from that of Pontchartrain specimens, and not entirely alike in the two

specimens; that of endopods alike. Leg 1, inner seta of basal segment 2 spiniform, short, barely reaching end of endopod segment 2. Exopod segment 3 with five setae on all legs, but the number of spines of legs 1-3 different in the two specimens, as follows:

	Specimen 1	Specimen 2
Leg 1	2	3
Leg 2	3	4
Leg 3	3	3

Large spines of all legs with narrow, serrate marginal membranes.

Leg 4: Exopod segment 3 like that of Pontchartrain specimens except that the seta between the two outer spines is much shorter, not reaching end of apical spine; the placement not so eccentric, arising from distal part of sclerotized lobe that is entirely marginal. Endopod segment 3, length to width as in Pontchartrain specimens (1.8 : 1); small protrusions at normal point of attachment of inner setae; average ratio of length of segment (expressed as 1) and spines (from outer to inner), 1 : 0.77 : 1.07 : 1.46.

Leg 5 like that of Pontchartrain specimens except that the seta is hardly longer than the inner spine. This observation is based on incomplete data since the spines and setae of the two specimens were variously missing or broken.

COMPARISON OF LAKE PONTCHARTRAIN AND TEXAS SPECIMENS

The two lots of specimens differ in the following points:

Size.—The Texas specimens are longer (0.64 as apposed to 0.47 mm) and more robust than the Pontchartrain.

Habitus.—Lateral flanges of genital segment of female more produced in Texas than in Pontchartrain specimens. Lateral seta of caudal ramus longer and placed more proximally in Lake Pontchartrain specimens.

Antenna.—The usual outer seta of the first segment present in Texas, absent in Pontchartrain specimens.

Spines of exopod segment 3, legs 1-3.—Number varying from one another in the two Texas specimens; no variation found in dissections of ten females and five males of Lake Pontchartrain material, nor noted in examination of whole specimens of the type lot. A comparative summary of the differences between the two lots of specimens shows that only the third legs of the two Texas specimens were like one another, and differ entirely from the Pontchartrain material:

	Texas	Pontchartrain
Leg 1	2 or 3	3
Leg 2	3 or 4	4
Leg 3	3	4

The close similarity of the fourth leg of the two lots of specimens, in both the distinctive structural modifications and quantitative characters, makes it imperative in light of present knowledge that they be regarded as the same species. Some of the differing characters, such as those found in the antenna and in the spinal formula of legs 1-3, point to the possible existence of two closely allied species, or of local races of a single species, as seem to exist in other *Halicyclops*. Herbst (1952, 1953) has interpreted populations with different spinal formulas as subspecies of *H. brevispinosus,* and has recorded (1955) differences between geographically separated populations of *H. crassicornis* in Brazil. *H. fosteri* may be represented by local races in the Gulf of Mexico area, and if so, the study of its distribution and variation might give insight into geographic speciation in both the genus and coastal brackish water copepods. The presently available material can only suggest the existence of the problem. No interpretation is valid that does not include both sexes and a larger number of individuals than was present in the Texas sample.

Taxonomy

The most strikingly distinctive character of *H. fosteri* is the combination of the modified spinal pattern of the third exopod segment of the fourth leg, and the dimorphism of its endopod as exemplified by the presence of inner marginal setae in the male and their absence in the adult female. There are three spines on exopod 3 of leg 4 in most of the described species of *Halicyclops,* of which two are on the outer margin and one on the outer apex. *H. fosteri* is not unique in the absence of the second outer marginal spine. Lindberg states that this spine is replaced by a seta in *setifer* from the Caspian Sea and *blachei* from India. In his illustrations, a seta similar in length to the first spine is shown in the usual place of the second spine. There is a question in

my mind as to whether the seta of *fosteri* can be interpreted as a modified spine. It is exceedingly slender, (much longer than the spine in the type lot), and is distally placed on a marginal sclerotization which does not correspond to the usual indentation in which the spines or other setae are normally placed. *H. fosteri* thus appears to differ from the other two species in the length and placement of this seta which may perhaps be more accurately interpreted as an accessory seta. In addition, *fosteri* and *setifer* differ from *blachei* in having normal spines on exopod 3 of the third leg. In *blachei*, the third or distal outer spine on this leg is also replaced by a seta, and Lindberg has expressed the spinal formula as 3,4,3,2. Following this mode, the formula of *setifer* and of typical *fosteri* is 3,4,4,2.

The absence of inner setae on endopod segment 3 of the fourth leg has been reported otherwise only in the Nigerian species, *korodiensis* Onabamiro. Exopod segment 3 of *korodiensis* differs from that of *fosteri* in having the normal number of spines. The endopod of *korodiensis* is described as having a "small papilla" in place of the proximal seta in contrast to the two areas of cuticular outgrowth in *fosteri*. The male of *korodiensis* has not been described, so whether the sexual dimorphism of *fosteri* is also characteristic of the other species is unknown.

The modifications of the fourth leg do not by themselves indicate close relationship of these four species. That there is no correlation between modification of exopod and endopod is indicated by *korodiensis* which lacks the inner endopod setae, but has normal spination of the exopod. Although any of the four species having modified fourth legs may be more closely related to species in which there is no modification, it is nevertheless apropos to compare their characters with one another and with the new American species. Table 2 gives a summary of the modifications of legs 3 and 4.

The armature of legs 1 and 2 of these four species does not differ. They all have slender, elongate spines on leg 5; where known, the males have the common armature for the genus (3 spines, 2 setae). In none are there spiniform processes on or conspicuous protrusion of the female genital segment. *H. setifer* differs strikingly from the others in its slender habitus and the greater length of the caudal rami.

In Lindberg's 1957 key, the females of both the Pontchartrain and Texas forms of *fosteri* can be placed in the first part by omitting from couplet 1 a statement of the complete spinal formula and including only a reference to leg 4. The species is then separable from *setifer* and *blachei* by the lack of inner setae on the third segment of the endopod, thus:

1. Leg 4, exopod segment 3 with total of two outer spines, between which is a marginally or eccentrically placed seta 2
   Leg 4, exopod segment 3 with three outer spines and no outer seta 4
2. Leg 4, endopod segment 3 without inner marginal setae. ..... *H. fosteri* sp. nov.
   Leg 4, endopod segment 3 with inner marginal setae 3
3. Leg 3, exopod segment 3 with three outer spines and distal outer seta. *H. blachei* Lindberg, 1952
   Leg 3, exopod segment 3 with four outer spines. ..... *H. setifer* Lindberg, 1949

TABLE 2.

Modified armature of outer margin of exopod segment 3 and inner of endopod segment 3 in some species of Halicyclops.
(s = seta; sp = spine; exo = exopod; endo = endopod).

Species	Leg 3, exo 3	Leg 4, exo 3	Leg 4, endo 3
H. korodiensis	4 sp	3 sp	inner setae absent ♀, unknown ♂
H. setifer	4 sp	2 sp, s	inner setae present ♀, ♂
H. fosteri	4 (3) sp	2 sp, s	inner setae absent ♀, present ♂
H. blachei	3 sp, s	2 sp, s	inner setae present ♀, unknown ♂

Lists of taxonomic characters to be used in studying *Halicyclops* have been given by Kiefer (1936) and Lindberg (1949). It appears to me, however, after reviewing the literature that there is still much to be learned about the structural characters, modifications and variations of the forms within the genus before any adequate evaluation of characters can be made, and relationships of species considered critically. Moreover, in order to achieve this, it is evident that taxonomists must present more complete descriptions of their material. In the study of *Halicyclops*, both the species and the specimens will always be widely scattered geographically, and comparative and revisionary work will depend much upon the literature. Only comprehensive knowledge of the species can lead to adequate and usable taxonomy, and to an understanding of the interrelationships of the species. Unfortunately, complete descriptions are available for only a few of the thirty-four species and subspecies that have been proposed in the genus. Of these, many appear to be indistinctly separated, and may be merely based upon variations or local races. It is comparatively easy to deal with species having distinctive modifications such as occur in *fosteri*, but I have found it impossible to arrive at any satisfactory conclusion as to the specific identity of some other available North American specimens. These show only minor quantitative or slight structural differences, such as variation in the marginal armature of spines, from forms that have been described in the literature under more than one specific name.

There are many structural characters of the genus that can be utilized in its taxonomy in addition to those commonly employed, and often in preference to less significant or overlapping quantitative differences. It is apparent, for instance, that the antennule of the female may have considerable taxonomic value for some species or groups. The extremely shortened antennule of *H. sinensis* Kiefer (1928, 1936) first drew attention to specific differences in the length of the antennule and in the relative lengths of its segments. Since then, authors have usually given relative proportions of the segments to one another and figured the outline. Measurements, however, are difficult to interpret. Some appear to refer to the midline, others to the margin. The total relative length is usually ignored and an unusually short antennule merely called "short" instead of being compared to some standard such as the cephalic segment, antenna, or total body length, so that the description has no comparative value. Very few figures of the antennule illustrate the armature or give details in the text. It is evident, however, from several examples such as the striking condition of *H. pilifer* Lindberg (1949) in which a stout spine occurs on the first segment and most of the setae are densely plumose, that the armature may be distinctive in individual or groups of species. In the description of *blachei*, Lindberg (1952) speaks of the segments as being armed with strongly ciliated setae, but gives no details. There may also be modifications of the aesthetes (apparently normally found on segments 4 and 6) as shown by Humes (1947) for *caridophilus*. Whether the number and distribution of the setae, spines and aesthetes follow a pattern or patterns within the genus is not known. The setation given here for *fosteri* agrees numerically with that given by Gurney (1933 : 20) for *"H. aequoreus"* and shown in the figure of *caridophilus* by Humes. In comparing *fosteri* with the few other illustrations in the literature, the agreement was not so close, or could not be judged with certainty because the figures are much too small to show such detail. It is suggested that a comparative study of the details of the antennules of several species, including those of distinctive form such as *pilifer* and *blachei*, might well give a basis for needed standards in description.

Attention should also be given to the antenna. That of *fosteri* agrees very well with the setation shown in the few figures given in the literature, except that the seta usually present on the distal outer edge of the first segment was lacking in specimens examined from Lake Pontchartrain and present in the two Texas specimens. This seta is usually present in gnathostome cyclopoids, so that its absence may have taxonomic significance. It is not shown in the figures given for *H. propinquus* (Sars, 1905), and *H. tenuispina* (Sewell, 1924).

There may also be specific differences in the mandible, but this appendage is rarely mentioned in descriptions. Sars (1905,

1913) and Gurney (1933) show the palp with three setae arising from a minute papilla. Such a papilla is absent in *fosteri*, the setae arising from an indentation in the blade. The number of setae may be presumed to be a specific character since only two setae occur in *fosteri*, and the number is reduced to one in *caridophilus*.

In *fosteri*, a group of short setae or spines is present on the dorsal face of the apical segment of the maxillule (figs. 7 and 8). Of the few illustrations of this appendage in literature, comparable armature is shown only by Humes (1947) and suggested in Sars's (1913) figure. The presence or absence of such setae in this position should be noted for species of *Halicyclops* because they are invariably present in other Cyclopidae, and their absence from even some species would constitute an important divergence. I suspect, though, that they will probably be found to be present in all species of *Halicyclops* upon critical examination.

Differences in the inner seta of the second basal segment of the first leg, as shown in figures in the literature, suggest that the length and stoutness of this seta should be noted in descriptions.

In addition to the need for complete description of species, there is need for studies of variation within populations. Most subspecies in this genus have been proposed without knowledge or analysis of such variation, or even of comparison with the nominate form—an unfortunate and invalid practice throughout much modern copepod literature. The continued publication of names for species, subspecies and forms, based upon incomplete investigation, inadequate numbers of specimens, unevaluated and indefinite characters, is rapidly placing the genus *Halicyclops* in a state of confusion. Investigators having access to adequate numbers of specimens and collections of several species or geographic races would advance our knowledge, and perhaps erase some of the difficulties of evaluation and identification, by presenting comprehensive, comparative studies of such material.

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Abstract

American records of the cyclopoid copepod genus *Halicyclops* are reviewed. Records of four species from West Indies and South America are considered valid, but all those from North America are questionable because they have been referred to European forms that have been confused in literature. Revisions and keys by Kiefer and Lindberg are evaluated and supplemented by a check list of species and forms known for the world to January, 1958, with appropriate bibliographic references.

A new species, *H. fosteri*, is described from the brackish waters of Lake Pontchartrain, Louisiana, and compared with females collected on the coast of Texas. The latter are referable to this species because of the distinctive modifications of both rami of the fourth leg. Differences in specimens from the two localities suggest the possible existence of local races of the species in the Gulf of Mexico area, but more material and both sexes of the Texas form are necessary for a valid interpretation.

Species with structural modifications, such as found in *H. fosteri*, are relatively easy to distinguish, but most species and subspecies proposed in the genus are based on minor quantitative and slight structural differences so that identification of species in the genus is often difficult and unsatisfactory. The need for complete descriptions and comparative morphological studies is emphasized, and taxonomic characters of appendages usually not considered in descriptions are indicated.