Copepoda (Crustacea) from Fresh Waters of the Florida Everglades, U.S.A., with a Description of Eucyclops conrowae n. sp.

Article *in* Transactions of the American Microscopical Society · July 1992

DOI: 10.2307/3226612

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Copepoda (Crustacea) from Fresh Waters of the Florida Everglades, U.S.A., with a Description of *Eucyclops conrowae* n. sp.[1]

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Abstract. This first collection of Copepoda (Crustacea) from fresh waters in the Florida Everglades yielded 13 species: the calanoid *Osphranticum labronectum*, the cyclopoids *Acanthocyclops robustus, Eucyclops bondi, Macrocyclops albidus, Mesocyclops americanus, Microcyclops rubellus, Microcyclops varicans,* and *Tropocyclops prasinus mexicanus,* the harpacticoids *Cletocamptus deitersi, Onychocamptus mohammed,* and *Phyllognathopus viguieri,* and two previously unknown species: *Thermocyclops parvus,* described elsewhere, and *Eucyclops conrowae,* n. sp., described herein. *Eucyclops conrowae* is distinguished principally by the posteriorly produced pedigers 2–4, caudal rami 3.5 times longer than broad, median terminal caudal setae with short coarse spiniform setules, antennule reaching posterior margin of pediger 2, leg 4 exopodite article 3 with some setae flanged, and leg 4 endopodite article 3 with lateral and distomedial setae short, sclerotized, and blunt. The neotropical species *E. bondi* is newly recorded for the United States. Specimens of *M. albidus* resemble tropical rather than European populations in having short caudal rami. As a result of this collection and additional material examined, the known range of *M. americanus* is extended from Ontario south to Florida and west to Indiana. The previously unknown male of *M. americanus* is described from specimens collected in the Everglades. The ornamentation of the anal somite and the relative lengths of the leg 4 endopodite article 2 terminal spines distinguished populations ascribed to *M. rubellus* and *M. varicans*. The Everglades copepods, collected from a shallow slough, have few species in common with assemblages reported from mainly planktonic collections in central Florida. Especially diaptomid calanoids, common in central and northern Florida, were absent from the Everglades collection.

The freshwater copepod crustacean fauna, especially the planktonic species, of central Florida has become well known from numerous reports (Bays & Crisman, 1983; Cowell et al., 1975; Elmore et al., 1984; and others). However, the freshwater copepods of the Florida Everglades are almost completely uninvestigated. To my knowledge, the only previous collection from the area was made by Davis (1948) from Long Lake, a small brackish-water lake (salinity 15.39‰, as measured by Davis) near the south end of Everglades National Park (Fig. 1). Davis reported three species, all since synonymized with other taxa: *Pseudodiaptomus coronatus* Williams, 1906 (=*P. pelagicus* Herrick, 1884),

[1] I thank Dr. Hans-Walter Mittmann for arranging the loan of specimens from the Friedrich Kiefer Copepod Collection at the Staatliches Museum für Naturkunde Karlsruhe, Germany. Dr. Richard L. Whitman allowed me to examine his collection of cyclopoid copepods from the Indiana Dunes National Lakeshore, and Ms. Dorinda Partsch authorized the long-term loan of a specimen from this collection to the National Museum of Natural History. Dr. Bruce C. Cowell kindly made me aware of additional references. Comments by Dr. Eugene H. Schmitz and two anonymous reviewers improved the text. Publication costs, in part, are being met by a grant from the Spencer-Tolles Fund of the American Microscopical Society.

TRANS. AM. MICROSC. SOC., 111(3): 229–254. 1992.

Acartia floridana Davis, 1948 (=*A. tonsa* Dana, 1852), and *Cyclops panamensis* var. *tannica* Davis, 1948 (=*Apocyclops panamensis* (Marsh, 1913)). All of these are typical inhabitants of coastal brackish waters.

Ms. Roxanne Conrow, formerly of the South Florida Research Center, Everglades National Park, confided to me for determination three samples of planktonic Copepoda taken from a shallow freshwater slough. These samples proved to contain 13 species of Copepoda, including two species new to science. One of these species is described herein, as is the previously unknown male of *Mesocyclops americanus* Dussart, 1985. Another, *Thermocyclops parvus*, was described elsewhere (Reid, 1989). The known distributions of several species were extended considerably by this collection. In the case of *M. americanus*, examination of additional specimens lent by the Staatliches Museum für Naturkunde Karlsruhe and by the Indiana Dunes National Lakeshore resulted in other new records, also listed herein.

Materials and Methods

The qualitative samples were taken with a plankton net in Shark River Slough, within and just outside Everglades National Park (Fig. 1). Sample 1 was consolidated from collections made at several locations in the slough on different dates in 1986. Collection data for the remaining two samples were supplied by R. Conrow: site 6 (25°37.2′N, 80°43.9′W), collected in April 1986, is in the central part of the slough, and site 23 (25°40.0′N, 80°36.9′W), collected in May 1986, in the northeastern part. Water depths were 14–23 cm at site 6 and 14–29 cm at site 23. At site 6, the substrate is predominantly peat, but at site 23 it is marl. Additional ambient data are not available for these sites on these dates. Loftus & Kushlan (1987) provided a detailed characterization of Everglades waters, from which the following data are summarized: pH varies from 7.0 to 8.5, specific conductance from 400 to 700 μSiemens·cm^{-1} during dry periods when concentrations of most major ions increase, and dissolved oxygen from 0.7 to 14.2 ppm, with marked diurnal fluctuation being the rule. Turbidity and color values, as well as nutrient levels, are low during much of the year, but they increase during the dry season.

Specimens were fixed in buffered 5% formalin and later transferred to 70% ethanol for long-term storage. For taxonomic determination, individual specimens were transferred to a solution of 70% ethanol-10% glycerin that was allowed to evaporate to nearly pure glycerin. Specimens were examined before dissection in glycerin or in lactic acid. Measurements were made of specimens in glycerin by means of an ocular micrometer. Permanent mounts of some were made in commercial polyvinyl lactophenol medium with a little chlorazol black E added. Drawings were made at magnifications of 400× or 600× using a Wild M50 compound microscope fitted with a camera lucida. Details of some structures were confirmed using an oil immersion lens at 1,000×. Specimens were deposited either in the collections of the National Museum of Natural History, Smithsonian Institution (USNM), or at the South Florida Research Center, Everglades National Park (SFRC).

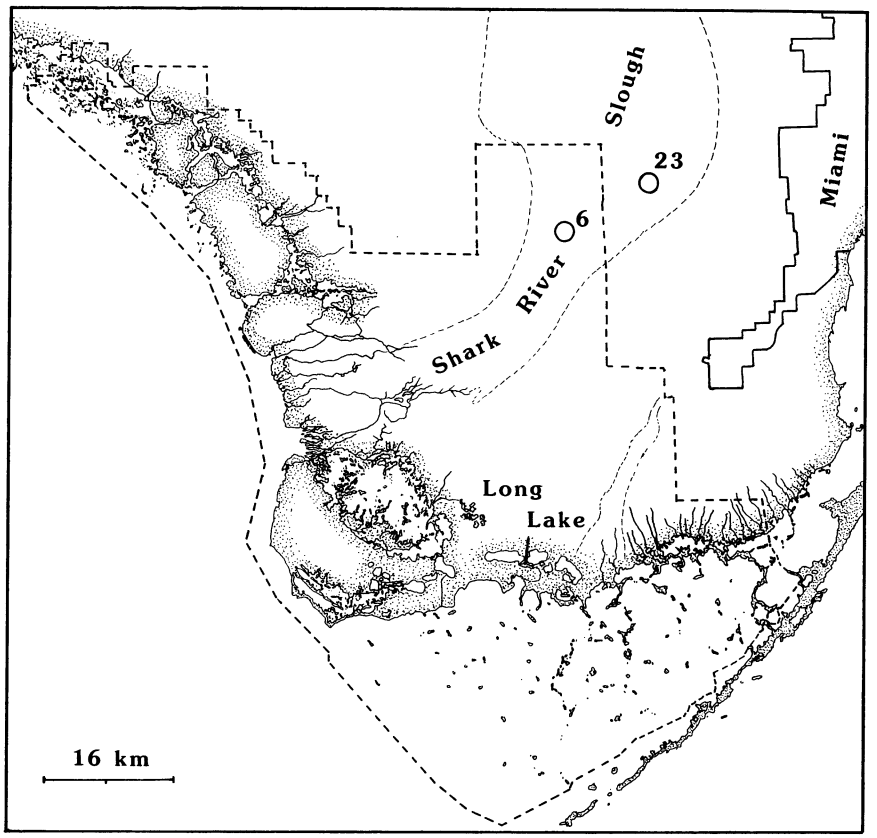

FIG. 1. The southern tip of the state of Florida, U.S.A., showing the locations of sample sites 6 and 23. The heavy dashed line indicates the boundaries of Everglades National Park; the light dashed line shows the approximate boundaries of Shark River Slough.

SPECIES INVENTORY

The 13 species contained in the samples are listed below, followed by sample numbers. The numerically predominant species in all samples were *Macrocyclops albidus*, *Microcyclops rubellus*, and *Microcyclops varicans*. At site 6, the next most abundant species were, in descending order of abundance, *Onychocamptus mohammed*, *Eucyclops conrowae*, and *Cletocamptus deitersi*. At site 23, *Thermocyclops parvus* was abundant.

Order Calanoida

Osphranticum labronectum S. A. Forbes, 1882: 6, 23

Order Cyclopoida

Acanthocyclops robustus (G. O. Sars, 1863): 1, 23
Eucyclops bondi Kiefer, 1934: 6

Eucyclops conrowae, n. sp.: 1, 6
Macrocyclops albidus (Jurine, 1820): 1, 6, 23
Mesocyclops americanus Dussart, 1985: 1, 23
Microcyclops rubellus (Lilljeborg, 1901): 1, 6, 23
Microcyclops varicans (G. O. Sars, 1862): 1, 6, 23
Thermocyclops parvus Reid, 1989: 1, 6, 23
Tropocyclops prasinus mexicanus Kiefer, 1938: 1

Order Harpacticoida

Cletocamptus deitersi (Richard, 1897): 1, 6, 23
Onychocamptus mohammed (Blanchard & Richard, 1891): 1, 6
Phyllognathopus viguieri (Maupas, 1892): 23

Distribution and Taxonomic Account of Selected Species

Order Cyclopoida G. O. Sars, 1886
Family Cyclopidae Burmeister, 1834
Genus *Eucyclops* Claus, 1893
Eucyclops conrowae n. sp.
(Figs. 2, 3, 4a–d)

Type specimens. Holotype: Female, dissected and mounted on two slides, sample 1, USNM 251325. Allotype: Male, sample 1, USNM 251326. Paratypes: One female, sample 1, and seven females, one male, and three copepodids, site 6, USNM 251327; six females and two males, site 6, SFRC; unmounted specimens ethanol-preserved.

Description of female. Length, excluding caudal setae, of holotype 0.63 mm; range of lengths of paratypes of 0.68–0.83 mm (median 0.79 mm, n = 14). Body (Fig. 2a) widest at midlength of cephalothorax in dorsal view; lateral surfaces of pedigers 2–4 produced posteriorly, pediger 4 completely covering pediger 5 in lateral view. Lateral margin of pediger 4 finely serrate (Fig. 2b). Lateral expansion of pediger 5 (Fig. 2a, c) with dorsoventral row of long stiff hairs. Genital segment (Fig. 2a, c) slightly longer than broad, anterior one-third broad, posterior two-thirds abruptly narrowed with lateral margins almost parallel in dorsal view. Seminal receptacle (Fig. 2c) with narrow anterior expansion, posterior expansion about twice breadth of anterior expansion. Hyaline membranes of posterior margins of urosomites (Fig. 2c–e) finely serrate. Anal operculum (Fig. 2d) slightly and irregularly convex. Caudal rami (Figs. 2a, e) about 3.5 times longer than broad, slightly divergent from base; lateral margin with row of spines (hereinafter termed "saw") extending along most of margin, more proximal spines smaller in size and length and set slightly more ventrally than distal spines. Lateral seta inserted somewhat dorsally, length of seta less than greatest breadth of caudal ramus. Both median terminal setae with short coarse spiniform setules set wide apart proximally and very close distally. Lateralmost terminal seta carried, in most specimens, nearly at right angle to ramus, in some paratypes bent anteriorly at midlength (Fig. 2f). Lengths of caudal setae of holotype in μm: dorsal 80, lateral 18, medialmost to lateralmost terminal 59, 436, 204, and 54.

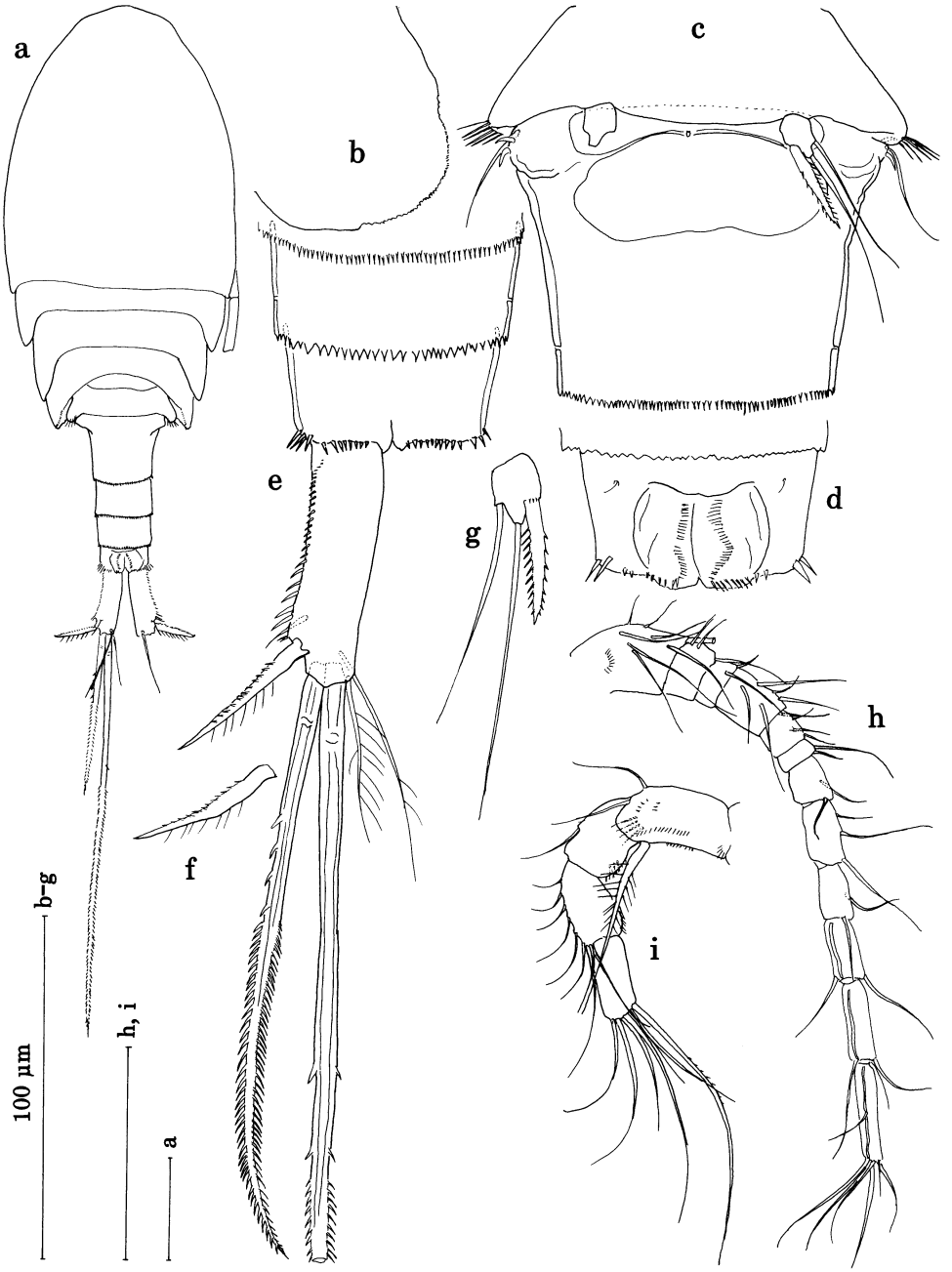

FIG. 2. *Eucyclops conrowae* n. sp., female. a, Paratype, sample 1, USNM 251327; b–e, g–i, Holotype, USNM 251325; f, A different paratype, sample 1, USNM 251327. a, Habitus, dorsal; b, Pediger 4, left lateral margin; c, Pediger 5 and genital segment, ventral; d, Anal somite, dorsal; e, Posterior urosomites and caudal ramus, ventral; f, Lateral-most terminal caudal seta; g, Leg 5; h, Antennule; i, Antenna, caudal side. Fig. 2a drawn at 400×; Figs. 2b–i drawn at 400×, details confirmed at 600× and 1,000×. Setules of most normally plumed setae omitted for clarity in this and subsequent figures.

Antennule (Fig. 2a, h) of 12 articles, when reflexed reaching posterior margin of pediger 2; hyaline membrane of articles 10–12 narrow, margin entire. Antennule (Fig. 2i) with three rows of small spines on caudal surface, one row along ventral margin, and one row of longer spines near distal margin of article 1. Lengths of two longest setae of palp of mandible (Fig. 3a) 2.3 times length of mandible; mandible additionally with semicircular row of small spines at level of and slightly proximal to palp. Maxillule (Fig. 3b) with no ornament on surface of palp. Maxilla (Fig. 3c) with row of teeth on proximal two-thirds of claw. Maxilliped (Fig. 3d) with curved row of spines on each of articles 2 and 3.

Legs 1–4 (Figs. 3e–j, 4a, b) with triarticulate rami and spine formula 3,4,4,3. Coxopodite, basipodite and rami of leg 3 armed and ornamented as leg 2, except leg 3 coxopodite with short transverse row of small spines on posterior surface near coupler. Posterior surface of coupler of leg 2 naked. Posterior surface of coupler of leg 3 with three rows of slender hairs on posterior surface; anterior surface of coupler with fewer small spines than on leg 2. Coupler of leg 4 with groups of spines on distal margin and posterior surface, coupler lacking ornament on anterior surface. Leg 4 exopodite article 3 with two slender, normally plumed setae; three setae with finely crenulate flanges along lateral margins, lacking plumage except few setules on proximalmost seta; and three serrate spines. Leg 4 endopodite article 3 about two times longer than broad; medial terminal spine 1.3 times longer than lateral terminal spine; proximal seta of medial margin slender, normally plumed; distal seta of medial margin and lateral seta normally plumed but short, distinctly sclerotized and slightly broader than other seta, with blunt tips.

Leg 5 (Fig. 2c, g) consisting of one free article bearing medial spine, terminal seta, and lateral seta; medial spine inserted at same level as lateral seta. Medial spine very stout, at base about five times breadth of terminal and lateral setae.

Description of male. Length of allotype 0.63 mm. Range of lengths of paratypes 0.52–0.58 mm (median 0.52 mm, n = 3). Habitus (Fig. 4c) more slender than, but otherwise similar to female. Caudal rami six times longer than broad, lateral margin lacking spines except for transverse row of few spines at level of lateral seta. Ornament of caudal setae similar to that of female. Lengths of caudal setae of allotype in μm: dorsal 53, lateral 15, medialmost to lateralmost terminal 44, 525, 137, 34; next medialmost terminal seta thus relatively longer than corresponding seta of female.

Antennule geniculate, similar in structure and armament to that of *E. agilis* as indicated by Gurney (1933, fig. 1286). Legs 1–5 similar to those of female except leg 3 endopodite article 3 (Fig. 4d) with three normal and two flanged setae. Medial (ventral) spine of leg 6 (Fig. 4e) reaching well past posterior margin of succeeding urosomite; two setae of leg 6 slender, neither seta reaching posterior margin of succeeding urosomite.

Type locality. Shark River Slough, Everglades, Florida.

Etymology. Named for the collector, Ms. Roxanne Conrow.

Comparisons. Eucyclops conrowae is similar in habitus, general proportions, and structure of leg 5 to the common, somewhat variable, possibly cosmopolitan

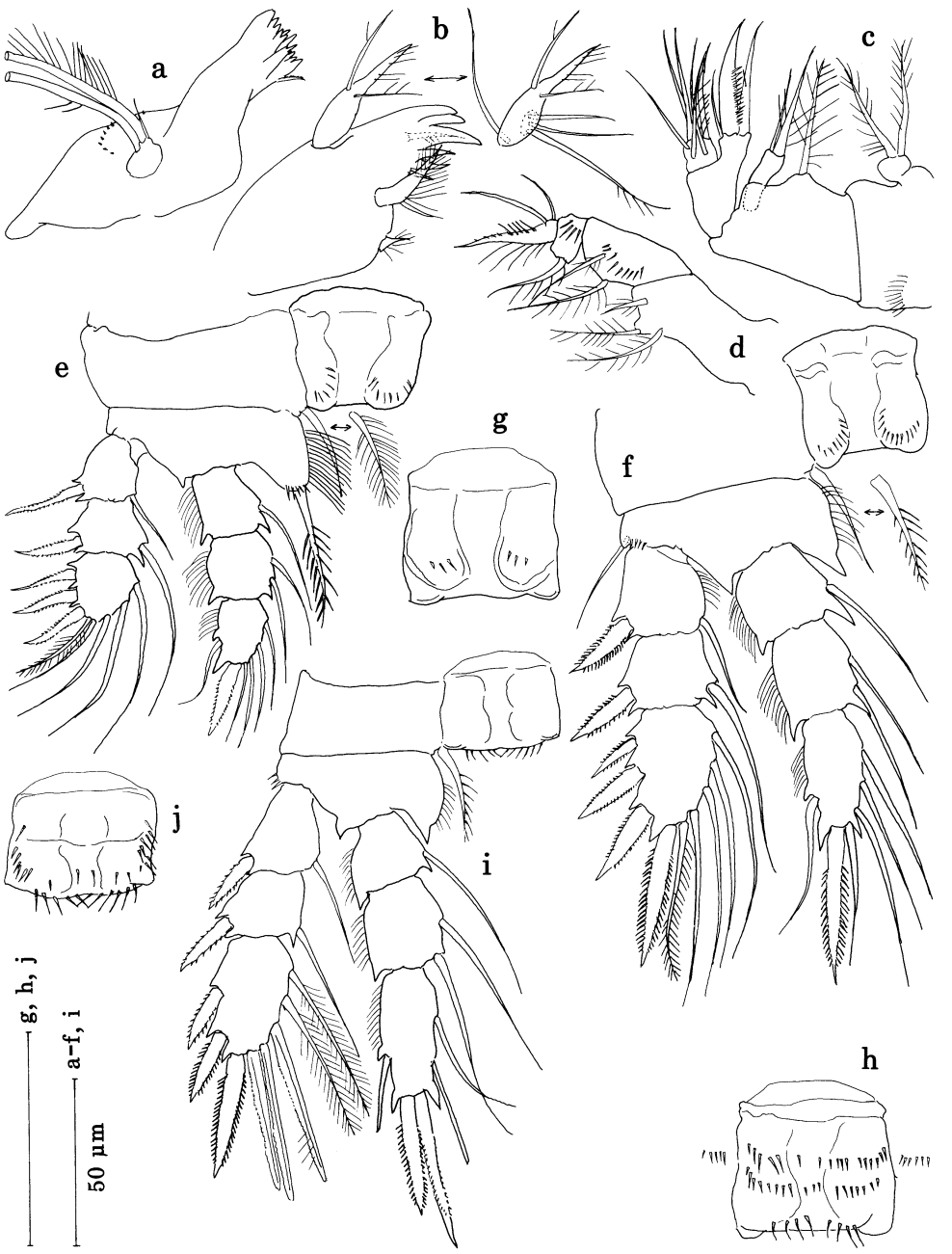

FIG. 3. *Eucyclops conrowae* n. sp. Female holotype, USNM 251325. a, Mandible; b, Maxillule and detail of palp; c, Maxilla; d, Maxilliped; e, Leg 1, coupler, and detail of seta of coxopodite, anterior; f, Leg 2, coupler, and detail of seta of coxopodite, anterior; g, Coupler of leg 3, anterior; h, Coupler of leg 3 and spines on adjacent part of coxopodite, posterior; i, Leg 4 and coupler, anterior; j, Leg 4 coupler, posterior. Figures drawn at 400×, details confirmed at 600× and 1,000×.

E. agilis (Koch, 1838), a much-employed synonym of which is *E. serrulatus* (Fischer, 1851). Because of similarities in the length of the antennule relative to the length of the prosomites and in the proportions of the caudal ramus, *E. conrowae* keys to *E. agilis* in the keys of Yeatman (1959a) and Pennak (1989). There are a number of subtle differences between the two species. In *E. agilis*, the posterior expansion of the seminal receptacle is approximately equal in anteroposterior breadth to the anterior expansion; the more distal spines of the caudal saw are only slightly longer than the more proximal spines; the leg 4 endopodite article 3 is consistently about three times longer than broad; the leg 4 coupler is ornamented only with fine hairs; and the dorsal caudal seta is always shorter than the medialmost terminal caudal seta. The proportions of the caudal ramus of *E. agilis* are variable, the ramus usually being about five times longer than broad. The plumage of the median terminal caudal setae of *E. agilis* is less coarse and closely set than that of *E. conrowae*. The ornament of antenna article 1 is simpler in *E. conrowae* than in *E. agilis* as described by Fiers & Van De Velde (1984). The lateral and distomedial seta of leg 4 endopodite 3 of *E. agilis* are finely tapered. Flanged setae on the distal articles of legs 3–4 sometimes may be present in *E. agilis* (e.g., Gurney, 1933, fig. 1389) and in other species such as *E. euacanthus* (G. O. Sars, 1909) as described by Dumont & Van De Velde (1977), *E. euacanthus* f. *lanceolata* Dussart, 1974, *E. nichollsi* Brehm, 1950 as redescribed by Morton (1990), and *E. spatulatus* Morton, 1990. However, I am unaware of reports of other species possessing sclerotized, blunt setae like those of the leg 4 endopodite article 3 of *E. conrowae*. Morton (1990) described a similarly reduced but narrowly flanged lateral seta on leg 4 endopodite 3 of *E. spatulatus*.

The medial spine of leg 6 of the male of *E. agilis* reaches only to the posterior margin of the succeeding urosomite.

Besides *E. agilis*, nine other congeners have been recorded from North and Central America and the Antilles. *Eucyclops elegans* (Herrick, 1884), *E. neomacruroides* Dussart & Fernando, 1990, and *E. speratus* (Lilljeborg, 1901) all have the caudal ramus extremely long, about 6–8 times longer than broad. *Eucyclops festivus* Lindberg, 1955, known only from Mexico, has the caudal ramus 5.0–5.5 times longer than broad, the antennular membrane coarsely serrate, the dorsal caudal seta shorter than the medialmost and lateralmost terminal caudal setae, and the leg 4 setae unmodified. *Eucyclops leptacanthus* Kiefer, 1956, a South American species reported from Costa Rica by Collado, Defaye et al. (1984), is similar to *E. conrowae* in having the caudal ramus 3.6–4.0 times longer than broad, with a lateral saw similar in extent, but differs in having the leg 5 medial spine narrow, at its base less than twice the breadth of the two leg 5 setae, the antennular membrane partly serrated, and the dorsal caudal seta shorter than the medialmost terminal caudal seta. *Eucyclops bondi* and *E. prionophorus* Kiefer, 1931, discussed in more detail in the following section, both differ from *E. conrowae* in having fine setules on the two median terminal caudal setae, unmodified leg 4 setae, and a relatively longer leg 5 medial spine. In *E. ensifer* Kiefer, 1936, the spines of the saw of the caudal ramus do not increase in size distally, the leg 4 setae are unmodified, and the

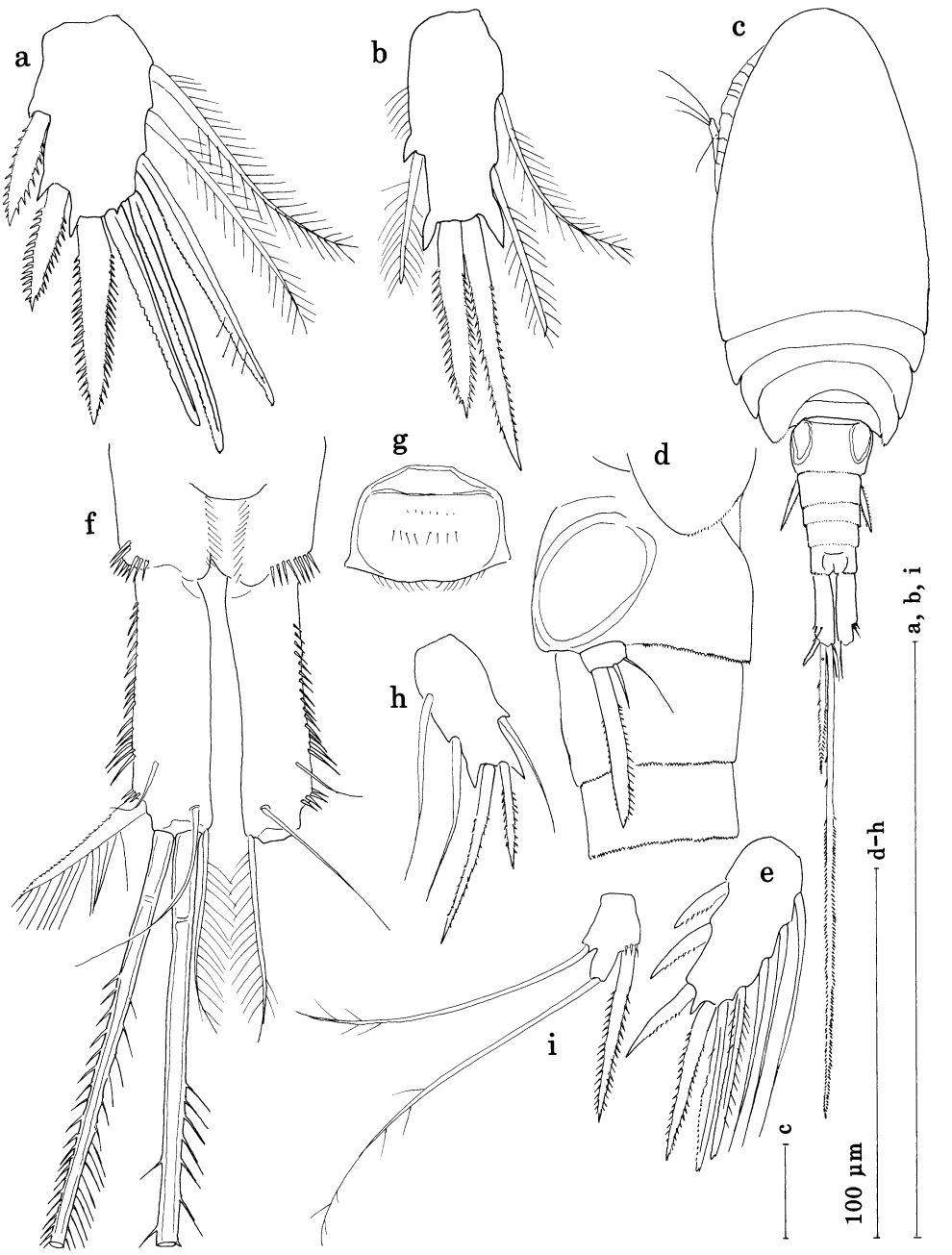

FIG. 4a–e. *Eucyclops conrowae* n. sp. a, b, Female holotype, USNM 251325; c–e, Male allotype, USNM 251326. a, Leg 4 exopodite article 3; b, Leg 4 endopodite article 3; c, Habitus, dorsal; d, Anterior urosomites, left lateral; e, Leg 3 exopodite article 3. FIG. 4f–i. *Eucyclops bondi* Kiefer, 1934, female, USNM 251324. f, Anal somite and caudal rami, dorsal; g, Leg 4 coupler, posterior; h, Leg 4 endopodite article 3; i, Leg 5. Figure 4c drawn at 400×; Figs. 4a, b, d–i drawn at 600×, details of Figs. 4a, b, d, and g confirmed at 1,000×; Fig. 4i drawn at 1,000×.

part of the free article of leg 5 bearing the lateral seta is much produced. The ninth species, *E. ariguanabensis*, has not been found since its description by Brehm (1948) from Cuba. This species, so cursorily described that Lindberg (1955) considered it incerta sedis, has the caudal ramus about four times longer than broad, the spines of the caudal ramus saw equal in size, and the leg 4 setae unmodified. *Eucyclops conrowae* is distinguished from all other congeners by the combined characters in both sexes of the posteriorly produced pedigers 2–4, the ornament of the caudal setae, the length of the antennule, and the modified setae of leg 4, and in the male, by the long, stout spine of leg 6.

Eucyclops bondi Kiefer, 1934
(Fig. 4f–i)

Specimen examined. Female, partly dissected on slide, site 6, USNM 251324.

Description of female. Length 0.69 mm. Antennule when reflexed reaching midlength of pediger 2. Caudal ramus (Fig. 4f) about 3.5 times longer than broad, saw extending along most of lateral margin, spines of saw increasing markedly in length distally. Dorsal caudal seta longer than lateralmost terminal seta; median terminal setae with heteronomous plumage, widely spaced stiff setules proximally and closely set, more slender setules distally. Coupler of leg 4 (Fig. 4g) with two groups of short fine hairs along distal margin, and two short transverse rows of fine hairs on posterior surface. Leg 4 endopodite article 3 (Fig. 4h) 2.1 times longer than broad, medial terminal seta about 1.4 times longer than article. Leg 5 (Fig. 4i), medial spine two times longer than article and two times broader at base than median and lateral setae.

Comparisons and discussion. Eucyclops bondi has been collected from Colombia (Marten et al., 1989; Reid, 1988), Cuba (Collado, Fernando & Sephton, 1984; Smith & Fernando, 1978a, 1980), Guatemala (Reid, 1988), Hispaniola (Kiefer, 1934, 1936a), and Trinidad (Collado, Fernando & Sephton, 1984). Collado, Defaye, Dussart & Fernando (1984) reported a population differing in a few morphological details but tentatively assigned to this species from Costa Rica. The present report is the first from North America.

Eucyclops bondi is distinguished from congeners by pedigers 3 and 4, which extend far posterolaterally over succeeding somites, the antennule, which when reflexed extends posteriorly slightly past the posterior margin of the cephalothorax, the caudal ramus about 3.5 times longer than broad, with the distal spines of the caudal saw elongate, and the leg 5 with the medial spine longer than the article and about two times the breadth of each of the two setae. In the male, the medial spine of leg 6 is shorter than the length of the succeeding somite. The most similar known species is *E. prionophorus* Kiefer, 1931, originally described from and widely reported in North America, with possible records from Paraguay and Uruguay (Kiefer, 1936b). Kiefer (1936a) discussed the great morphological similarity between these two species, but maintained the taxonomic distinction, basing his opinion primarily on a difference in the leg 6 of the male. The medial spine of leg 6 of the male of *E. prionophorus* is about three times the length of that of *E. bondi* and reaches well past the posterior border of the succeeding somite. The principal difference between

the females of these species lies in the length of the antennule, which in *E. prionophorus* is much less than the length of the cephalothorax. Also, in all representations of the caudal ramus of *E. prionophorus,* the length of the dorsal caudal seta is equal to, or, usually, is much less than that of the lateralmost terminal caudal seta (Harris, 1973; Kiefer, 1931, 1936b; Smith & Fernando, 1978b). I have assigned the single female specimen from the Everglades to *E. bondi* on the basis of the relatively long antennule and dorsal caudal seta. Unfortunately, no male of this species was included in the collection.

Genus *Macrocyclops* Claus, 1893
Macrocyclops albidus (Jurine, 1820)
(Fig. 5)

Specimens examined. Three females and one male, each dissected and mounted on slide, and four females, four males, and two copepodids, sample 1; five females and one copepodid, site 23; 20 females, 17 males, and 13 copepodids, site 6, USNM 251318; 10 females and 10 males, site 6, SFRC; unmounted specimens ethanol-preserved.

Description and comparisons. Lengths (not including caudal setae) of three females from sample 1 were 1.30 mm, lengths of remaining four females 0.95–1.08 mm. The females from site 23 also showed two distinct size classes, two measuring 1.30 mm and three ranging from 1.00 to 1.15 mm. Females from site 6 were more uniform in length, ranging from 0.96 to 1.11 mm (n = 10). The discrepancy in size classes in two samples led me to examine more closely the morphology of representatives of each class. The morphology of females from both classes was congruent with the general diagnosis of *Macrocyclops albidus* (Jurine) s. str. However, females from each size class varied in some respects from descriptions of European specimens (Dussart, 1969; Gurney, 1933; Kiefer, 1978; Neubaur, 1913).

The larger form has caudal rami (Fig. 5a) about 1.95 times longer than broad, not three times as has been reported uniformly for European forms. The medialmost appendage of the terminal article of leg 5 (Fig. 1b) is a seta, not a spine. Otherwise, the armament of the swimming legs and mouthparts (Fig. 5b–h) is identical to that of European specimens described by Neubaur (1913) and subsequent authors.

The small form has caudal rami also about two times longer than broad, but differs from the large form in having the leg 4 endopodite article 3 medial terminal spine longer than the lateral terminal spine (Fig. 5i). The females from site 6 had leg 4 spines similarly proportioned to the small form.

Earlier workers also described populations of *M. albidus* that varied morphologically from European populations. Short caudal rami (i.e., about two times longer than broad) seem to be found more often in specimens from the tropics, a phenomenon first noted by Kiefer (1933). Such rami were noted or figured for specimens from southern Brazil (Fallavena, 1985), the Brazilian Amazon (Herbst, 1962), and Venezuela (Dussart, 1984); forms with short caudal rami also are widespread in the U.S.A. (Marsh, 1910). Marsh (1910) observed as well that the possession of a medial seta rather than a spine on the free

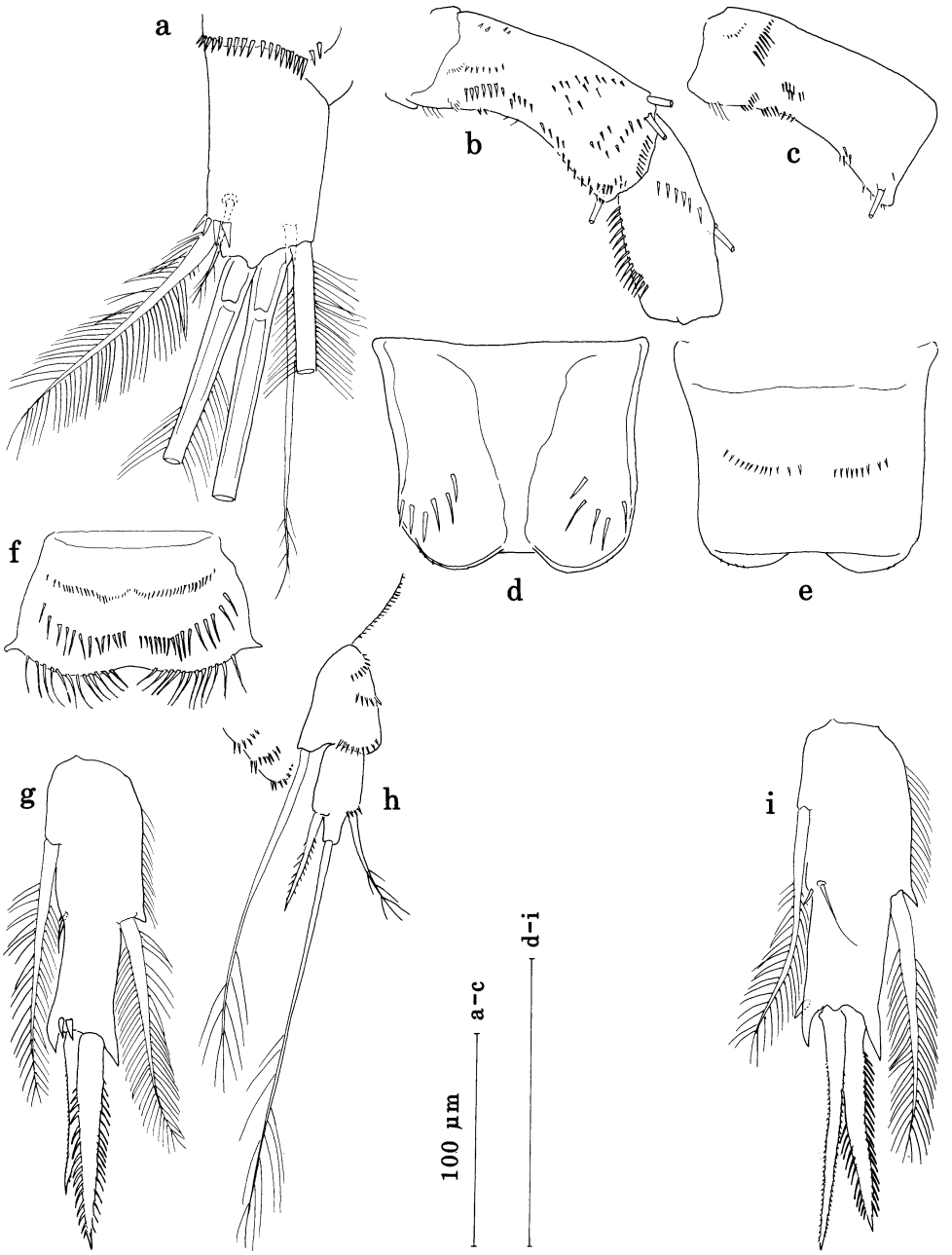

FIG. 5. *Macrocyclops albidus* (Jurine, 1820). a–h, Large female dissected on slide from sample 1; i, Small female dissected on slide from sample 1, both USNM 251318. a, Caudal ramus, ventral; b, Antennule articles 1 and 2, caudal side; c, Antennule article 1, frontal side; d, Leg 1 coupler, anterior; e, Leg 1 coupler, posterior; f, Leg 4 coupler, posterior; g, Leg 4 endopodite article 3, anterior; h, Leg 5; i, Leg 4 endopodite article 3, posterior. Figures drawn at 400×, details confirmed at 600× and, for Figs. 5b–f, at 1,000×.

article of leg 5 seems to be a general characteristic of North American populations of *M. albidus*. The leg 4 endopodite 3 medial terminal spine is equal to or longer than the lateral terminal spine in many populations (Dussart, 1984, Venezuela; Marsh, 1910, U.S.A.; Pleşa, 1981, Smith & Fernando, 1978a, 1980, Cuba). Pleşa (1981) also remarked on variations in the relative length of the antennule in several Cuban populations of of *M. albidus*; some specimens that he observed also lacked a hyaline membrane on the terminal article of the antennule. In addition, Pleşa located one female that lacked the small seta on the medial margin of the terminal article of leg 4, as in the subspecies *M. albidus oligolasius* Kiefer, 1928 originally described from Africa.

Morphological variations within *M. albidus* s. l. seem to show no coherent patterns in their geographical distribution. Perhaps changing environmental conditions stimulate the development of slightly different morphologies in succeeding cohorts. Such effects of ambient conditions on morphology were recorded for several other species of cyclopoids, particularly in the genus *Acanthocyclops* (see Aycock, 1942; Coker, 1934; Yeatman, 1959b). To sustain the notion of subspecies within *Macrocyclops albidus* s. l. on morphological grounds alone is difficult in view of such plasticity.

Genus *Mesocyclops* G. O. Sars, 1914
Mesocyclops americanus Dussart, 1985
(Figs. 6, 7)

Specimens examined. One female and one male, each dissected and mounted on slide, and one male, sample 1, USNM 251320; one female, site 23, SFRC; unmounted specimens ethanol-preserved. One female, partly dissected and mounted on slide, Miller Woods pond, Indiana Dunes National Lakeshore, 1984, col. and prep. R. L. Whitman, USNM 251348. From Kiefer Copepod Collection, Staatliches Museum für Naturkunde Karlsruhe: Mikropräparate 1522 and 1523, partly dissected female mounted on two slides, New Jersey, U.S.A., 16 July 1929, prep. F. Kiefer, September 1930; Mikropräparat 1911, Black Pond, Connecticut, U.S.A., prep. F. Kiefer, undated.

Description of female. Lengths of two specimens from Everglades, 0.88 and 0.91 mm. Morphological details of the females from Florida are congruent with most aspects of the original description (Dussart, 1985) of specimens from Ontario, with some minor additions and differences.

Lateral expansions of seminal receptacle (Fig. 6a) broader and more posteriorly curved than description of Ontario specimen. Membranes of posterior margins of urosomites shallowly serrate. Pediger 5 (Fig. 6a, b) without hairs laterally but with transverse mediodorsal row of few hairs. Leg 6 (Fig. 6c) elongate dorsoventrally, dorsal seta very long; plate of leg 6 and area posterior to plate without ornament.

Antenna article 1 (Fig. 6d) with basic pattern of surface ornament for genus (Van De Velde 1984a,b), row of spines on caudal side divided rather than continuous as described by Dussart. "Ponctuations" on caudal side of antenna of Ontario specimens found by Dussart (1985) not visible on Florida specimens. Mandible similar to that of *M. leuckarti* as redescribed by Van De Velde (1984a),

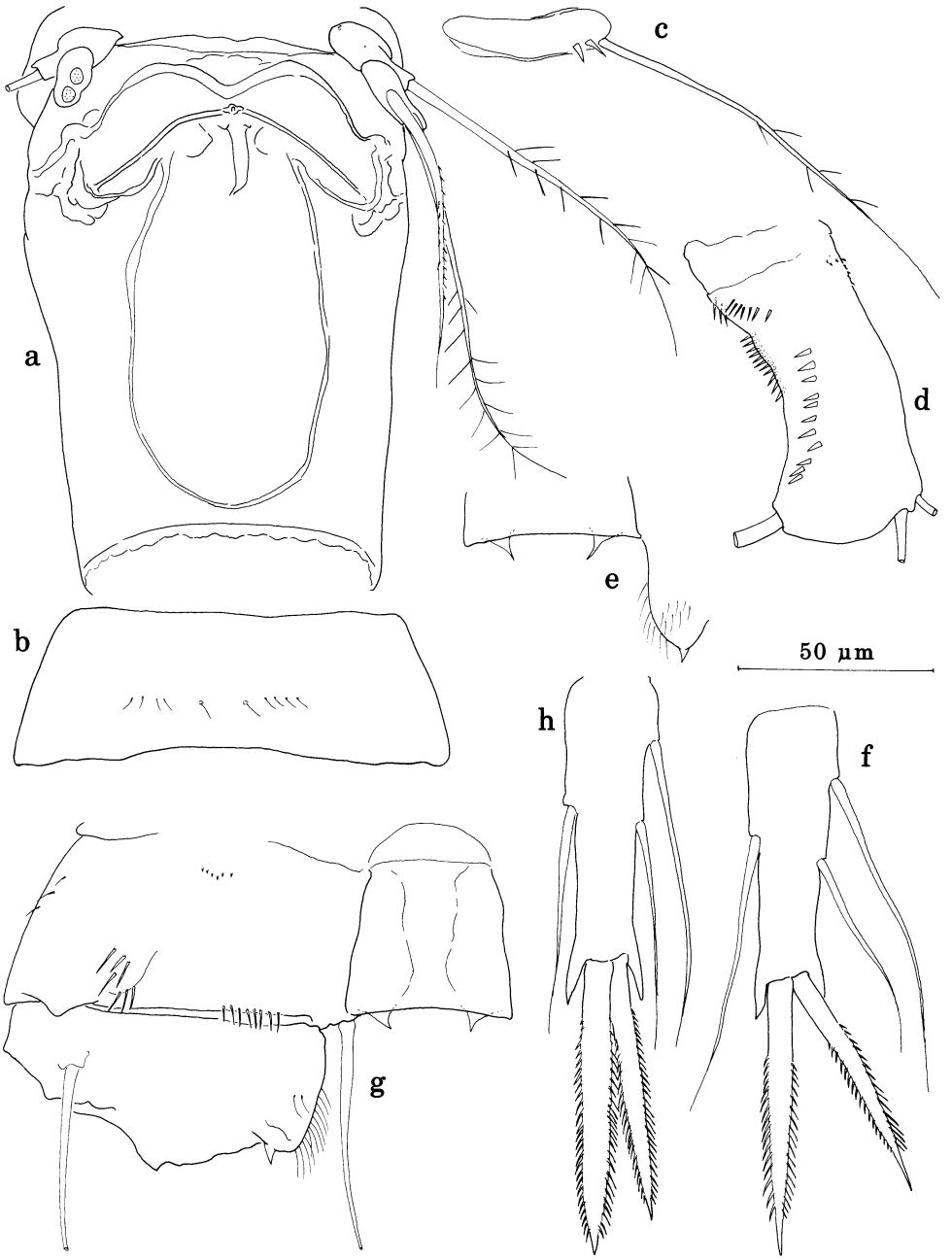

FIG. 6. *Mesocyclops americanus* Dussart, 1985. a–f, Female dissected on slide from sample 1, Shark River Slough, USNM 251320; g, h, Female on slide from Kiefer Collection, Mikropräparat 1911. a, Pediger 5 and genital segment, ventral; b, Pediger 5, dorsal; c, Leg 6, left lateral; d, Antenna article 1, caudal side; e, Leg 4 coupler and part of right basipodite, posterior; f, Leg 4 endopodite article 3; g, Leg 4 coupler and coxo-basipodite, posterior; h, Leg 4 endopodite article 3. Figures drawn at 600×; details of Figs. 6c–e and g confirmed at 1,000×.

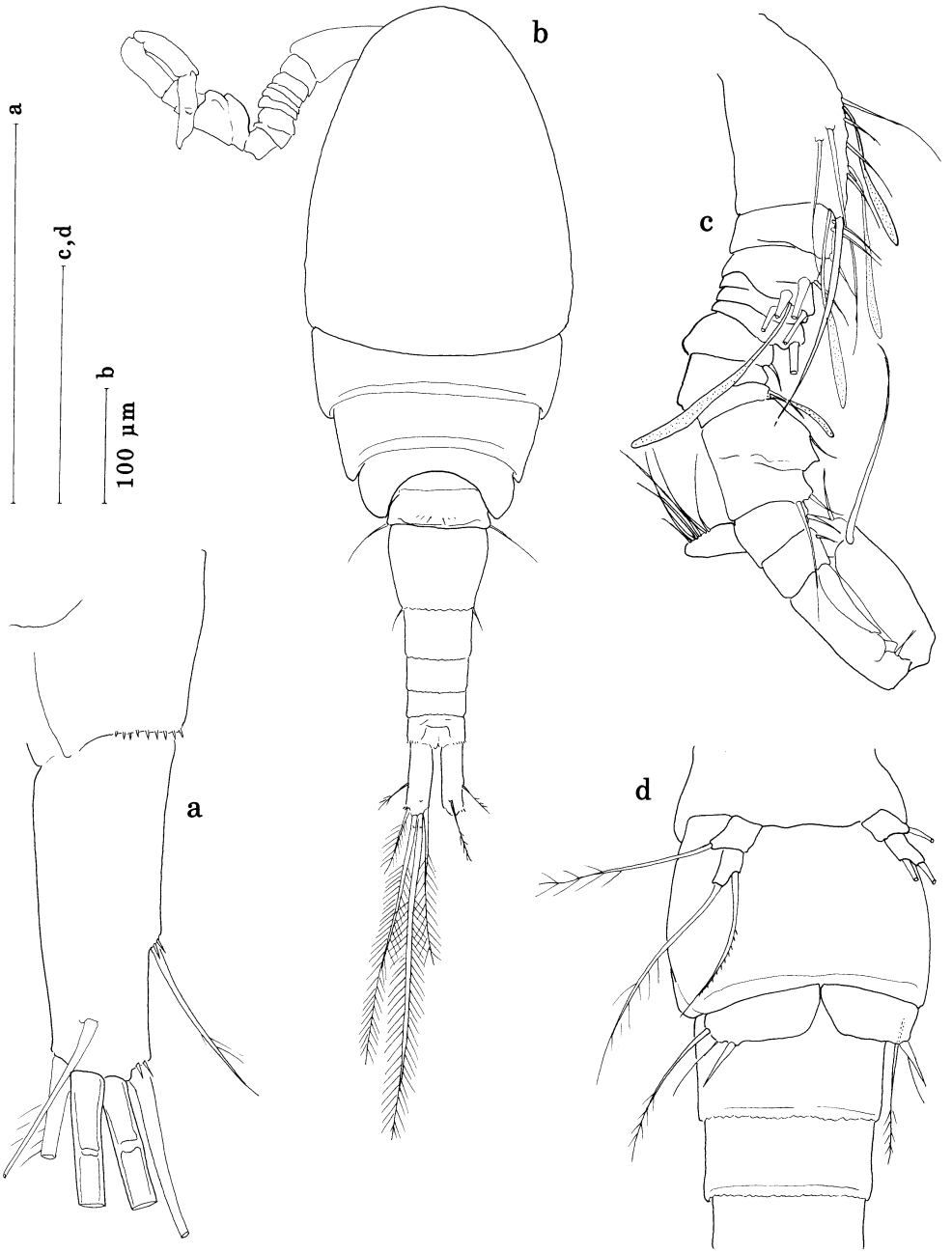

FIG. 7. *Mesocyclops americanus* Dussart, 1985. a, Female on slide from Kiefer Collection, Mikropräparat 1911; b–d, Male on slide from sample 1, Shark River Slough, USNM 251320. a, Caudal ramus, dorsal; b, Habitus, dorsal; c, Antennule; d, Anterior urosomites, ventral. Figure 7a drawn at 600×, Figs. 7b–d drawn at 400×; details of Fig. 7c confirmed at 1,000×.

except lacking ornament on surface near palp. Palp of maxillule likewise lacking surface ornament.

Leg 4 (Fig. 6e, f), spiniform processes of coupler strongly acuminate, directed medially; fine hairs of medial expansion of basipodite distributed along most of distal part of margin and extending onto posterior surface; setae of endopodite article 3 reaching about midlength of terminal spines; medial terminal spine slightly shorter than lateral terminal spine.

Caudal rami of both females without spines proximal to insertion of lateral and lateralmost terminal setae.

Description of male. Lengths of the two Florida specimens 0.68 and 0.65 mm. Habitus (Fig. 7b) slender, posterolateral margins of pedigers 2–4 rounded, pediger 5 rounded and closely appressed over anterior margin of pediger 6. Caudal ramus three times longer than broad. Ramus with small spines at base of lateral and lateralmost terminal seta. Lengths of caudal setae of mounted specimen in μm: dorsal 52, lateral 40, medialmost to lateralmost terminal 135, 280, 225, 60.

Antennule (Fig. 7b, c) with long esthetascs on articles 1, 3, and 9. Mouthparts and legs 1–5 similar to corresponding structures of female. Leg 6 (Fig. 7d) composed of subrectangular plate bearing small medial (ventral) spine and two setae, dorsalmost seta about two times length of median seta.

Discussion. The visible morphological details of the partly dried slides from the Kiefer Collection agree with the diagnosis of *M. americanus*. These features include the caudal ramus lacking hairs on the medial surface, the hyaline membrane of article 17 of the antennule with a single deep notch, the couplers of legs 1–3 without ornament and the leg 4 coupler with two triangular spiniform processes, the leg 1 basipodite lacking a seta on its medial expansion, the setae of leg 4 endopodite article 3 not extending past the ends of the terminal spines of this article, and each terminal spine of leg 4 endopodite 3 with conspicuous spinules along most of both margins. Most of these details also are visible on the slide of the female from Indiana Dunes National Lakeshore. All of these characters serve to distinguish *M. americanus* from the common North American congener *M. edax* (S. A. Forbes, 1891). *Mesocyclops longisetus* (Thiébaud, 1914), another widely distributed American congener reported from the southern U.S.A. (Dussart & Fernando, 1986; Marten, 1989; Reddell, 1965), shares with *M. americanus* the antennular membrane with a single, deeply incised notch and the leg 4 coupler with two triangular spiniform processes, but the former species is easily distinguished by the spiniform seta on the medial expansion of the leg 1 basipodite and the thickly haired medial surface of the caudal ramus. Dussart (1985, fig. 13) showed small spines at the base of the lateralmost terminal caudal seta and none at the base of the lateral seta in the specimens of *M. americanus* from Ontario. This character seems to vary in *M. americanus*, because the Kiefer specimens (Fig. 7a) have spines at both locations; in the Florida specimens, the females have no spines at the base of either seta and the males have spines at the bases of both. Dussart (1985) described both the triangular spiniform processes of the leg 4 coupler and the setae of leg 4 endopodite 3 as rather short. The Kiefer specimens are intermediate

between the Ontario and Florida populations in the size of these processes (Fig. 6g) and the lengths of these setae (Fig. 6f). The spine pattern on the posterior surface of the leg 4 coxo-basipodite, which was not described fully by Dussart, is similar in the Kiefer and the Florida specimens.

The present records greatly extend the known distribution of *M. americanus* to the south and west, confirming the prediction of Dussart (1985) that the species would be found to occur widely on the North American continent. The figure of the antenna article 1 of a *Mesocyclops* sp. from Québec, Canada, by Van De Velde (1984b, fig. 5B) shows a spine pattern almost identical to that of *M. americanus*. A very few specimens collected from South Carolina and belonging to the *M. leuckarti* species group were identified tentatively as *M. americanus* by B. H. Dussart (personal communication to J. Reid and G. Wyngaard, 1989). These were reported as *M. leuckarti* s. l. by Taylor & Mahoney (1990) upon my recommendation. The Kiefer specimen from New Jersey (Mikropräparate 1522 and 1523) was reported as *Mesocyclops leuckarti* by Kiefer (1931). Material from Indiana that was reported originally as *Mesocyclops dybowskii* (Landé, 1893) by Whitman et al. (1988) and that I examined for the present report included the single specimen of *M. americanus* and specimens of *Orthocyclops modestus* (Herrick, 1883).

Genus *Microcyclops* Claus, 1893
Microcyclops rubellus (Lilljeborg, 1901
(Figs. 8a–c, e–i, 9a, b, d, e)

Specimens examined. Female, dissected and mounted on slide, and eight females, eight males, and two copepodids, sample 1; and nine females and one male, site 23, USNM 251322; 14 females, four males, and one copepodid, site 23, SFRC; unmounted specimens ethanol-preserved.

Description of female. Range of lengths of specimens from sample 1, 0.412–0.472 mm (median 0.460 mm, n = 8); other measurements given in Table I. Body (Fig. 8a) widest at cephalothorax in dorsal view. Lateral margins of pedigers 2–4 rounded, smooth. Genital segment (Fig. 8b) slightly expanded anteriorly; seminal receptacle usually with horned anterior and rounded posterior expansions, but shape of receptacle varying considerably in different specimens. Hyaline membranes of posterior margins of urosomites coarsely serrate. Anal somite (Fig. 8c) with minute spines on posterodorsal border and many spines along all of posteroventral border, these spines increasing in size medially. Anal operculum slightly convex, distal border irregular. Caudal ramus averaging 2.6 times longer than broad; lateral seta inserted at posterior one-third. Ramus with one or two tiny spines anterior to insertion of lateral seta and row of five or six large spines along lateral half of posteroventral margin, ramus otherwise without surface ornament. Median terminal caudal setae with heteronomous plumage, short stiff setules proximally and fine slender setules distally; dorsal seta naked; remaining caudal seta finely and homonomously plumed.

Antennule shorter than cephalothorax, composed of 11 articles, article 5 with small spine, otherwise identical in proportions of articles and in armament to

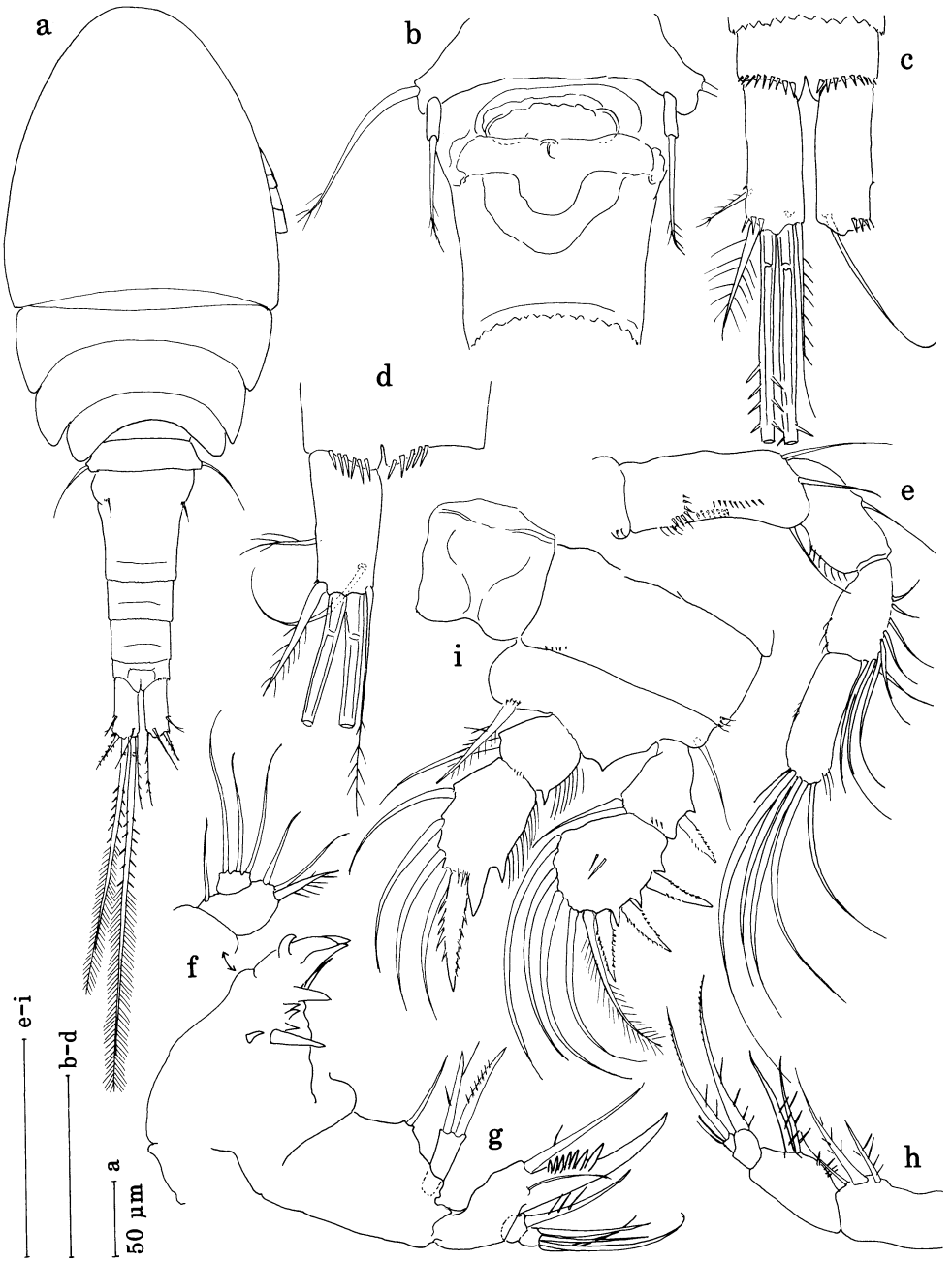

FIG. 8. *Microcyclops rubellus* (Lilljeborg, 1901). a–c, e–i, Dissected female from sample 1, USNM 251322. *Microcyclops varicans* (G. O. Sars, 1862). d, Dissected female from sample 1, USNM 251321. a, Habitus, dorsal; b, Pediger 5 and genital segment, ventral; c, d, Anal somite and caudal ramus, ventral; e, Antenna, caudal side; f, Maxillule and detail of palp; g, Maxilla; h, Maxilliped; i, Leg 1 and coupler, anterior. Figures 8a–c drawn at 400×; Figs. 8d–i drawn at 600×; details of Figs. 8e–i confirmed at 1,000×.

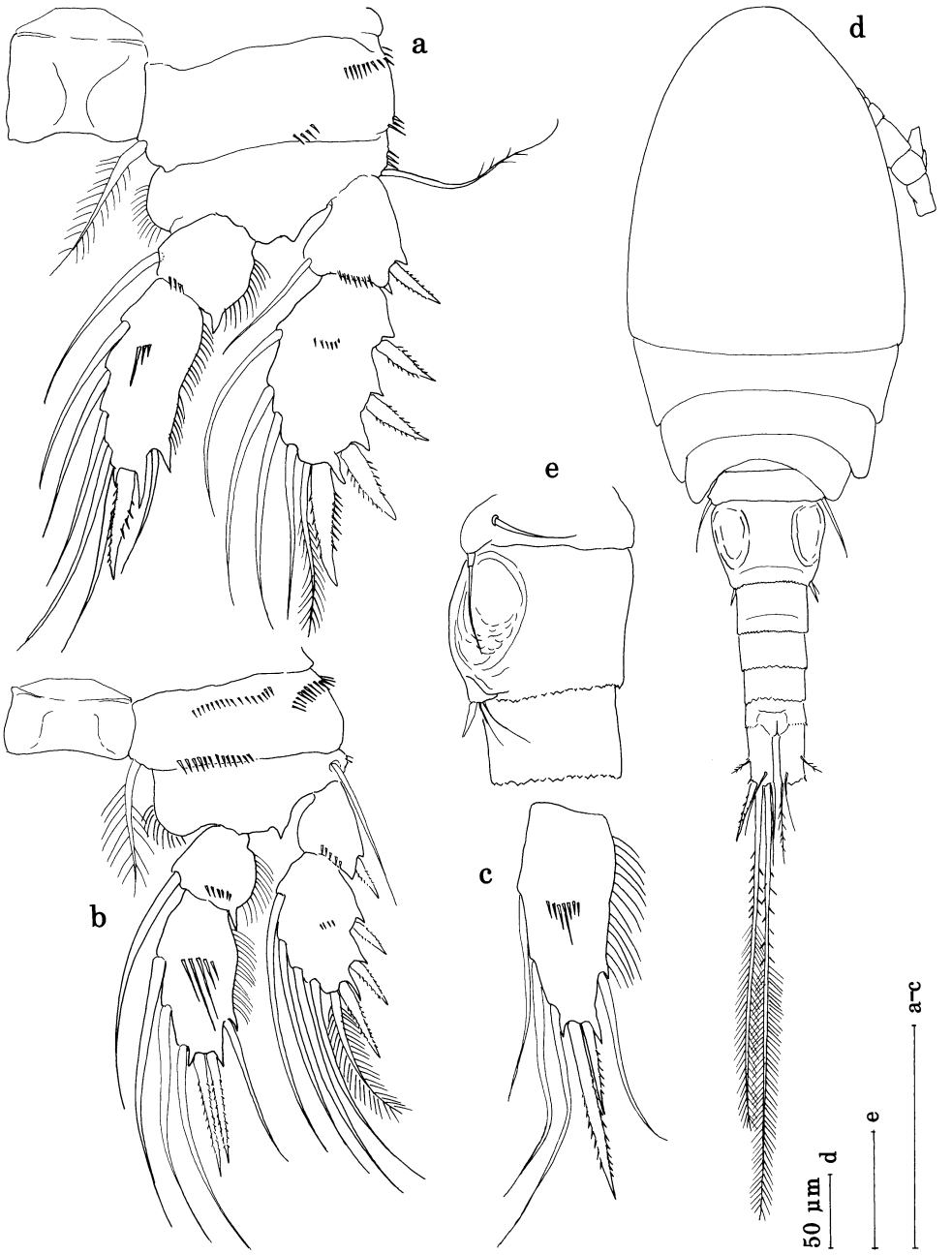

FIG. 9. *Microcyclops rubellus* (Lilljeborg, 1901). a, b, Dissected female from sample 1; d, e, Male from sample 1, both USNM 251322. *Microcyclops varicans* (G. O. Sars, 1862). c, Dissected female from sample 1, USNM 251321. a, Leg 2 and coupler, anterior; b, Leg 4 and coupler, posterior; c, Leg 4 endopodite 3; d, Habitus, dorsal; e, Anterior urosome, left lateral. Figures 9a–c drawn at 600×, Figs. 9d and e drawn at 400×.

TABLE I

Measurements of *Microcyclops rubellus* from sample 1[a]

Character	Sex	N	Range	Mean	SE	CV
Body length	♀	8	412–472	451	7.54	4.7
	♂	8	360–424	377	7.55	5.7
CR, length	♀	8	37–43	38.7	0.77	5.6
	♂	8	28–33	29.9	0.64	6.0
CR, breadth	♀	8	14–16	15.0	0.19	3.5
	♂	8	12–13	12.7	0.16	3.6
Seat 1	♀	8	35–56	43.9	2.27	14.6
	♂	8	38–49	41.9	1.45	9.8
Seta 2	♀	8	192–248	222	6.29	8.0
	♂	8	136–216	185	8.45	12.9
Seta 3	♀	8	144–172	159	3.02	5.3
	♂	8	124–160	138	4.91	10.0
Seta 4	♀	8	26–36	30.2	1.19	11.1
	♂	8	23–29	25.7	0.77	8.5
Dorsal seta	♀	8	30–45	35.2	1.81	14.5
	♂	8	20–33	25.1	1.44	16.3
Insertion, LS	♀	8	24–29	26.1	0.58	6.3
	♂	8	18–20	19.1	0.22	3.3
P4enp3, length	♀	8	30–55	37.5	2.68	20.2
	♂	8	26–33	27.9	0.87	8.9
P4enp3, breadth	♀	8	16–26	17.9	1.19	18.8
	♂	8	15–16	15.7	0.16	2.9
P4enp3, MTS	♀	8	23–41	28.6	2.07	20.5
	♂	8	22–25	24.1	0.44	5.1
P4enp3, LTS	♀	8	15–36	22.0	2.26	29.1
	♂	8	17–19	17.7	0.25	4.0

[a] Dimensions in μm; CR, caudal ramus; CV, coefficient of variation; insertion, LS, distance along caudal ramus from proximal margin to insertion of lateral seta; LTS, lateral terminal spine; MTS, medial terminal spine; P4enp3, leg 4 endopodite article 3; SE, standard error of mean; Seta 1–4, medialmost to lateralmost terminal caudal seta, respectively.

antennule of *Microcyclops varicans* as described by Gurney (1933, fig. 1753). Antenna (Fig. 8e) with three rows of spines on caudal and lateral surfaces of article 1; exopodite seta subequal in thickness and in length to other two setae of article 1. Mandible (not figured) similar in proportions and length of setae of palp to that of *Microcyclops minutus* (Claus, 1863) as figured by Gurney (1933, fig. 1792). Maxillule (Fig. 8f) with five large terminal and subterminal claw-like teeth; surface of palp without ornament. Maxilla (Fig. 8g) with row of large teeth on proximal half of claw. Maxilliped (Fig. 8h), surface with group of spines on article 2, otherwise without ornament except normal complement of setae.

Legs 1–4 (Figs. 8i, 9a, b) with biarticulate rami; leg 3 (not figured) similar to leg 2 in proportions and armament. Couplers of all legs without ornament. Spine on leg 1 basipodite medial expansion reaching midlength of endopodite article 2. Medial expansion of basipodite of leg 1 otherwise naked; medial expansions of basipodites of legs 2–4 each with fine hairs. Terminal spine of

leg 1 endopodite article 2 very stout. Leg 4 endopodite article 2 averaging 2.1 times longer than broad, bearing two terminal spines, lateral terminal spine about 0.88 length of medial terminal spine.

Free article of leg 5 (Fig. 8b) cylindrical, with long, slender terminal seta. Leg 6 (Fig. 8a) consisting of small ovoid plate bearing one small seta and two tiny spines.

Description of male. Lengths of specimens from sample 1, 0.360–0.424 mm (median 0.364 mm, n = 8). Habitus (Fig. 9d) similar to female, except caudal setae relatively somewhat longer. Antennule geniculate, similar to that of *M. varicans* as figured by Gurney (1933, fig. 1754), with three long esthetascs on article 1, one long esthetasc on each of articles 4 and 9, and one shorter esthetasc on article 13. Antennule, mouthparts, swimming legs and leg 5 much as in female. Leg 6 (Fig. 9e) with short medial spine and two median and lateral setae, median seta shortest.

Comparisons. The principal distinguishing characters of *M. rubellus* were summarized by Gurney (1933), Pennak & Ward (1985), and Yeatman (1944). The Everglades specimens assigned to this species agree in most respects with these characters. Differences are that the spines along the posteroventral margin of the anal somite usually are described as small in *M. rubellus*, but in the Florida population the medialmost spines are large; in *M. rubellus* the leg 4 endopodite 3 medial terminal spine usually is only one-half as long as the article, although this spine is relatively longer in the Florida specimens. Because the relative lengths of the leg 4 spines and other aspects of the morphology of *M. rubellus* have been shown to vary in European populations (Gurney, 1933), I do not consider these differences to be meaningful at the specific level. Probably *M. rubellus* is cosmopolitan. The species has been reported numerous times from North America and the neotropics.

Microcyclops varicans (G. O. Sars, 1862)
(Figs. 8d, 9c)

Specimens examined. Female and male, each dissected and mounted on slide, and 12 females and two males, sample 1; female and male, mounted whole together on slide, site 6; 41 females and five males, site 23, USNM 251321; 39 females, eight males, and four copepodids, site 6, SFRC; unmounted specimens ethanol-preserved.

Description of female. Range of lengths of specimens from sample 1, 0.560–0.618 mm (median 0.582 mm, n = 10); other measurements given in Table II. Similar to *M. rubellus* in habitus, shape of seminal receptacle, plumage of caudal setae, mouthparts, legs 1–3, and leg 5. Anal somite with 4–6 large spines along ventral margin, these spines not extending to lateral margin of somite. Caudal ramus usually without spines at base of lateral and lateralmost terminal setae, in few specimens with tiny spine at base of lateral seta; ramus otherwise without surface ornament. Leg 4 endopodite article 3 lateral terminal spine much shorter than medial terminal spine. Free article of leg 5 lacking spine on medial surface in all specimens examined. Antennule of all specimens with 12 articles, article 6 with small spine.

TABLE II

Measurements of *Microcyclops varicans* from sample 1[a]

Character	Sex	N	Range	Mean	SE	CV
Body length	♀	10	560–618	586	6.91	3.7
	♂	3	444–500	473	16.2	5.9
CR, length	♀	10	46–50	48.1	0.34	2.5
	♂	3	36–37	36.3	0.47	2.2
CR, breadth	♀	10	17–19	17.9	0.18	3.2
	♂	3	15–16	15.3	0.34	3.8
Seta 1	♀	10	60–81	68.8	2.22	10.2
	♂	3	63–66	64.7	0.88	2.4
Seta 2	♀	10	308–352	329	4.70	4.5
	♂	3	270–312	293	12.3	7.3
Seta 3	♀	10	220–256	240	3.61	4.6
	♂	3	195–216	205	6.08	5.1
Seta 4	♀	10	40–49	43.7	0.89	6.5
	♂	3	37–43	40.0	8.74	7.5
Dorsal seta	♀	10	35–55	43.5	1.71	12.4
	♂	3	28–30	28.7	0.37	4.0
Insertion, LS	♀	10	28–32	30.0	0.36	3.8
	♂	3	22–23	22.7	0.33	2.5
P4enp3, length	♀	10	52–59	54.0	0.79	4.6
	♂	3	40–44	42.0	1.15	4.8
P4enp3, breadth	♀	10	19–23	21.9	0.50	7.3
	♂	3	17–18	17.3	0.34	3.4
P4enp3, MTS	♀	10	41–51	46.0	0.95	6.6
	♂	3	33–35	34.3	0.67	3.4
P4enp3, LTS	♀	10	21–26	24.0	0.61	8.1
	♂	3	14–17	15.7	0.88	9.7

[a] Units and abbreviations as in Table I.

Description of male. Range of lengths of specimens from sample 1, 0.444–0.500 mm (median 0.476 mm, n = 3). Similar to male of *M. rubellus*, except leg 4 endopodite article 3 lateral terminal spine much shorter than medial terminal spine (Table II).

Comparison. Microcyclops varicans is distinguished primarily by the short lateral terminal spine of leg 4 endopodite 3, and by the few and stout spines along the posteroventral margin of the anal somite. The free article of leg 5 usually bears a small spine on the medial surface, but in some populations such a spine is lacking. The medialmost terminal caudal seta usually is shorter than the caudal ramus, but there is considerable interpopulational variation in this character (Gurney, 1933). Article 1 of the antenna is proportionately stouter, and the distal row of spines on the caudal surface of this article is set nearly at the distal margin in at least some European populations of *M. varicans* (Fiers & Van De Velde, 1984, fig. 9e). Like *M. rubellus*, *M. varicans* probably is a cosmopolitan species, and has been recorded widely in the Americas. *Microcyclops rubellus* is commonly considered to be a subspecies of *M. varicans* (e.g., Gurney, 1933; Yeatman, 1944), because of the great morphological similarity

and variation in these taxa. To my knowledge, appropriate hybridization experiments have not yet been conducted. The small but consistent morphological differences in the cooccurring Florida populations lead me to consider the two as distinct species.

Discussion

From these limited collections, the Everglades copepod fauna appears to be diverse, with some neotropical affinities and two species that are possibly endemic. The 13 species reported herein approach the total of 19 species and subspecies recorded to date from central and northern Florida, although collections from other parts of the state, having been made mainly from plankton, are not strictly comparable. The only investigation of shallow-water habitats somewhat like Shark River Slough was reported by Dickinson [1948(1949)], who collected six species of calanoids and cyclopoids from small ponds, roadside ditches, and ephemeral waters in northern Florida.

The Everglades collection has generated a number of new records. *Eucyclops bondi* is newly recorded for the United States. *Osphranticum labronectum, Mesocyclops americanus, Cletocamptus deitersi, Onychocamptus mohammed,* and *Phyllognathopus viguieri* are new records for the state of Florida, although each of these species is widely distributed elsewhere. The occurrence of the neotropical *E. bondi* and of *Thermocyclops parvus,* the latter of which is a member of a genus composed mainly of tropical species, indicates the neotropical affinities of the collection. *Eucyclops conrowae* and *T. parvus* have been collected so far only from the Everglades.

These new records and new taxa emphasize the differences between the Everglades fauna and the species assemblages reported from farther north on the Florida peninsula. The following summary of area records is not intended to be a complete review of collections in Florida; mainly papers establishing new records have been included.

The plankton of central Florida lakes is dominated by three species of calanoids of the family Diaptomidae, *Arctodiaptomus dorsalis* (Marsh, 1907), *Arctodiaptomus floridanus* (Marsh, 1926), and *Skistodiaptomus mississippiensis* (Marsh, 1894) [Bays & Crisman, 1983; Cowell et al., 1975; Dawes et al., 1987; Dickinson, 1948(1949); Elmore et al., 1984; Fry & Osborne, 1980]. *Mesocyclops edax* also is a consistent component of the fauna of these lakes (Cowell et al., 1975; Dawes et al., 1987; Elmore et al., 1984; Fry & Osborne, 1980), and there are reports of three additional species of planktonic cyclopoids, *Diacyclops thomasi* (S. A. Forbes, 1882) by Cowell et al. (1975), *Ergasilus chautauquaensis* Fellows, 1887 by Cowell et al. (1975) and Dawes et al. (1987) and *Tropocyclops prasinus* (Fischer, 1860) by Dawes et al. (1987), Elmore et al. (1984), and Fry & Osborne (1980). Littoral or benthic cyclopoid species reported from central and northern Florida include *Acanthocyclops vernalis* (Fischer, 1853), reported by Dawes et al. (1987) and Elmore et al. (1984); *Eucyclops agilis* by Cowell et al. (1975), Dickinson [1948 (1949)], and Fry & Osborne (1980); *Eucyclops agilis montanus* (Brady, 1878) by Dawes et al. (1987); *Eucyclops macrurus* and *Eucyclops speratus* by Fry & Osborne (1980);

Ectocyclops phaleratus (Koch, 1838), *Homocyclops ater* (Herrick, 1882), and *Macrocyclops albidus* by Dickinson [1948(1949)]; *Microcyclops rubellus* by Dawes et al. (1987) and Fry & Osborne (1980); *Paracyclops poppei* (Rehberg, 1880) by Dawes et al. (1987); and *Microcyclops varicans* by Avery & Undeen (1990). The only harpacticoid previously reported was an unidentified species of *Canthocamptus*, by Fry & Osborne (1980).

None of the most common planktonic diaptomid or cyclopoid species of central Florida lakes appeared in the shallow Shark River Slough, even though some were reported from shallow marshy waters elsewhere. Moreover, the list of Everglades species has only *Macrocyclops albidus*, *Microcyclops rubellus*, and *Microcyclops varicans* in common with the species recorded north of Lake Okeechobee. This apparent faunistic difference, although requiring substantiation by more extensive collecting, may be related to the distinct hydrological regime and water quality of the Everglades. The presence of several species with neotropical distributions or relationships is in agreement with the subtropical climatic regime and the Antillean affinities of the flora and vertebrate fauna of the extreme southern tip of the peninsula, briefly reviewed by Beaver et al. (1981). Although future collections from benthic habitats in this and other areas of Florida probably will add to the list of shared species, the discovery of additional Antillean elements in the Everglades aquatic invertebrate fauna would not be surprising.

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