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***Diacyclops virginianus*, a New Species of Cyclopoida (Crustacea:
Copepoda) from Goose Creek, Virginia**

Janet W. Reid

Abstract

Diacyclops virginianus, new species (Cyclopoida) is described from the streambed of Goose Creek, Virginia. The species has highly reduced leg segmentation for the genus: both rami of legs 1 and 2 and the endopodites of legs 3 and 4 are biarticulate, while the exopodites of legs 3 and 4 are usually biarticulate with the distal articles partly divided. The species differs from all known congeners in this partial division of some rami of the swimming legs. Leg 5 is also unusual for the genus *Diacyclops* in having the proximal article fused to the somite and the armament of the distal article consisting of two slender setae. *Diacyclops virginianus* most resembles two rare and poorly described European species.

Introduction

North American limnologists historically have placed greatest emphasis on understanding biological processes in the lakes and rivers of the continent. During the past decade, increasing interest in other aquatic habitats such as small surface wetlands, ephemeral waters, and subterranean waters including the hyporheic zone of streams has augmented the rate of discovery of previously unknown species of invertebrates. For instance, 39 of the 45 new taxa of copepods discovered in North America since 1980 have been collected from such non-lacustrine sites (Reid 1992c). Copepods are small crustaceans that have been very successful in colonizing aquatic and semi-aquatic habitats of all sorts. For several years, Dr. Margaret A. Palmer and associates from the University of Maryland-College Park have conducted intensive ecological investigations of the meiofauna, the smaller metazoans, inhabiting the sediments of the streambed of Goose Creek, Virginia. It is not surprising that a byproduct of these investigations has been the discovery of several new species of copepods (Reid 1992a,b). I describe herein the fifth new species found in the creek.

Goose Creek is a fourth-order, relatively undisturbed stream in the Potomac River drainage basin. The creek has been more fully described elsewhere (Palmer 1990a,b, Vadas 1992). The specimens were sorted from samples of streambed sediments that had been preserved in 5% buffered formalin, and transferred to 70% ethanol for permanent storage. Habitus drawings were made from specimens in lactic acid at magnifications of 600 X; dissected body parts were permanently mounted in commercial polyvinyl lactophenol (PVL) or CMC-10 media and drawn at 1000 X or 1500 X using an oil immersion lens. The specimens are deposited in the collections of the Division of Crustacea, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution (USNM).

Systematics of the Copepoda, especially at the genus level, traditionally has relied heavily on the structure of the fifth legs, which are usually strongly modified and tend to be among the most conservative morphological features. The structure and armament of the fifth leg of the new species from Goose Creek are unusual and render the generic assignment problematical. I have tentatively placed it in *Diacyclops* and discuss known variations in the structure of the fifth

leg within that genus, as well as other issues regarding the present diagnosis of *Diacyclops*, following the species description.

Taxonomic Section

Family Cyclopidae Burmeister, 1834

Genus *Diacyclops* Kiefer, 1927, 1928, emend. Morton, 1985, Reid et al., 1989

Diacyclops virginianus, new species

Figs. 1-3

Material.-- Holotype female, fully dissected on slide in PVL, Sample T4 Dam 31 coarse, May 1992, USNM 259513. Allotype male, Sample T4 Dam 32 midchannel, May 1992, USNM 259514. Paratypes: 1 female, fully dissected on slide in CMC-10, Sample T4 Dam 31 midchannel, May 1992, USNM 259515; 1 female, Sample T4 Dam 32 coarse, May 1992, USNM 259516; 1 female, 2 males and 1 copepodid, Sample T11 D31 II, June 1992, USNM 259517. All from Goose Creek, Loudoun County, Virginia, 38°57'N, 77°45'W; coll. M. A. Palmer. Undissected specimens in 70% ethanol.

Description of female.--Length, excluding caudal setae, of holotype 410 μ m; lengths and other dimensions of holotype and three paratypes given in Table 1. Preserved specimens colorless. Habitus (Figure 1a) cyclopoid, body little sclerotized, widest at cephalosome and pediger 2 in dorsal view. Lateral margins of prosomites rounded, smooth. Genital segment (Figure 1a-c) about 1.2 times broader than long, anterior half expanded, much produced ventrally, leg 5 (Figure 1 b-d) partly obscured in undissected specimens. Genital field (Figure 1c) bilobate, anterior and posterior lobes indistinct and more or less enlarged in different specimens; pore-canal short, broad, sclerotized, directed anteriorly; lateral canals more or less horizontal. Hyaline fringes of posterior margins of genital segment and two succeeding urosomites smooth. Anal somite (Figure 1a,e,f), posterior margin naked dorsally and spinose ventrally; anal operculum rounded, sclerotized, reaching or slightly exceeding lateral posterior margin of anal somite. Caudal ramus (Figure 1a,e,f) about 1.9 times longer than broad, medial surface hairless, lateral surface ornamented only with two or three small spines anterior to insertion of lateral seta and five or six slightly larger spines (best visible in lateral view) anterior to insertion of lateralmost terminal seta. Lateral seta inserted slightly posterior to midlength of caudal ramus. Terminal caudal setae with fine plumage, dorsal and lateral setae naked. Lengths of caudal setae of holotype given in Table 1.

Antennule (Figures 1a, 2a) of 11 articles, shorter than cephalosome; article 5 with spine, articles 8 and 10 each with sensillum (spine and sensilla indicated by arrows in Figure 2a); no hyaline membrane visible on distalmost articles. Antenna (Figure 2b) lacking exopodite seta and one of two setae normally present on anterodistal margin of article 1, this article with few small spines visible on proximal part of posterior margin; article 3 with six setae. Labrum (Figure 2c) with many small irregular teeth. Mandible (Figure 2d) with palp bearing one short and two long setae, length of long setae on undissected paratype about equal to length of mandible. Maxillule (Figure 2e) with four large terminal and subterminal teeth, three distal setae of palp short. Maxilla (Figure 2f) with two small teeth on beaklike extension of article 3; tip of maxilla of holotype broken in dissection and good mount not obtained from other dissected specimen,

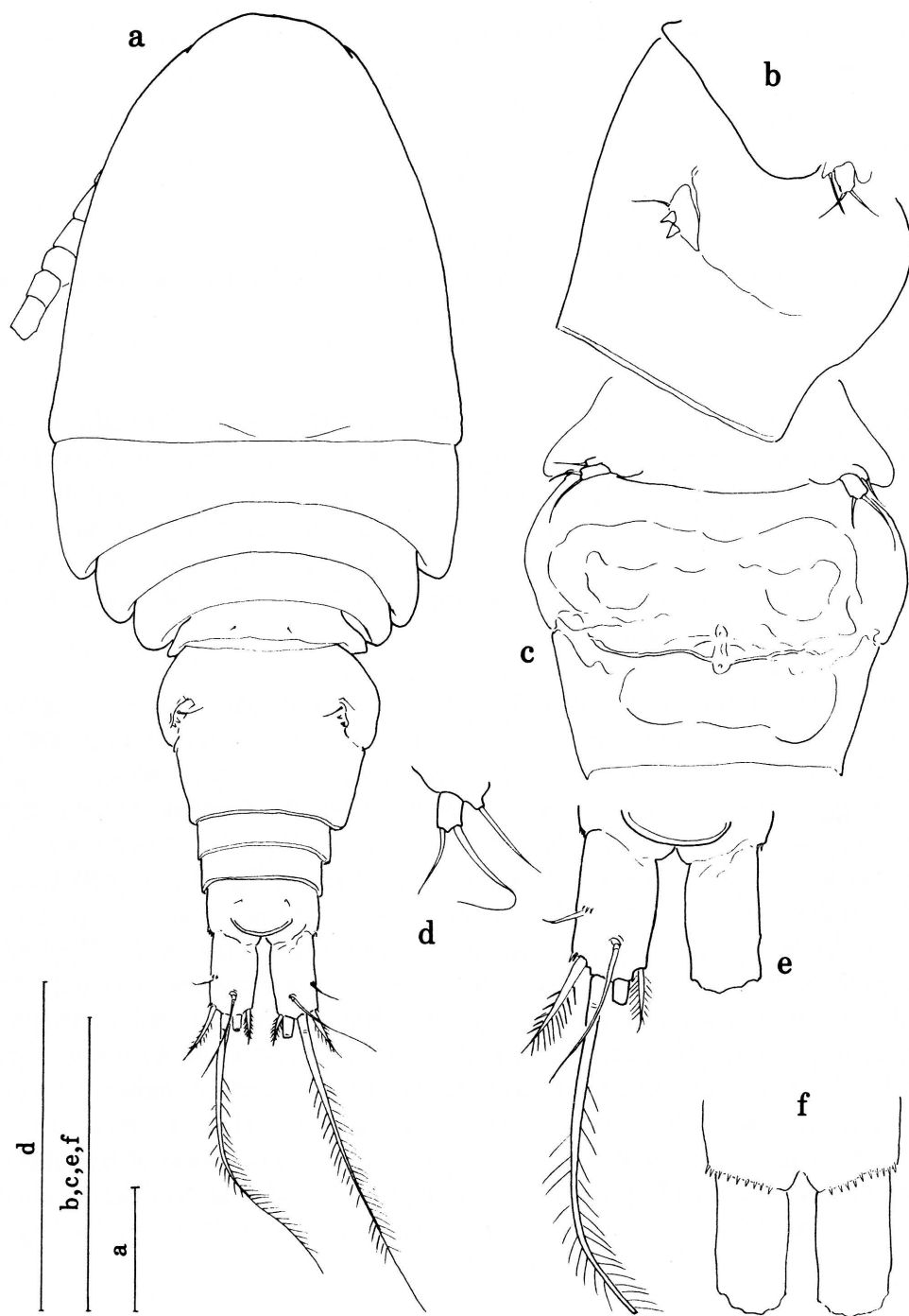


Figure 1. *Diacyclops virginianus*, new species, female; a, d-f, Holotype, USNM 259513; b, c, Paratype, USNM 259515: a, Habitus, dorsal; b, Pediger 5 (part) and genital segment, right lateral; c, Pediger 5 and genital segment, ventral; d, Right leg 5; e, Posterior part of anal somite and caudal ramus, dorsal; f, Posterior part of anal somite and caudal ramus, ventral. Figure 1a-c, e, f drawn at 600 X from whole specimen in lactic acid; Figure 1d drawn and details of Figure 1e, f verified at 1000 X from dissected specimen in PVL; all scales indicate 50 μ m.

however distal articles of maxilla, observed on undissected female paratype and male allotype, normal for family (cf. *Diacyclops sororum* Reid, 1992b). Maxilliped (Figure 2g) short, composed of normal four articles, article 2 with only one seta and with two rows of small surface spines. Swimming legs 1 and 2 (Figure 2h,i) each with biarticulate rami. Legs 3 and 4 (Figure 3a,b) each with biarticulate endopodite, exopodites also biarticulate but with distal articles each divided by partial suture on lateral margin. Partial division of these articles distinct on both anterior and posterior surfaces between proximalmost and next distal spines, extending to about midline of each article, and marked on leg 3 also by transverse row of spines on anterior surface. Couplers of all legs without ornament; coupler of leg 2 broken in dissection but similar to coupler of leg 3 in shape. Leg 1 basipodite little expanded medially; medial expansions of legs 2-4 basipodites lobate, haired. Leg 1 with short serrate spine on medial expansion of basipodite, slightly longer than endopodite article 1. Spine formula of distal articles of exopodites, considering semi-divided distal articles of legs 3 and 4 as one article, 3,4,4,4; seta formula 5,5,5,5. Spines of leg 4 exopodite smaller than spines of more anterior legs. More distal setae of posterior legs stout basally, with thin whiplike tips. Leg 4 endopodite article 2 about 1.5 times longer than broad, with two stout serrate terminal spines, medial spine longer than lateral spine.

Table 1. Measurements of *Diacyclops virginianus*, new species.

	Females				Males		
Total length	410*	380	312	307	260**	310	280
Caudal ramus							
Length	28	28	28	28	28	26	23
Breadth	15	15	15	14	14	13	13
Seta 1	10	9	13	10	8	9	8
Seta 2	b	b	148	b	182	162	170
Seta 3	95	105	98	115	94	83	97
Seta 4	19	17	18	18	15	17	17
Dorsal seta	37	34	35	35	28	31	30
Insertion ls	16	16	16	17	15	17	17
Leg 4							
Enp2, Length	23	25	27	25	23	22	23
Enp2, Breadth	15	16	15	15	15	15	15
MTS	17	16	19	17	14	15	17
LTS	12	12	13	13	12	12	12

Note: Dimensions are given in μm ; Seta 1-4, medialmost to lateralmost terminal caudal setae; Enp2, endopodite article 2; Insertion ls, distance along lateral margin of caudal ramus from anal somite to insertion of lateral seta; MTS, medial terminal spine; LTS, lateral terminal spine; b indicates both setae broken; * indicates holotype; ** indicates allotype.

Leg 5 (Figure 1b-d), article 1 fused to pediger 5; article 2 distinct. Article 1 with seta on lateral expansion. Article 2 with medial terminal seta and longer lateral terminal seta, both setae with fine hairlike tips. Lateral terminal seta about twice width of medial subterminal seta at base. Because of fineness of tips, length of all setae difficult to determine except by means of phase-interference microscopy, setae appearing much shorter by conventional microscopy, as in Figure 1b,c.

Description of male.--Length of allotype 260 μm ; measurements of allotype and male paratypes given in Table 1. Habitus (Figure 3c) except for normal sexual dimorphism, antenna, mouthparts, swimming legs and leg 5 like corresponding structures of female in two of three specimens. In allotype and one paratype, legs 3 and 4 exopodites as in females; in one paratype, distal articles of legs 3 and 4 exopodites fully divided, exopodites thus triarticulate. Caudal ramus 2 times longer than broad, ornamented with single spine anterior to insertion of lateral seta and several smaller spines at base of lateralmost terminal seta; caudal ramus and setae otherwise similar to those of female. Lengths of caudal setae given in Table 1.

Antennule (Figure 3d) reaching past posterior border of cephalosome, geniculate, of 17 articles, two distalmost articles indistinctly divided. Visible esthetascs short, narrow, two on article 1 and one on article 9 (indicated by arrows in figure).

Leg 6 (Figure 3e) consisting of large subrectangular flap bearing three setae, all setae shorter than succeeding urosomite.

Etymology.--Named for the state in which the specimens were collected.

Ecology.--The specimens were collected during two time periods (T4 and T11), each after the stream flow had returned nearly to normal (less than 5 m^3/s) following a flood pulse. All specimens were found in a single short reach of the creek near a debris dam, in coarse sands or in midchannel sediments of the creek bed.

Discussion.--Partial division of some articles of the swimming legs like that in most specimens of *Diacyclops virginianus* has not to my knowledge been found in other species of the genus. The lateral divisions are so distinct in *D. virginianus* that the number of articles might be miscounted; care should be taken to check the medial margin of the article, which is slightly indented but not divided. Traces of ancestral divisions certainly can be seen on the swimming legs of many species in the Cyclopidae. These traces however consist of homologies in setae and spines, or of a small spiniform structure on the lateral margin marking the original distal corner of an article. Such spines are present in *D. virginianus* on the distal articles of the endopodites of legs 2 and 3.

Few known species of *Diacyclops* have most or all rami of the swimming legs biarticulate. Two species have legs 1-4 with all rami biarticulate except for the triarticulate exopodites of legs 3 and 4. These are *Diacyclops imparilis* Monchenko, 1985, from the Republic of Georgia, and *Diacyclops yezoensis* (Ito, 1954; male described by Ishida 1992), from Japan and Alaska. The divisions between articles are complete in both species, and no variation in the leg structure has been reported. These species also differ from *D. virginianus* in having large triangular anal opercula and in other details. *Diacyclops minutissimus* sensu Petkovski 1954,

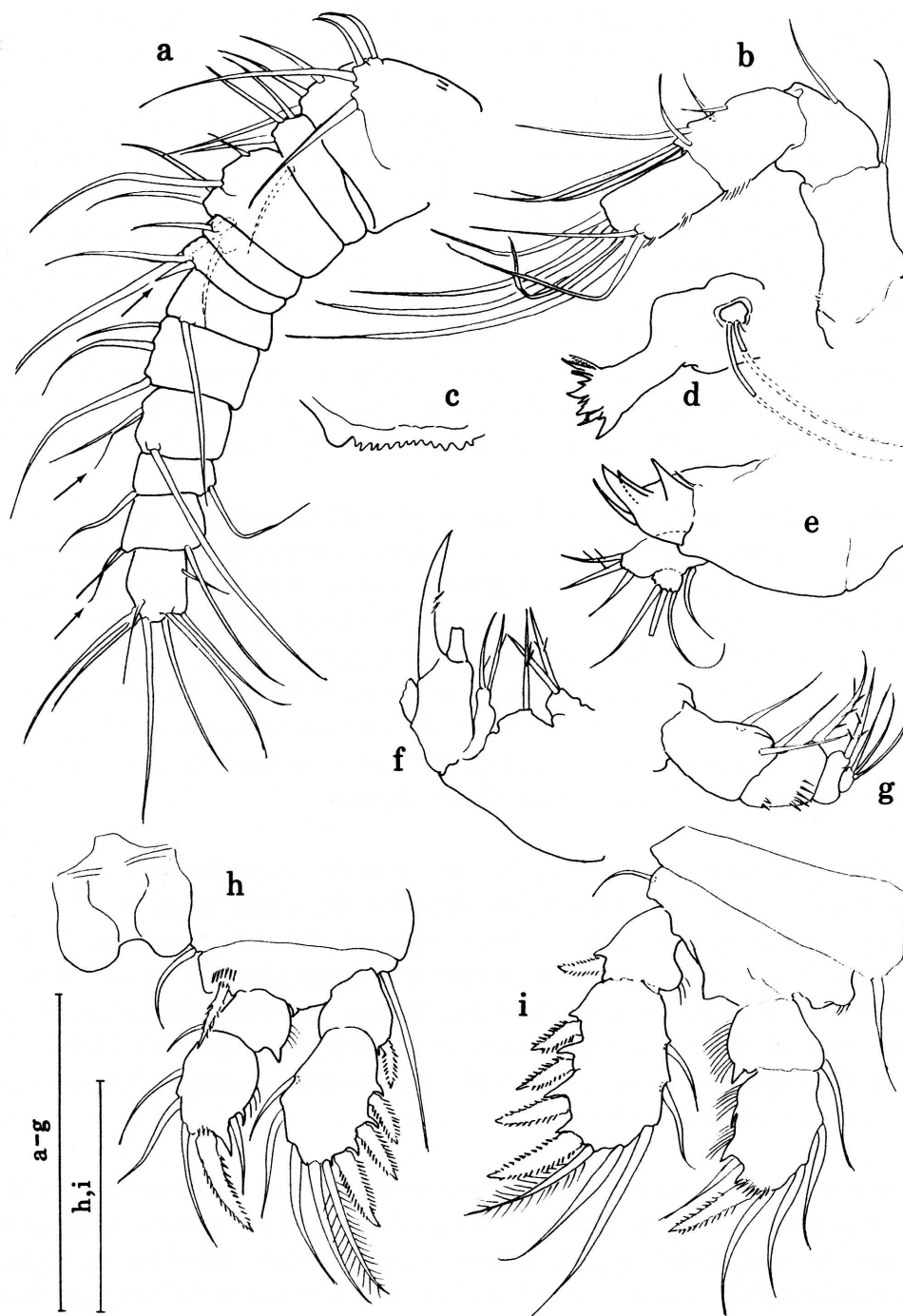


Figure 2. *Diacyclops virginianus*, new species, female; a, b, d-f, h, i, Holotype, USNM 259513; c, g, Paratype, USNM 259515: a, Antennule; b, Antenna; c, Labrum, left corner missing; d, Mandible (length of setae of palp estimated from paratype, USNM 259516; e, Maxillule; f, Maxilla (distalmost articles missing); g, Maxilliped; h, Leg 1 and coupler, anterior; i, Leg 2, anterior. Figure 2a, b, d-f, h, i drawn at 1500 X from dissected and mounted specimen in PVL; Figure 2c, g drawn at 1000 X from dissected and mounted specimen in CMC-10; both scales indicate 50 μm .

from Yugoslavia, although incompletely described, apparently has fully biarticulate rami of the swimming legs, as well as a large, bluntly triangular anal operculum. This species was transferred to the genus *Diacyclops* by Monchenko (1985) and has not yet been formally named.

One of the unusual features of the structure of the leg 5 of *D. virginianus* is the fusion of the proximal article to the body somite. Fusion of the proximal article and the somite is not unknown in *Diacyclops*, either as a permanent or a variable feature: the article and somite vary from distinct to fused in *Diacyclops nanus* (G. O. Sars, 1863, after the redescription of Gurney 1933), and are invariably fused in *Diacyclops abyssicola* (Lilljeborg, 1901, after the redescription of Kiefer 1926), *Diacyclops michaelsoni* (Mrázek, 1901, after the redescription of Lindberg 1949) [= *Diacyclops skottsbergi* (Lindberg, 1949)], *Diacyclops mirnyi* (Borutzky and Vinogradov, 1957), and *D. yezoensis*. In some species the division between the proximal and distal articles of the leg may be indistinct, although none of the few specimens of *D. virginianus* shows this feature. This condition is variable in *D. mirnyi* and invariable in *D. abyssicola*.

The more important feature is the nature of the two terminal appendages on the leg 5 distal article. Most species of *Diacyclops* have a medial subterminal spine rather than a seta, and indeed the presence of this spine is the fundamental feature of the generic diagnosis (Kiefer 1927, 1928, Morton 1985, Reid et al. 1989). However, *D. minutissimus* sensu Petkovski 1954 has a narrow, almost setiform medial subterminal appendage. *Diacyclops stygius* sensu stricto (Chappuis, 1924), another European species, has similarly narrow terminal appendages. In *D. stygius* the swimming legs are not much reduced, only the endopodites of legs 1 and 2 being biarticulate. When more information is available about these latter taxa it may become apparent that they form a monophyletic group with *D. virginianus*.

The slender terminal appendages and proximal fusion of the fifth leg of *D. virginianus* together constitute a situation intermediate between the usual structure of the fifth leg in *Diacyclops* and some genera with a more reduced structure, particularly the European *Graeteriella* and *Speocyclops*, composed of subterranean species. In *Graeteriella* the proximal article together with its seta is usually completely lacking, but the seta may rarely occur inserted lateral to the base of the remaining (distal) article (Lescher-Moutoué 1968). The terminal appendages of leg 5 in *Graeteriella* are setiform. In *Speocyclops* the leg 5 articles are fused, and the three appendages are also setiform in most cases.

The genus *Diacyclops* as now composed includes some 77 species and many additional subspecies. It is the most successful and diverse of the cyclopoid genera, with species living in all known types of continental epigean and hypogean habitats. Most of the hypogean species have been described from Europe where studies of subterranean habitats are well advanced. Because of this bias in available information, it is not surprising that some of the known species that are most similar to *D. virginianus* are European.

The variety of body forms and modifications of appendages contained within the genus has led to difficulties in adequate definition. The most recent reformulation of the genus concept by Monchenko (1985) consisted of a return to the structure of leg 5 as the fundamental unifying generic feature, while accepting a broad range of variation in other structures. The discovery of *D. virginianus* further confuses the issue of definition while demonstrating a close relationship between some of the more reduced interstitial members of the genus and other subterranean genera.

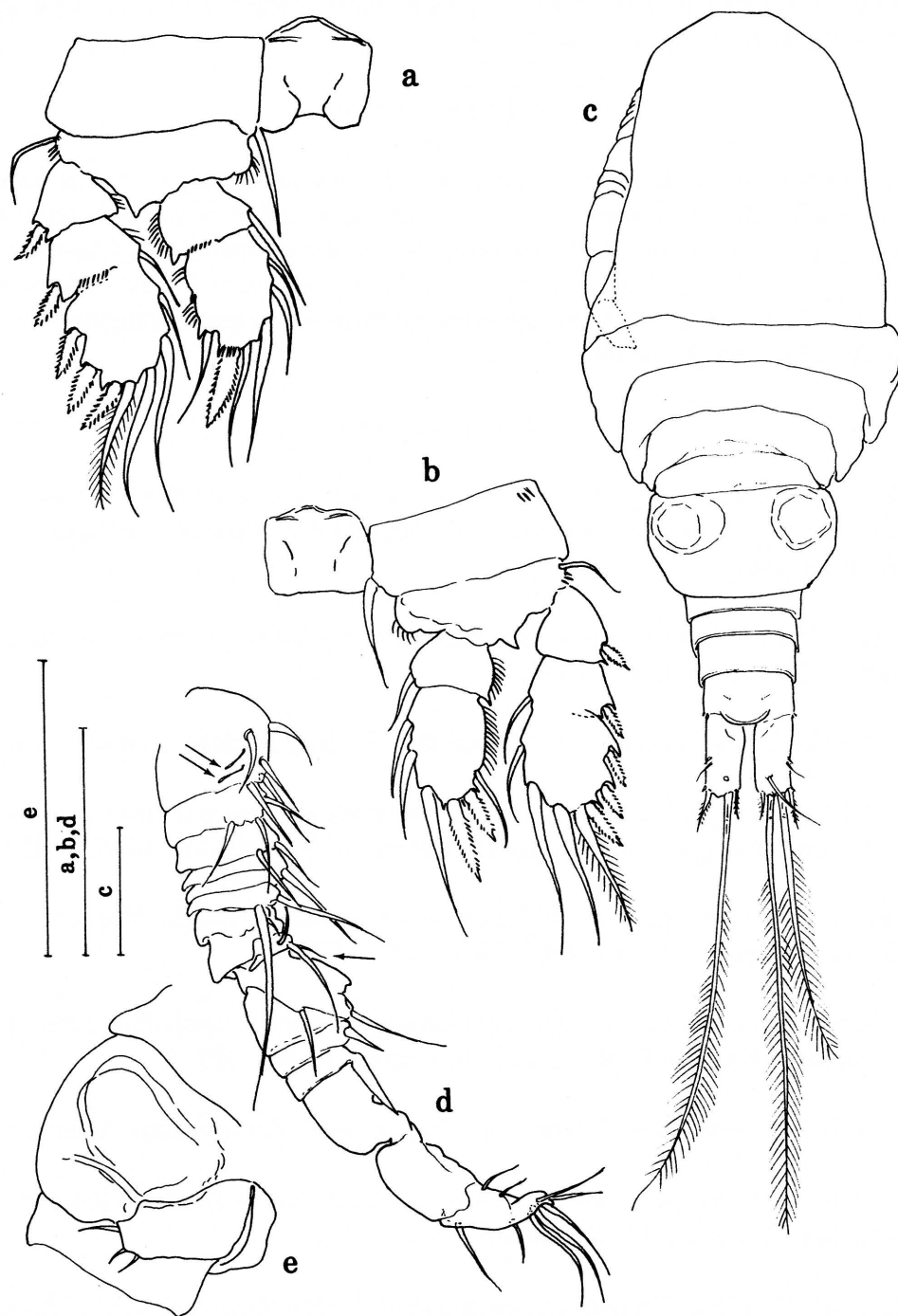


Figure 3. *Diacyclops virginianus*, new species: a, b, Female holotype, USNM 259513; c-e, Male allotype, USNM 259514: a, Leg 3 and coupler, anterior; b, Leg 4 and coupler, posterior; c, Habitus (anterior part of body slightly compressed); d, Antennule; e, Anterior urosome, right lateral. Figure 3a, b drawn at 1000 X from dissected and mounted specimen in PVL; Figure 3c, e drawn at 600 X in glycerine; Figure 3d drawn at 1000 X in glycerine; all scales indicate 50 μ m.

As additional species are discovered on continents outside Europe we can expect that understanding of systematic and biogeographical relationships within the Cyclopidae will be improved beyond its present fragmentary state.

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