Hydrobiologia 153: 97–107 (1987)



# Copepods of the Juréia Ecological Reserve, State of São Paulo, Brazil. II. The genera *Hesperocyclops*, *Muscocyclops*, and *Bryocyclops* (Cyclopoida, Cyclopidae)

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Received 30 July 1986; in revised form 13 October 1986; 25 October 1986

Keywords: taxonomy, freshwater crustaceans, Copepoda, Cyclopoida, neotropical fauna, Brazil

**Abstract**

Cyclopid copepods collected mainly in aquatic microcosms and semiterrestrial habitats in the Juréia Ecological Reserve are studied. *Hesperocyclops herbsti* and *Bryocyclops campaneri* are described as new species and their taxonomical relationships discussed. Females of *Muscocyclops operculatus* (Chappuis) are redescribed and the males described for the first time. An emended diagnosis for *Muscocyclops* is proposed.

The Juréia Ecological Reserve is part of the Baixada do Ribeira de Iguape, the Atlantic alluvial plain in the southeast of the State of São Paulo. Since the establishment of the reserve a number of studies have described the area (Por & Fonseca, 1984) and provided data on the hydrobiological conditions (Por *et al.*, 1984; Por, 1986). Studies on the estuarine zooplankton dynamics of the most important rivers have also been made (Toha, 1985; Lopes *et al.*, in press).

From 1982 to 1985 a large number of collections was made in as many different habitats as possible, mainly in the Rio Una do Prelado catchment basin. The material analysed here was chiefly collected in aquatic microcosms and semiterrestrial habitats, such as moist mosses, bromeliads, trenches and forest litter. Zooplankton and fauna living on roots of aquatic vegetation were extensively sampled and will be treated in subsequent papers.

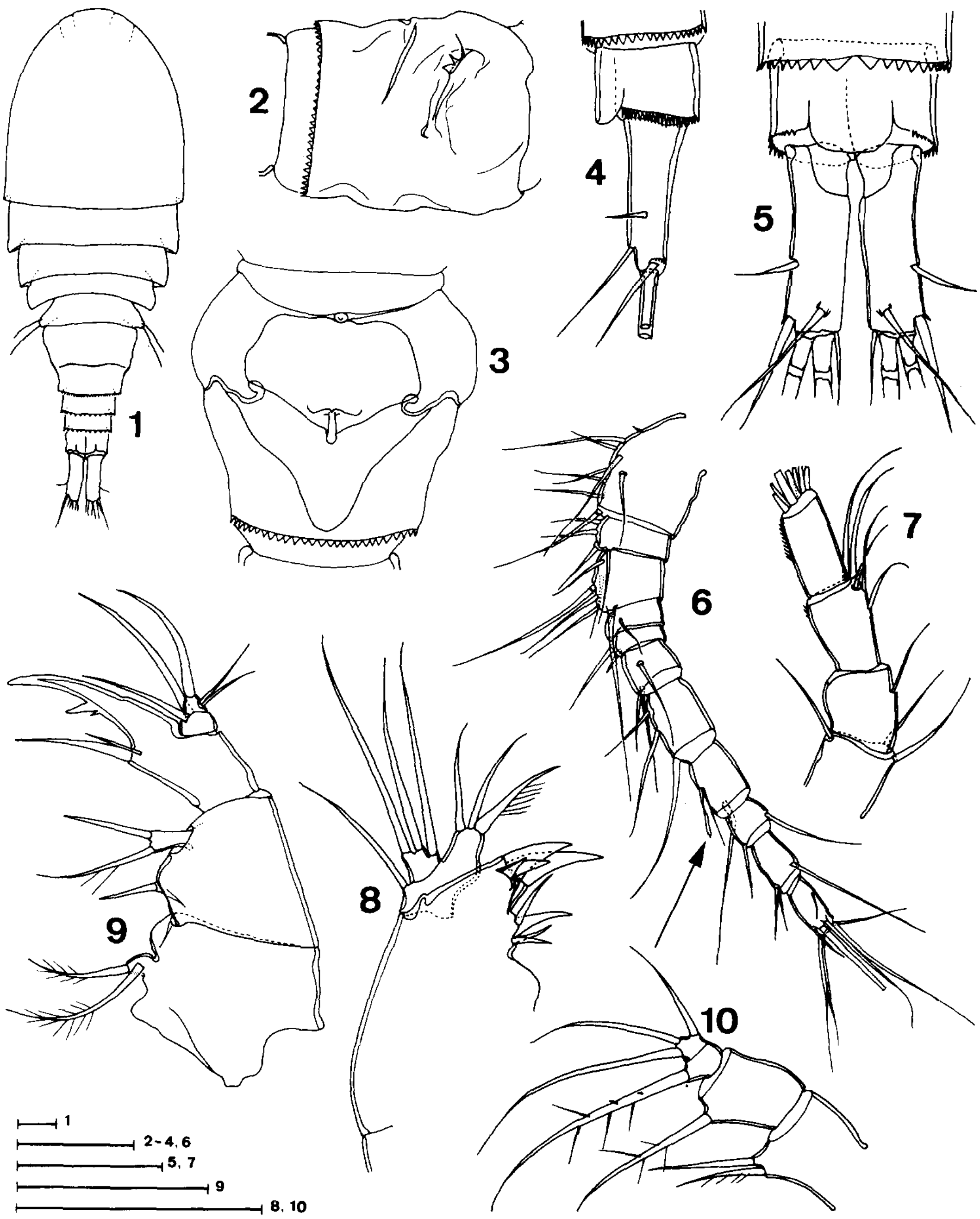
The following abbreviations are used in the descriptive text: MZUSP = Museu de Zoologia, Universidade de São Paulo; ae = aesthetask; A1 = antennule; A2 = antenna; Baspl–2 = 1st to 2nd segments of basipodite; Enp2 = 2nd segment of the endopodite; Exp2 = 2nd segment of the exopodite; Mx1 = maxillule; Mx2 = maxilla; Mxp = maxillipede; P1-P6 = 1st to 6th legs.

### *Hesperocyclops herbsti* sp. n. (Figs. 1–15)

*Material examined.* Brazil, State of São Paulo, Guaraú, near Peruíbe, 31 Aug 1984, C. E. F. da Rocha col., 13 adult females, 12 copepodids. Female holotype (no. 7332), 5 female paratypes (no. 7333) and all copepodids (no. 7334) in MZUSP.

*Female.* Length 650–840 μm; holotype 650 μm. Prosome: urosome = 1.4:1. Distal border of genital complex and of 2 following urosomal somites (Fig. 1) crenulate.

Genital complex (Fig. 1) 1.3 times wider than long, with well visible transversal suture line dividing somite dorsally into two almost equal parts,




*Figs. 1–10. Hesperocyclops herbsti* sp. n. Female: 1. habitus, dorsal; 2. genital complex, lateral; 3. genital complex with seminal receptacle, ventral; 4. anal somite and right caudal ramus, lateral; 5. anal somite and caudal rami, dorsal; 6. A1 (the arrow indicates the aesthetask); 7. A2; 8. Mxl; 9. Mx2; 10. Mxp. Figs. 1 and 5 from holotype; other figs. from 2 paratypes. Scale bars: 50 $\mu$m.

and not protruded into keel-like expansion proximally if observed in lateral view (Fig. 2). Seminal receptacle as illustrated by Fig. 3.

Anal somite (Figs. 4, 5) expanded dorsally into operculum reaching its posterior border. Free border of operculum smooth (Fig. 5).

Caudal rami (Fig. 5) thrice as long as wide (60:20 $\mu$m). Outer apical seta stronger and approximately twice as long as inner one (40:25 $\mu$m). Dorsal seta inserted on protuberance and shorter than ramus (50 $\mu$m). Lateral seta placed on posterior third of ramus.

A1 (Fig. 6) 11-segmented and ornamented as follows (Roman numerals = segments; Arabic numerals = number of setae): I = 8, II = 4, III = 6, IV = 1, V = 2, VI = 3, VII = 3, VIII = 2+lae, IX = 2, X = 3, XI = 8. A2 (Fig. 7) 4-segmented; 3rd segment with 5 setae. Mx1 as represented by Fig. 8. Mx2 (Fig. 9) 5-segmented; beak-like outgrowth of third segment with 2 spinules on inner margin, distal much stronger and larger than proximal one. Mxp as Fig. 10.

P1-P4 (Figs. 11–14) each with seta on inner corner of Basp1. Basp2 P1 with inner seta adjacent to Enp. Basp2 P2-P4 with inner corner expanded into pointed protuberance. Number of spines on Exp2 P1-P4 = 3.4.3.3. Single segment of Enp P4 (Fig. 14) 1.7 times as long as wide (60:35 $\mu$m), bearing weak apical spine and 5 setae. Outer marginal seta and inner distalmost marginal seta similar in length, both as long as Enp. Apical seta the longest, 2.8 times longer than spine and 1.17 times length of Enp. Measurements of Enp P4 setae and spine from inner to outer: 40, 35, 55, 70, 25 and 60 $\mu$m.

Terminal segment of P5 (Fig. 15) free, wider than long, and with short spine (10 $\mu$m) and seta 6 times longer than spine.

Ovigerous females bearing maximum of 16 eggs in each sac.

*Male.* Unknown.

*Etymology.* The species was named after the eminent copepodologist Dr. Hans-Volkmar Herbst, who established the genus *Hesperocyclops*.

*Habitat. Hesperocyclops herbsti* was found in the residential area of Guaraú living in a trench with still, shallow water, and much filamentous algae.

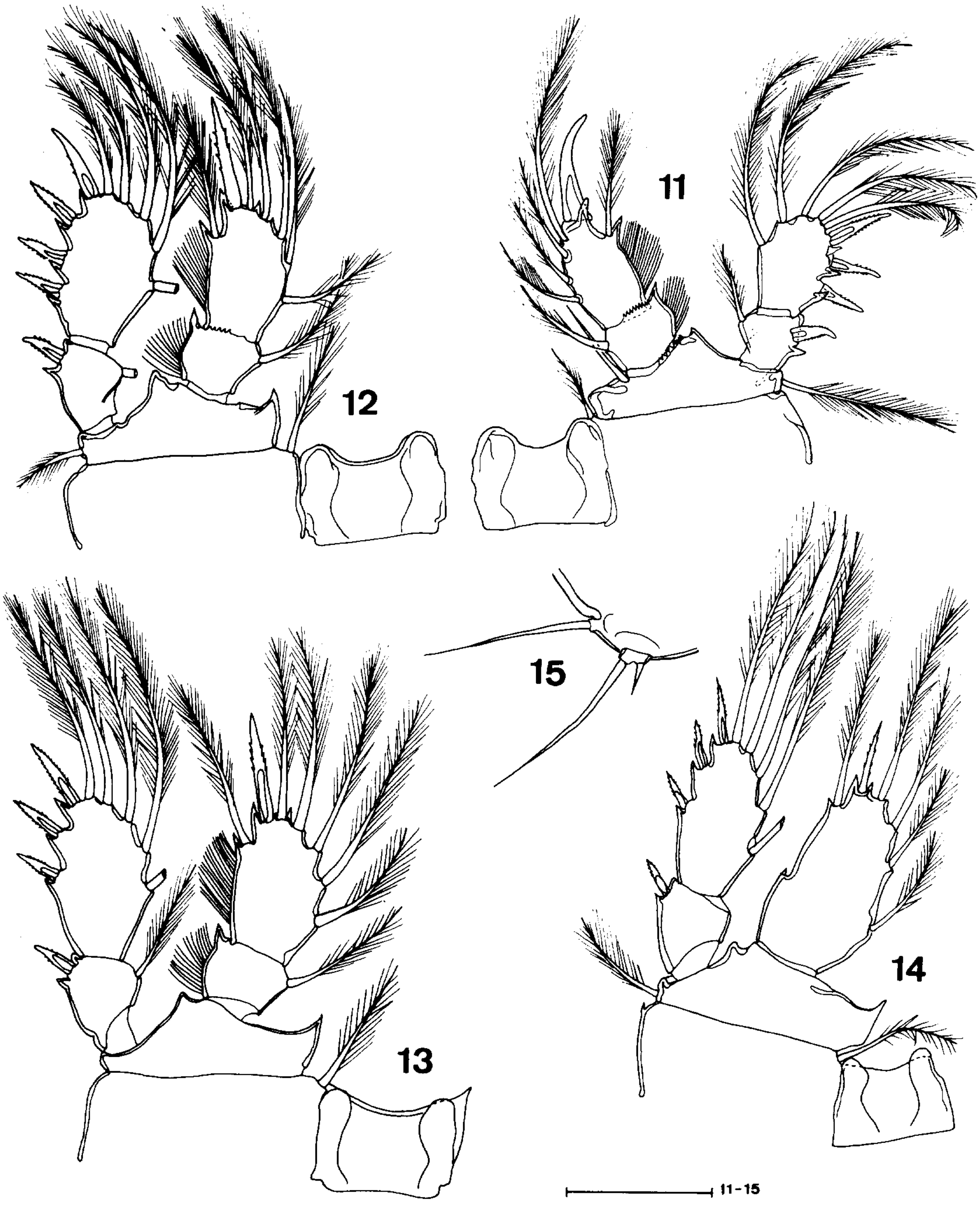
*Differential Diagnosis. H. herbsti* differs from the type-species *H. improvisus* Herbst, 1984 by having only 3 spines on Exp2 P3, 2 rather unequal spinules on the inner margin of the beak-like outgrowth of the third segment of the Mx2, more slender Enp P4 bearing longer inner setae, and the genital somite not protruded into a ventral keel-like expansion proximally when observed in lateral view.

Differences could also be observed in the setation of the A1 (segments 2, 3, 6 and 8), A2 and Mx2 of both species. Besides, the Mx2 of *H. improvisus* has four segments, instead of five as in *H. herbsti*. Since the structure of these appendages has rather been homogeneous in the majority of the genera of Cyclopidae, it is proposed that such differences would disappear after re-examination of those appendages of *H. improvisus*. Because of this, the differences observed have not been considered as diagnostic characters in separating the species.

*Discussion.* Herbst (1984) erected *Hesperocyclops* to accommodate some cyclopids from West Indies (Antigua and Guadalupe Islands) which did not fit into any known genus mainly because of the reduced, 1-segmented Enp P4 in females. The affinities with *Apocyclops* (viz. *A. dengizicus*) were pointed out.

Pesce (1985) identified very similar cyclopids from the same region as *Metacyclops* (*Apocyclops*) *stocki*, stating that his species occupied an intermediate position between the subgenera *Metacyclops* s. str. and *Apocyclops*. It seems to us that *Apocyclops*, although closely related to *Metacyclops*, has peculiar characteristics which make it possible to consider it as an independent genus, as has been proposed by Lindberg (1942) and later accepted by Kiefer (1967), Dussart (1982) and Monchenko (1974), among others. Since Pesce's species lies in neither *Metacyclops* nor *Apocyclops*, it should be transferred to *Hesperocyclops*, which appears to be a valid genus.

Pesce (1985) registered intraspecific variation in

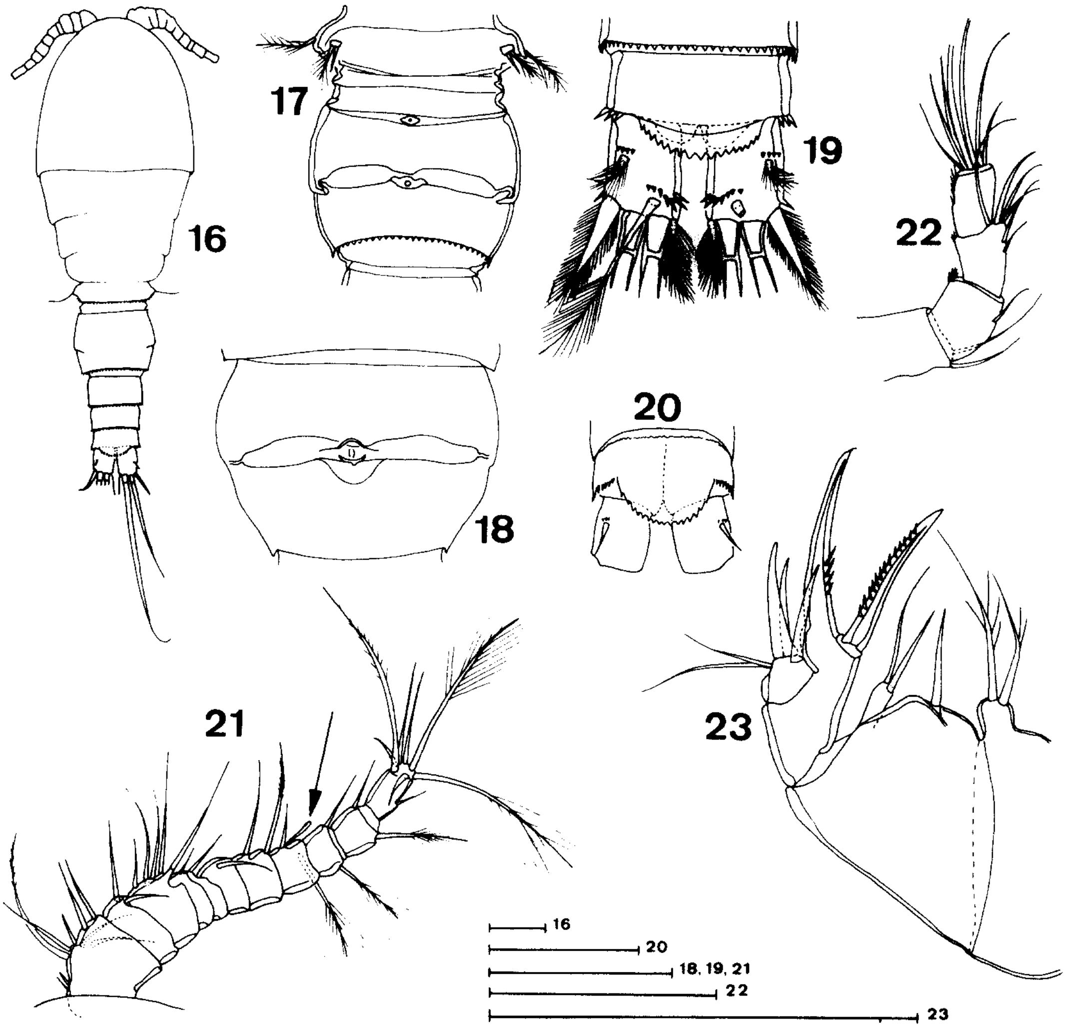



*Figs. 11–15. Hesperocyclops herbsti* sp. n. Female: 11. P1; 12. P2; 13. P3; 14. P4; 15. P5. All figures from paratype. Scale bar: 50 μm

the length of setae on Enp P4 in both female and male of *M.* (*A.*) *stocki*. One of these forms agrees with *Hesperocyclops improvisus* Herbst in this respect. Thus, it is probable that *M.* (*A.*) *stocki* is a junior synonym of *H. improvisus*. However, there is need for re-examination of both type-materials to form conclusions about the identity of both species.

*Muscocyclops operculatus* **(Chappuis, 1917)**
**(Figs. 16–28)**

*Material examined.* Brazil, State of São Paulo: 2 females from Rio Juqueriquerê, plankton sample, Porto Novo (23°41'15''S – 45°26'25''W), 19 Jan 1982, C. E. F. da Rocha col.; 1 female from Rio Verde, 100 m upstream from the lodgings of the Juréia Ecological Reserve (24°32'30''S–47°13'50''W), fallen leaves on sand-bank, 22 Sep 1983, C. E. F. da Rocha col.; 1 female from Rio Una do Prelado (24°25'10''S–47°05'30''W), 15 Mar 1983, F. A. L. Toha col.; 4 females, 2 males, 1 copepodid, 22 Aug 1983, and 1 female, 20 Jul 1983, from bromeliads in Serra da Juréia, V. F. Hadel col.; 1 female from mosses on stream bank near lodgings of Est. Ecol. da Juréia, 11 Dec 1984, C. E. F. da Rocha col.; 4 females, 1 male from forest litter, Serra de Juréia, May 1986,

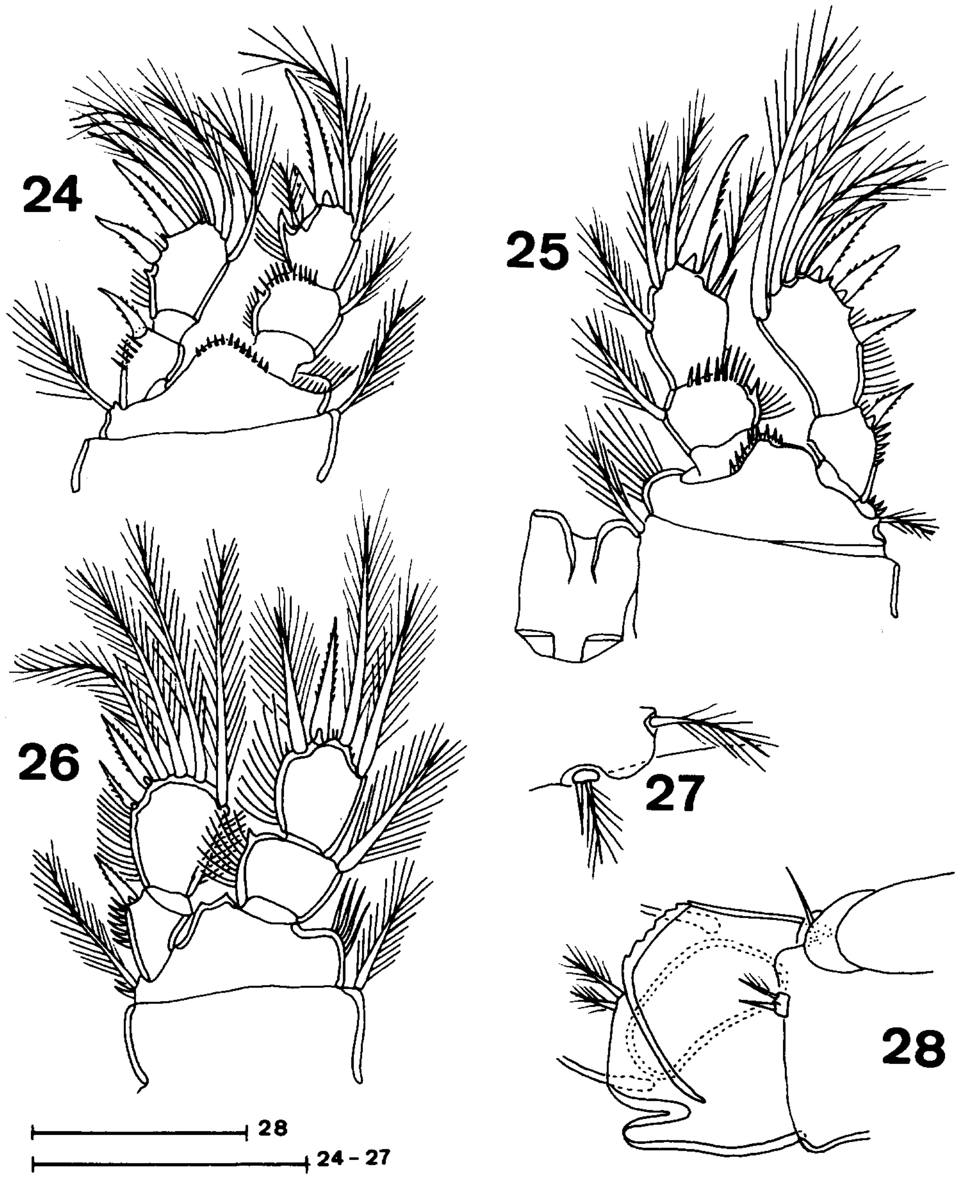



*Figs. 16–23. Muscocylops operculatus* (Chappuis, 1917). Female: 16. habitus, dorsal; 17. 1st urosomal somite and genital complex with seminal receptacle; 18. seminal receptacle of other specimen; 19. anal somite and caudal rami, dorsal; 20. anal somite and caudal rami of other specimen; 21. A1 (the arrow indicates the aesthetask); 22. A2; 23. Mx2. Scale bars: 50 $\mu$m.

R. M. Lopes col. Lot of 5 females (no. 7335–7338) and 1 male (no. 7339) in MZUSP.

*Female.* Body length ranging from 355 to 420 μm. Prosome: urosome = 1.3:1. Cephalothorax as long as wide (150 μm). Posterior border of first to fourth urosomal somites denticulate (Fig. 16). Genital complex 1.5 times wider than long (Fig. 17, 18) and with band-shaped seminal receptable. Anal somite (Fig. 19, 20) with row of spinules ventrally and produced dorsally into crescentic operculum with free border crenulate.

Caudal rami (Fig. 19) little longer than wide (22:18 μm). Lateral seta (17 μm) dorsolaterally placed, slightly shorter than breadth of ramus and reaching beyond posterior end of ramus. Outermost apical seta thrice thicker and 1.3 times longer than innermost apical seta. Median apical setae




*Figs. 24–28. Muscocylops operculatus* (Chappuis, 1917). Female: 24. Pl; 25. P2; 26. P4; 27. P5. Male: 28. 1st urosomal and genital somites with P5 and P6, respectively. Scale bars: 50 μm.

homogeneously plumose. Dorsal seta (45 μm) about 2.5 times length of innermost apical seta (17 μm).

A1 (Fig. 21) with 11 segments and ornamented as follows (Roman numerals = segments; Arabic numerals = number of setae): I = 7, II = 2, III = 5, IV = 1, V = 1, VI = 1, VII = 2, VIII = 2 + 1ae, IX = 2, X = 2, XI = 8. A2 (Fig. 22) with 4 segments; segment 1 without outer seta; segment 3 with 6 setae. Mx2 (Fig. 23) 4-segmented; 3rd segment with articulated spine serrate along outer margin and beak-like outgrowth with spinules on inner margin.

P1-P4 (Figs. 24–26) with bisegmented rami; P2 (Fig. 25) and P3 differing only in size. All legs with seta on inner corner of Basp1. Number of spines on Exp2 P1-P4 = 2.3.3.2. P1 (Fig. 24) without spine on inner corner of Basp2. Enp2 P1 with spine longer than segment, apical seta longer than spine, and outer seta reduced and inserted between two developed spiniform expansions of segment. P4 (Fig. 26) with 3 setae longer than single spine on Enp2.

Terminal segment of P5 (Fig. 27) reduced to minute bud wider than long and bearing 2 setae, the outer plumose and longer than inner.

*Male.* Length of both specimens 320 μm. Swimming legs as in female. Terminal segment of P5 with 2 setae not so different in length as in female. P6 (Fig. 28) represented by 2 plumose setae inserted ventrolaterally and directly on posterior edge of genital somite, being the outermost the longest.

*Discussion.* The specimens identified here as *M. operculatus* differ from the original description (Chappuis, 1917) and subsequent redescriptions (Kiefer, 1935; 1937) only in possessing longer setae on Enp2 of P1 and P4. Such differences may be considered an intraspecific variation or caused by the inadequacies in the previous descriptions. The structure of the swimming legs seems not to be useful in distinguishing species of *Muscocyclops* since Reid (in preparation) has separated two new species of this genus mainly based on the shape and ornamentation of the anal operculum and found the swimming legs to be very similar in both species.

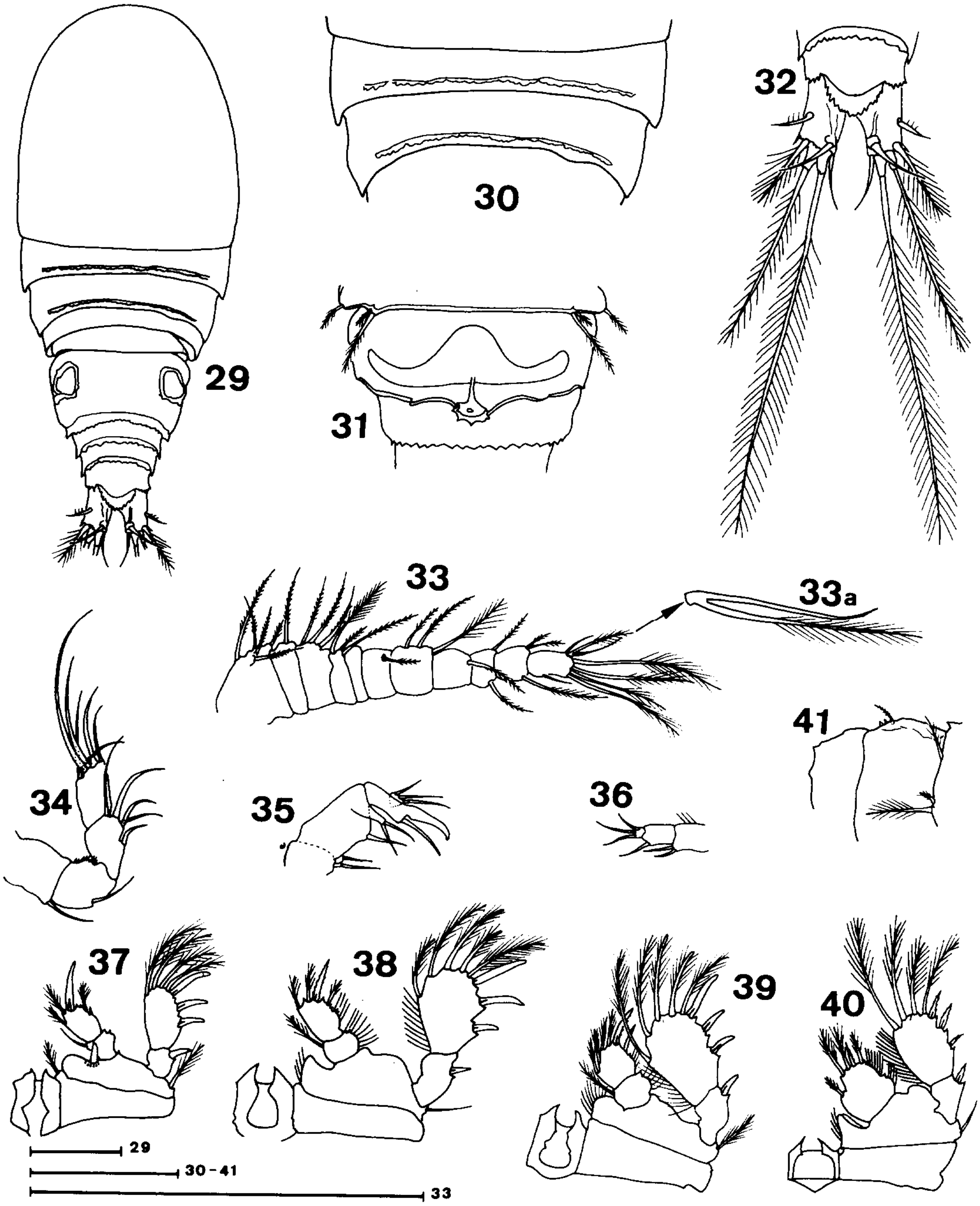
*Muscocyclops* was created by Kiefer (1937) to include *Cyclops operculatus* and *C. staheli* Chappuis, 1917. Lindberg (1954) improved the diagnosis of *Muscocyclops* at the same time transferring *M. staheli* to *Menzeliella*. *M. operculatus* has since remained as the only species of the genus.

The finding of the specimens in Juréia made it possible to confirm some morphological features used by Lindberg in his diagnosis, such as the absence of a spine on the inner corner of Basp2 P1, the setation of the Enp P4, the spine formula of the Exp2 P1-P4, and the structure of the P5. On the other hand, the more detailed examination of the present material allowed better knowledge of the seta formula of the Exp2 P1-P4, which Lindberg (1954) proposed with some doubt, as well as the slight variation in the shape of the seminal receptacle. An emended diagnosis for the genus is proposed below.

## *Muscocyclops* Kiefer, 1937

*Type-species. Cyclops operculatus* Chappuis, 1917.

Genital complex of female expanded laterally, wider than long. Seminal receptacle band-shaped, with or without a median posterior dilatation. Caudal rami short, with inner apical seta slightly shorter than outer apical seta. Anal operculum well developed. A1 of 11 segments. A2 without external seta on 1st segment and with 2 marginal setae and 4 terminal setae on 3rd segment. Mx2 4-segmented. Basp1 P1-P4 with inner seta. Basp2 P1 without inner spine. Rami of P1-P4 2-segmented. Spine formula for Exp2 P1-P4, 2.3.3.2 and seta formula 5.4.4.4. Exp1 P1-P4 with 1 outer spine and no inner seta. Enp2 P1-P4 with apical spine, and seta formula 3.4.4.3. P5: basal segment completely fused to first urosomal somite, its seta inserting directly on dorsolateral surface of somite and being separated from terminal segment by semicircular marginal expansion of somite; terminal segment reduced to small bud clearly articulated to urosomal somite and bearing 2 fine setae, the innermost shorter than outermost. P6 of male represented by 2 setae implanted directly on border of genital somite.




*Figs. 29–41. **Bryocyclops campaneri*** sp. n. Female: 29. habitus, dorsal; 30. 1st and 2nd metasomal somites, dorsal; 31. posterior part of 1st urosomal somite with P5 and genital complex with seminal receptacle, ventral; 32. anal somite and caudal rami, dorsal; 33. A1; 33a. detail of outer terminal setae on 11th antennular segment; 34. A2; 35. Mx2; 36. Mxp; 37. P1; 38. P2; 39. P3; 40. P4; 41. P5 and P6. Figs. 29 to 32 from holotype; others from paratype. Scale bars: 50 $\mu$m.

*Habitat and Distribution. M. operculatus* was first registered from moist mosses near Brownsberg (Surinam) by Chappuis (1917) and later found in bromeliads from a small forest area near Recife (Kiefer, 1935). This area was a remnant of the Atlantic rain forest which covered the Brazilian east coast 500 years ago, but now is almost completely destroyed. The species is now recorded from similar habitats in a southern remnant of this same forest.

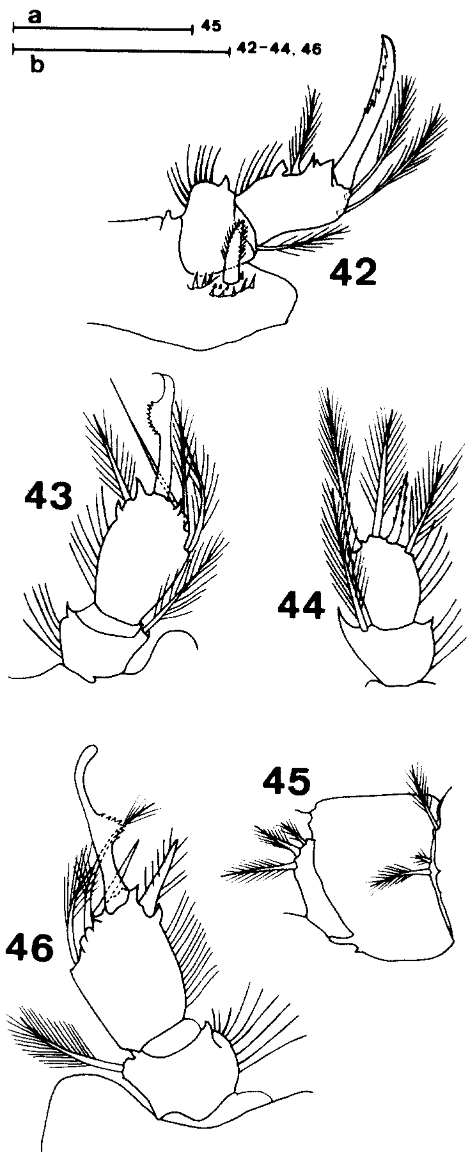
Since *M. operculatus* lives in phytotelm habitats in rain forests it must have had its range heavily influenced by expansions and retreats of the forest caused by climatic fluctuations in the past. The disrupted distribution of the species nowadays is evidence that when the Amazon forest extended into eastern Brazil during the period of optimum climate about 5,000–6,000 B P (Bigarella & Andrade-Lima, 1982), the species was spread at least from Surinam to southern Brazil, in the belt of forest along the coast.

Two new species of *Muscocyclops* which are to be described (Reid, in preparation) were found near Brasilia, suggesting that not all the representatives of this genus are restricted to tropical rain forest, but that some of them are adapted to survive in other kinds of cryptic habitats for copepods, such as the moist organic soil in the "wet campo" marsh in the "cerrado" (savanna) of Central Brazil (Reid, 1984). Probably *Muscocyclops* is widespread in tropical South America, living in habitats not frequently sampled. More intensive collecting is required in order to provide new data on the morphology and the range of these cyclopids.

**_Bryocyclops campaneri_ sp. n. (Figs. 29–46)**

*Material examined.* Brazil, State of São Paulo, 2 females and 1 male from Rio Una do Prelado (24°25′S – 47°04′W), 25 May 1983, F. A. Toha col. Female holotype (no. 7341), male paratype (no 7342) in MZUSP. Female paratype dissected.

*Female.* Length 297 μm (holotype), 295 μm (paratype). Cephalothorax (Fig. 29) oval anteriorly; longer (130 μm) than wide (120 μm). Prosome about 1.5 times longer than urosome. First and second metasomal somites (Figs. 29, 30) with linear crenulate ornamentation near posterior dorsal margin. Genital complex (Fig. 29) strongly developed, almost twice as wide as long with pair of sclerotized rounded dorsolateral structures. Seminal receptacle (Fig. 31) with area of copulatory pore heavily chitinized, straight pore canal anteriorly




*Figs. 42–46. **Bryocyclops campaneri*** sp. n. Male: 42. Enp P1; 43. Enp P3; 44. Enp P4; 45. P5 and P6. ***Bryocyclops caroli*** Bjornberg, 1985. Male 46. Enp P3. Figs. 42–45 from an undissected male. Scale bars: a = 50 μm; b = 25 μm.

directed, lateral arms slightly curved, and median anterior margin strongly expanded. Posterior border of genital complex and of 2 subsequent somites irregularly indented, the indentation stronger dorsally than ventrally. Posterior margin of anal somite (Fig. 32) fringed, with spinules as far as the anal operculum. Anal operculum semicircular, prominent, reaching midlength of caudal rami.

Caudal rami (Fig. 32) about 1.5 times as long as wide, slightly divergent, each with a dorsal longitudinal keel. Lateral seta inserted at distal third of ramus. Dorsal seta slightly longer than inner terminal seta, outer terminal seta about 1.5 times longer than both.

A1 (Fig. 33) 11-segmented, and ornamented as follows (Roman numerals = segments; Arabic numerals = number of setae): I = 5, II = 1, III = 3, IV = 3, V = 0, VI = 1, VII = 3, VIII = 1, IX = 2, X = 3, XI = 7, reaching the posterior margin of cephalothorax. A2, Mx2 and Mxp as in Figs. 34–36.

P1-P4 (Figs. 37–40) with both rami bisegmented, except for Enp P4 which is of 1 segment. Baspl P1 with seta on inner corner. Baspl P2-P4 without seta; Basp2 P1 with stout inner spine surrounded with a row of spinules. Exp2 P1-P4 with spine formula 3.3.3.3 and seta formula 4.5.5.4 Enp2 P1-P3 bearing 1 spine each and 3,3 and 5 setae respectively. Enp4 with both inner terminal setae equal in length and twice as long as terminal spine. Intercoxal plates of all swimming legs with pointed tubercles on each side. P5 (Fig. 41) reduced as usual in genus, its basal segment represented by 1 seta on posterolateral margin of first urosomal somite and its distal segment reduced to minute protuberance with inner seta considerably longer than outer seta. P6 (Fig. 41) consisting of 2 spinules of about equal length and 1 seta.

*Male.* Length 240 μm. P1 and P3 dimorphic as follows: Enp2 P1 (Fig. 42) with longer inner seta; Enp2 P3 (Fig. 43) with 3 inner setae, the distalmost smooth and positioned under strongly modified terminal spine, which bears denticulate subterminal external expansion. Enp P4 (Fig. 44) bisegmented; Enp2 with 3 setae and 1 spine terminally, all of them longer than in female. P6 (Fig. 45) with 3 setae.

*Etymology.* The species is named after Dr. A. F. Campaner, a professor in the Zoology Department, University of São Paulo.

*Habitat.* The true habitat of this species remains unknown. Its occurrence in the Rio Una is to be considered accidental because this copepod is undoubtedly morphologically adapted to a benthic existence, and the specimens caught there were likely washed out of their habitats by rainfall.

*Differential Diagnosis. Bryocyclops campaneri* sp. n. can be differentiated from all its congeners by a new seta formula (4.5.5.4) for Exp2 P1-P4, the crenulate linear ornamentation on the first and second metasomal somites in both sexes, and the shape of the seminal receptacle.

*Bryocyclops campaneri* closely resembles the other Brazilian species, *B. caroli* Bjornberg, 1985. Females can be separated by the seta formulae, the length of the second inner seta on Enp P4, and by the shape of the seminal receptacle. Males of both species can be distinguished by the length of the third inner seta under the modified spine on Enp2 P3, by the distance between the tip of the modified spine and its denticulate outgrowth, and the aspect of the outer seta. The Enp2 P3 of *B. caroli* was reexamined under oil immersion and is illustrated in Fig. 46.

*Discussion.* The genus *Bryocyclops* comprises a somewhat heterogeneous assemblage of species. The characters used by Kiefer (1927, 1928, 1929, 1937), Lindberg (1953, 1954) and Dussart (1982) for the diagnosis of the genus, except for the absence of the seta on the inner corner of Baspl P4, have been found to be variable in all species of the genus.

The problem was perceived by Lindberg (1953, 1954) who concluded that it was impossible to subdivide the genus into new genera or subgenera because the species were insufficiently described. Nevertheless he separated the genus into six species groups.

At the present time, four subgenera of *Bryocyclops* are recognized: *Bryocyclops* s. str., *Haplocyclops, Palaeocyclops* and *Rybocyclops.* However, there are also some doubts about the validity of these subgenera, again due to the deficiency of some descriptions. A revision of the genus based on reexamination of the type material is called for.

Among the characters traditionally used to differentiate *Bryocyclops* species, the structure of the male Enp2 P3 should be emphasized in any future studies, since distinctive patterns have been found in the species in which this leg has been accurately examined.

## Acknowledgements

The authors thank Dr. T. K. S. Björnberg and Dr. J. W. Reid for reviewing the manuscript. Thanks are also due to V. F. Hadel and R. L. Mendes for kindly providing part of the material examined. This paper is Scientific Contribution No. 13 from the Juréia Ecological Reserve in the State of São Paulo, Brazil.

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