SPIXIANA	24	1	19–27	München, 01. März 2001	ISSN 0341-8391

Description of *Allocyclops montenegrinus*, spec. nov. and a revision of the genus *Allocyclops* Kiefer, 1932

(Crustacea, Copepoda, Cyclopoida)

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Karanovic, T. (2001): Description of *Allocyclops montenegrinus*, spec. nov. and a revision of the genus *Allocyclops* Kiefer, 1932 (Crustacea, Copepoda, Cyclopoida). – Spixiana **24/1:** 19-27

A new species of the genus *Allocyclops* Kiefer, 1932 is described on the basis of a single female collected from subterranean waters in Montenegro (SE Europe). This genus is revised and divided into three subgenera: *Allocyclops* s. str., *Psammocyclops* Kiefer, 1955, and *Stolonicyclops* Reid & Spooner, 1998. Also, two species from the genus *Speocyclops (S. transsaharicus* and *S. orcinus)* are transferred to the genus *Allocyclops*. The species *Allocyclops ritae* Dumont & Lamoot, 1978 is found as a synonym of *Psammocyclops excellens* Kiefer, 1955. With the addition of the new species, and after this revision, the genus *Allocyclops* now includes twelve species throughout the world. At the end of this paper a key for their determination is given.

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Introduction

The genus *Allocyclops* was established by Kiefer (1932) to accommodate a new species, *A. chappuisi*, which he redescribed very soon after that description (Kiefer 1933), also from Ivory Coast. At the same time Kiefer (1933a) described one new species from Macedonia, *Cyclops (Diacyclops) minutissimus*, but in some further papers he doubted about its taxonomic position (Kiefer 1937, 1937a). Redescription of this species by Petkovski (1971), and its allocation to the genus *Allocyclops*, finally resolved its taxonomic status.

However, another taxonomic problem caused more confusion which maintained until today. It is related to the description of a new species from France, *Speocyclops orcinus*, which is based only on a single male (Kiefer 1937b). The isolated position of this species within the genus was noticed already by Petkovski (1954). Dussart (1967) even refused to place it in the genus *Speocyclops*. However, a lot of copepodologists left this species in the genus *Speocyclops*, without particular comments (Rylov 1948, Lescher-Moutoue 1967, 1973, 1986, Kiefer 1978, Dussart & Defaye 1985). Although the description was very poor in detail, there is no doubt that this species belongs to the genus *Allocyclops*. The appearance of the endopodite of the fourth swimming leg, as well as the fifth leg (although it was hardly visible at that time and especially difficult for the verbal description) confirm this claim. Similar situation is with *Metacyclops arenicolus*, which was described from Lake Nyasa (Fryer, 1956) and until now considered as a member of the genus *Bryocyclops* (see Dussart & Defaye, 1985). Chappuis (1951) described *Allocyclops cavicola* from a cave in Zaire, and Petkovski (1971) described *Allocyclops kieferi* from interstitial waters in Macedonia. Later Dumont & Lamoot (1978) described *Allocyclops ritae* from Ivory Coast, but strange enough as the second species in the genus (even though four species were known by that time).

Even more strange was that the same authors three years later (Lamoot et al. 1981) described a very similar species from Ivory Coast in the genus *Speocyclops (S. transsaharicus)*. This species also belongs to the genus *Allocyclops*, although in the meantime it was uncritically accepted by few authors as the first representative of the genus *Speocyclops* in tropical Africa (Dussart & Defaye 1985, Lescher-Moutoue 1986). Plesa (1981) described *Allocyclops botosaneanui* from a cave in Cuba. Dussart (1984) described *Allocyclops neotropicalis* from Venezuela only after the male which Reid (1988) correctly transferred to a new genus, *Yansacyclops*. Rocha & Bjorberg (1988) described *Allocyclops silvaticus* from Brazil and remarked: "*Allocyclops* badly needs revision". Reid & Spooner (1998) described *Stolonicyclops heggiensis* as a new genus and new species from the USA, but there are not enough differential characteristics between this genus and the genus *Allocyclops*. They did not compare it with *Allocyclops ritae*, which also has endopodite of the fourth swimming leg slightly fused. Partial oligomerization of that appendage was known as a specific variability (Monchenko 1974) in some species in the genus *Metacyclops*. We think that *Stolonicyclops heggiens* also belongs to the genus *Allocyclops*.

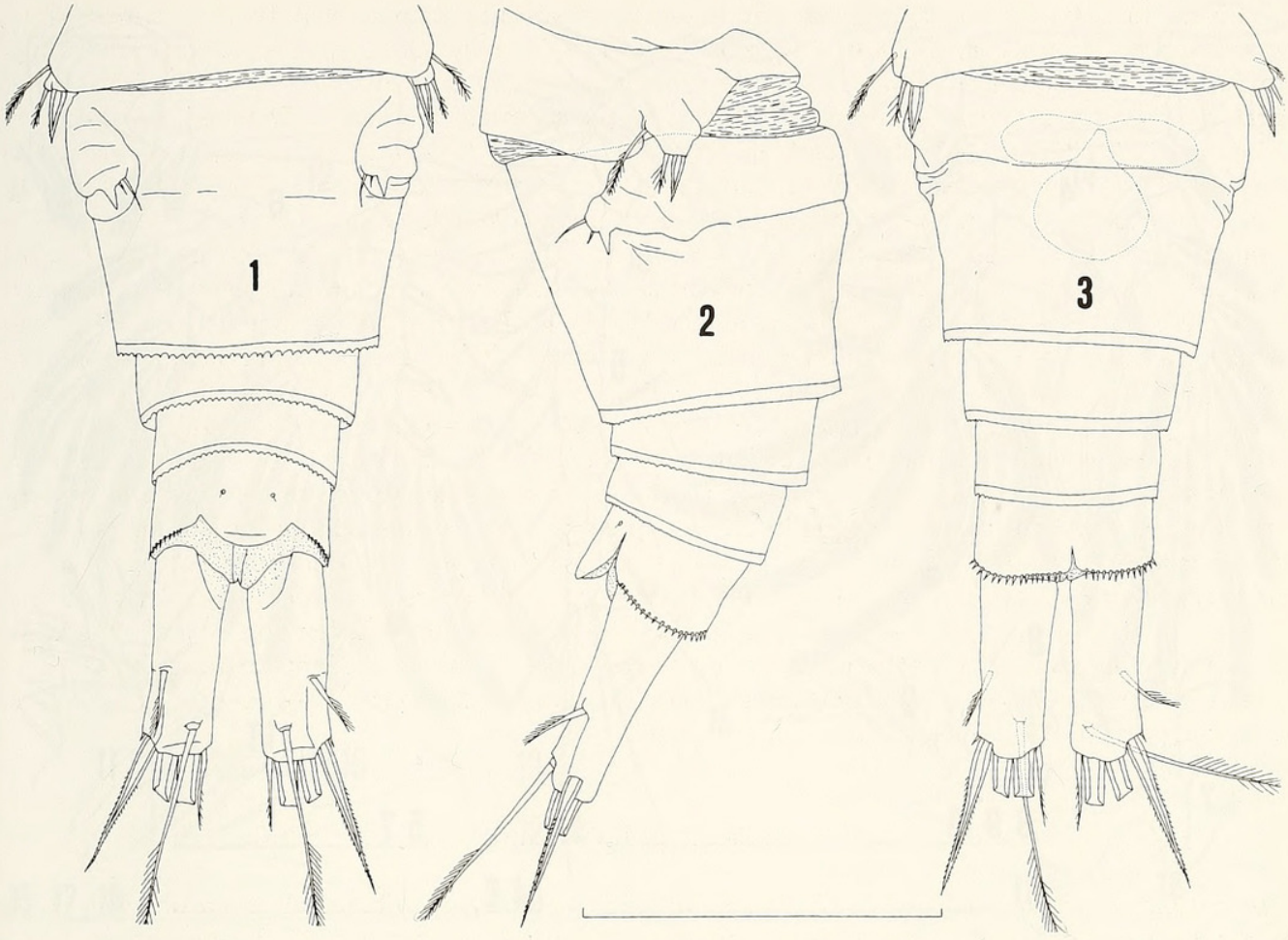
At the end we must mention one more curiosity. Kiefer (1955, 1956) twice described *Psammocyclops excellens*, as a new genus and new species from Madagascar. His description of the fifth leg was very provisional, although later it was uncritically accepted by many authors. From the drawings of that appendage of the male it is clear that the fifth leg is not a distinct segment, but completely fused to the somite. Even more, we think that this species is synonymous (of course the older one) with *Allocyclops ritae* Dumont & Lamoot, 1978 which is mentioned before. So, until now eleven species were known in the genus *Allocyclops*. During an investigation of the copepod fauna in Montenegro, a further new species of that genus was identified. This new species is herein described as *A. montenegrinus*, spec. nov. Also a revision of the genus *Allocyclops* is proposed.

Material and Methods

The sample was collected using the Karaman-Chappuis method from interstitial waters of a very small and nameless stream in the village Vrela, near the town Cetinje, Montenegro, SE Europe (type locality), on May 9, 1998. The material was preserved by adding several drops of 36 % formaldehyde. Copepods were separated with a Wild-M5 stereomicroscope and moved to 70 % ethyl alcohol. Specimens were dissected in a mixture of equal parts of distilled water and glycerol, with fine entomological needles (mark 000). Dissected appendages were placed on a slide, in the same mixture of distilled water and glycerol, and covered with a coverslip. For larger parts (abdomen, etc.) two human hairs were mounted between slide and coverslip, so the parts could not be crushed. During the examination water slowly evaporates, and after some time appendages remain in the pure glycerol. All drawings have been prepared using a drawing attachment (tube) on a Leica-DMLS microscope, with C-PLAN achromatic objectives. Dissected appendages were preserved in Faure's medium. Non-dissected specimens, after examination, were again preserved in 70 % ethyl alcohol. In that sample following species were found:

1. *Diacyclops bicuspidatus* (Claus, 1857) – 2♂♂, 6♀♀
2. *Diacyclops bisetosus* (Rehberg, 1880) – 5♂♂, 5♀♀ (3 ovigerous)
3. *Allocyclops montenegrinus*, spec. nov. – 1♀ (holotype)
4. *Bryocamptus* (s. str.) *minutus* (Claus, 1863) – 6♂♂, 13♀♀ (6 ovigerous), 2 copepodids
5. *Bryocamptus (Rheocamptus) pygmaeus* (Sars, 1863) – 5♂♂, 17♀♀ (2 ovigerous)

All specimens are deposited in the author's collection in Italy. The holotype of the new species (*Allocyclops montenegrinus*) was completely dissected and mounted on a slide in Faure's medium (Number: 9/43/0606/e). In the description, diagnosis, keys and figure legends no abbreviations were used.



Figs 1-3. *Allocyclops montenegrinus* spec. nov., holotype (female 0.563 mm). **1.** Urosome, dorsal view. **2.** Urosome, lateral view. **3.** Urosome, ventral view. Scale = 0.1 mm.

Results

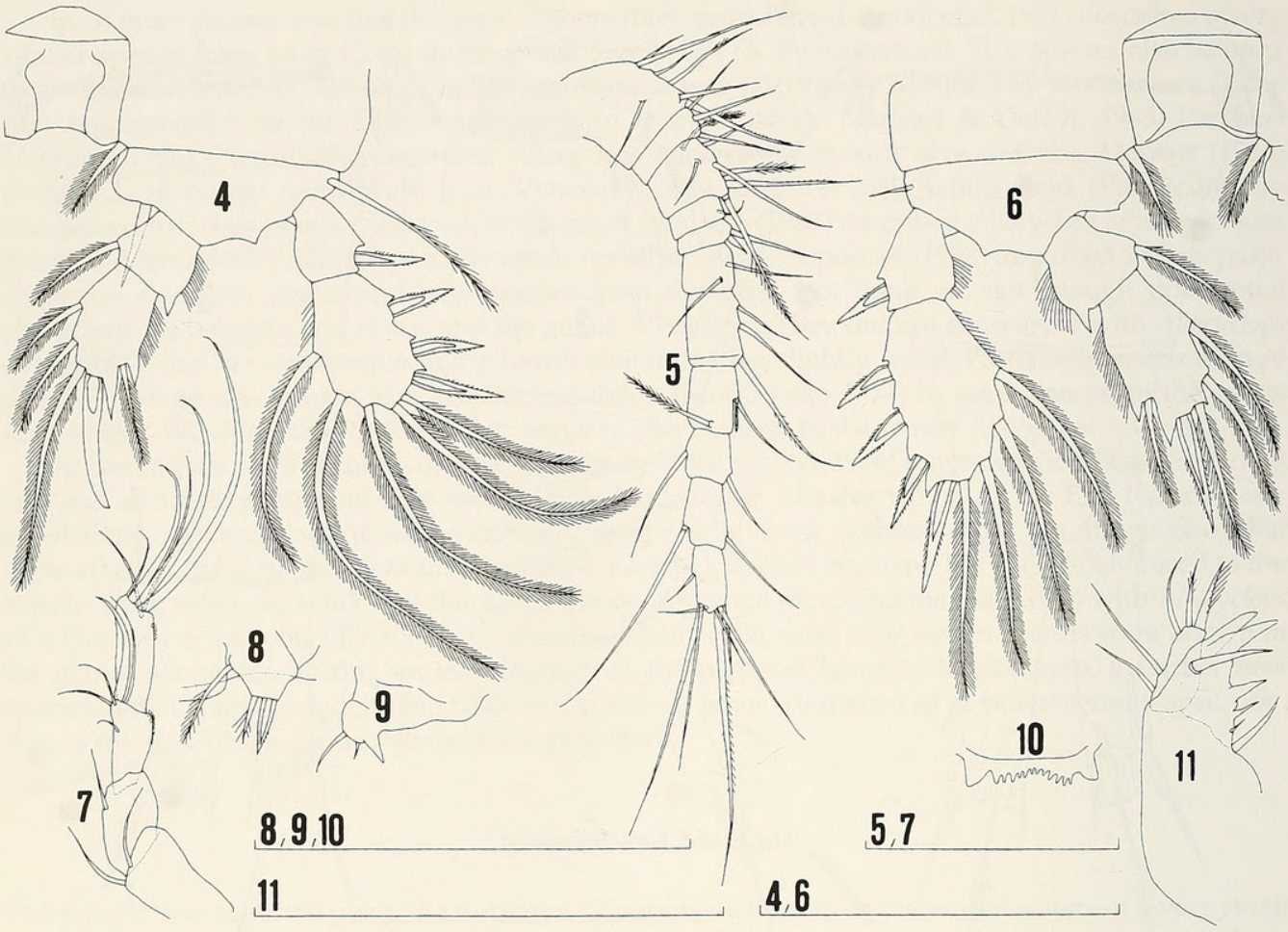
Allocyclops montenegrinus, spec. nov.

(Figs 1-18)

Holotype: ♀, stream near Vrela, near Cetinje, Montenegro, SE Europe, May 9, 1998.

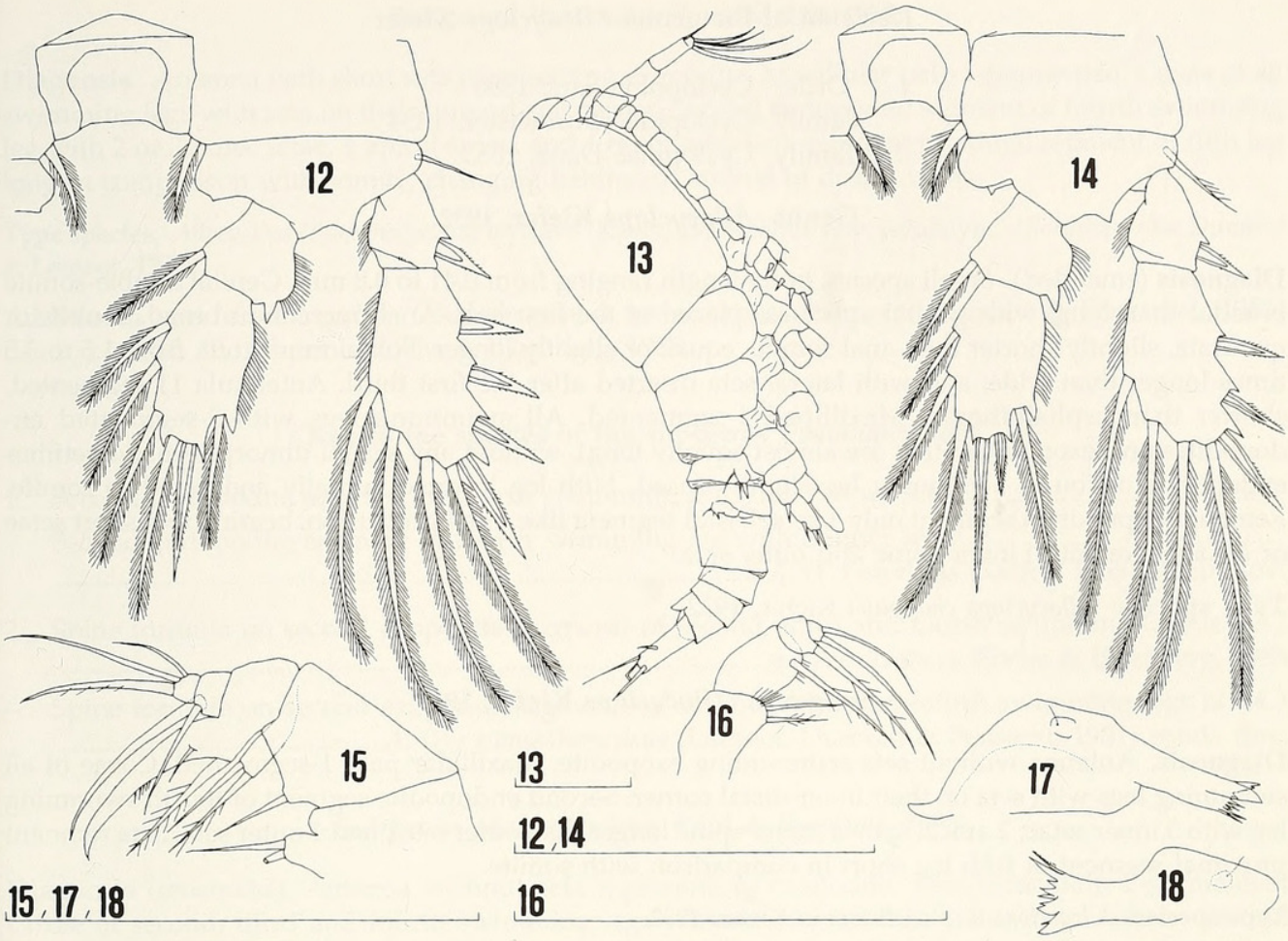
Description

Female. Body length, excluding furcal setae, 0.563 mm. Habitus compact, dorsoventrally compressed. Prosome comprising cephalothorax, incorporating first pedigerous somite, and 3 free pedigerous somites. Surface of dorsal shield covering cephalothorax without any ornamentation, as well as 3 free pedigerous somites (Fig. 13). Body widest at prosomite first pedigerous somite. Urosome comprising fifth pedigerous somite, genital double-somite (representing fused genital and first abdominal somites), and 3 free abdominal somites. More or less sclerotized joint (as pseudosomite) present between prosome and urosome, as well as between fifth pedigerous somite and genital double-somite (Figs 2, 13). Body colourless, nauplius eye absent. Genital double-somite about 1.3 times broader than long, trapeziform, with hind margin ventrally smooth and dorsally serrated (Figs 1, 3). Genital apertures placed dorsolaterally at the first third, and covered by operculum derived from fused sixth legs. Seminal receptacle with broad anterior and ovoid posterior expansions (Fig. 3). First and second free abdominal somites with hind margins ventrally smooth and dorsally serrated. Anal somite ornamented with pair of sensillae, and with row of spinules along posterior margin. Anal operculum convex, not reaching beyond limit of anal somite. Anal sinus smooth (Fig. 1). Furcal rami slightly divergent, close, without ornamentation, and about 2.7 times longer than wide (Fig. 3). Lateral seta inserted dorsolaterally, just to midlength of ramus. Dorsal seta slightly longer than ramus. Outermost



Figs 4-11. *Allocyclops montenegrinus*, spec. nov., holotype (female 0.563 mm). **4.** First swimming leg. **5.** Antennula. **6.** Second swimming leg. **7.** Antenna. **8.** Fifth leg. **9.** Sixth leg. **10.** Labrum. **11.** Maxillula. Scales = 0.1 mm.

apical seta very stout (spiniform), subterminal, and about twice longer than innermost apical seta. Two middle apical setae broken (Fig. 1). Rostrum large, even wellrounded, but not reaching beyond end of antennula first segment (Fig. 13). Antennula 11-segmented, shorter than cephalothorax, with short aesthetasc on eighth segment and setal formula as follows: 7.3.7.1.2.2.3.2.2.2.8 (Fig. 5). Distal seta on fifth segment very stout and short (maybe spiniform). Antenna 4-segmented, without seta representing exopodite (Fig. 7). No ornamentation visible on surface of basipodite. This appendage makes right angle with body ose (Fig. 13), and with setal formula as follows: 2.1.5.6 (Fig. 7). Labrum with strong teeth on posterior margin, but without any other ornamentation (Fig. 10). Mandibula with strong teeth on distal end of coxa (Fig. 18), and with palp represented by only 1 very thin and short seta (Fig. 17). Maxillula comprised of elongated praecoxa and 1-segmented palp (Fig. 11). Praecoxa arithrite with 7 smooth setae and spines, while palp bears 2 apical (plumose) and 3 lateral (smooth) setae. Maxilla 5-segmented, comprising praecoxa, coxa, basis, and 2-segmented endopodite (Fig. 15). Praecoxa with proximal endite bearing 2 setae (proximal one broken), and distal endite unarmed and very small. Coxa with 2 endites; proximal with 1 smooth seta, distal endite highly mobile and bearing 1 plumose and 1 smooth setae. Basis drawn out into claw, with 5 teeth on inner margin and 2 setae. First endopodite segment armed with 2, second with 3 setae (Fig. 15). Maxilliped 4-segmented, with setal formula as follows: 2.1.1.2 (Fig. 16). All swimming legs with smooth coxae, and 1 plumose seta on their inner-distal corner (Fig. 4, 6, 12 and 14). Couplers (intercoxal sclerites) without surface ornamentation. Basis of each swimming leg with epipodite seta on outer margin, especially well-developed on first leg (Fig. 4). Basis of first leg also with short and stout spine on distomedial corner. That corner on other swimming legs with small spinous process. All swimming legs with 2-segmented endopodites and exopodites. First exopodite segment of all legs lacking seta, and bearing 1 outer spine. Second exopodite segments with spine formula 3.4.4.3, and setal formula 5.4.4.4. First endopodite segment of all legs bearing 1 seta on inner-distal corner. Second endopodite segment of first swimming leg with 3 inner setae, 1 smooth and



Figs 12-18. *Allocyclops montenegrinus*, spec. nov., holotype (female 0.563 mm). **12.** Third swimming leg. **13.** Habitus, lateral view. **14.** Fourth swimming leg. **15.** Maxilla. **16.** Maxilliped. **17.** Mandibula. **18.** Mandibula. Scales = 0.1 mm.

curved apical spine, and 1 outer seta (Fig. 4). Second endopodite segment of second swimming leg with 2 inner setae, 1 apical seta, 1 apical spine, and 1 outer seta (Fig. 6). The same segment of third leg with 1 more inner seta (Fig. 12). Second endopodite segment of fourth swimming leg with 3 inner setae, 2 apical spines (inner spine about 2.4 times longer than outer one), and 1 outer seta (Fig. 14). This segment about 1.7 times longer than broad. Outer margins of endopodites, as well as inner margins of exopodites, of all swimming legs (except first exopodite segment of first leg) ornamented with rows of long pinnules. Also, all setae (except epipodite setae on second and third legs) are plumose. Fifth leg inserted laterally and fused to somite (Fig. 2). Remnant of proximal segment only 1 plumose and short (in comparison with somite) seta. Distal segment like small protrusion, and with inner short and stout spine and even shorter outer seta (Fig. 8). Sixth leg inserted dorsolaterally, consisting of small plate bearing 2 short and smooth setae (dorsal seta about 2.7 times longer) and 1 short and smooth spine, completely fused to leg (Fig. 9). This leg also fused to somite, and covers genital aperture.

Male. Unknown.

Etymology. The species name *montenegrinus* is taken from the name of republic Montenegro where the material was collected, i.e., as an adjective agreeing in gender with the (masculine) generic name.

Distribution. At present *Allocyclops montenegrinus*, spec. nov. is known only from type locality. We suppose that it inhabits a wide area of south Dinaric Alps.

Revision of the genus *Allocyclops* Kiefer

Order Cyclopoida Sars, 1886
Family Cyclopidae Burmeister, 1834
Subfamily Cyclopinae Dana, 1853

Genus *Allocyclops* Kiefer, 1932

Diagnosis (emended). Small species, body length ranging from 0.41 to 0.8 mm. Genital double-somite broader than long, with genital apertures placed at the first half. Anal operculum broad, convex or quadrate, slightly shorter than anal somite, equal, or slightly longer. Furcal rami stout, from 1.5 to 3.5 times longer than wide, and with lateral seta inserted after the first third. Antennula 11-segmented, shorter than cephalothorax. Maxilliped 4-segmented. All swimming legs with 2-segmented endopodites and exopodites (that are almost equally long), without any sexual dimorphism. Sometimes endopodite of fourth swimming leg slightly fused. Fifth leg inserted laterally and fused to somite. Remnant of proximal segment only 1 seta. Distal segment like small protrusion, bearing two short setae or (more frequently) inner spine and outer seta.

Type species: *Allocyclops chappuisi* Kiefer, 1932.

Subgenus *Allocyclops* Kiefer, 1932

Diagnosis. Antenna without seta representing exopodite. Maxillular palp 1-segmented. Coxae of all swimming legs with seta on their inner-distal corner. Second endopodite segment of fourth swimming leg with 3 inner setae, 2 apical spines (inner spine longer than outer one), and 1 outer seta. Seta remnant proximal segment of fifth leg short in comparison with somite.

Type species: *Allocyclops* (s. str.) *chappuisi* Kiefer, 1932.

Additional species: *Allocyclops* (s. str.) *cavicola* Chappuis, 1951; *A.* (s. str.) *botosaneanui* Plesa, 1981; *A.* (s. str.) *orcinus* (Kiefer, 1937) comb. nov.; *A.* (s. str.) *montenegrinus*, spec. nov.; *A.* (s. str.) *kieferi* Petkovski, 1971; *A.* (s. str.) *minutissimus* (Kiefer, 1933); *A.* (s. str.) *arenicolous* (Fryer, 1956), comb. nov.

Key to the species of the subgenus *Allocyclops*

1. Innermost apical seta on furcal rami longer than outermost one ..... 2.
– Innermost apical seta on furcal rami shorter than outermost one ..... 4.
2. Anal operculum short and quadrate ..... 3.
– Anal operculum clearly convex ..... *A.* (s. str.) *chappuisi* Kiefer, 1932
3. Furcal rami more than 3 times longer than wide ..... *A.* (s. str.) *cavicola* Chappuis, 1951
– Furcal rami less than 3 times longer than wide ..... *A.* (s. str.) *botosaneanui* Plesa, 1981
4. Anal operculum smooth ..... 5.
– Anal operculum finely serrated ..... *A.* (s. str.) *orcinus* (Kiefer, 1937) comb. nov.
5. Basis of first leg with spine an distomedial corner ..... 6.
– Basis of first leg without that spine ..... *A.* (s. str.) *arenicolous* (Fryer, 1956) comb. nov.
6. Setal formula on second exopodite segments of swimming legs is 5.5.5.5 ..... 7.
– Setal formula on second exopodite segments of swimming legs is 5.4.4.4 ..... *A.* (s. str.) *montenegrinus*, spec. nov.
7. Furcal rami about 3 times longer than wide; innermost apical seta on ramus about 2 times shorter than outermost one ..... *A.* (s. str.) *kieferi* Petkovski, 1971
– Furcal rami about 1.5 times longer than wide; innermost apical seta on ramus slightly shorter than outermost one ..... *A.* (s. str.) *minutissimus* (Kiefer, 1933)

Subgenus *Psammocyclops* Kiefer, 1955

Diagnosis. Antenna with short seta representing exopodite. Maxillular palp 1-segmented. Coxae of all swimming legs with seta on their inner-distal corner. Second endopodite segment of fourth swimming leg with 2 or 3 inner setae, 1 apical spine, and 1 outer seta. Seta remnant proximal segment of fifth leg long in comparison with somite, changing habitus of animal in dorsal view.

Type species: *Allocyclops (Psammocyclops) excellens* (Kiefer, 1955) comb. nov. [synonym: *Allocyclops ritae* Dumont & Lamoot, 1978].

Additional species: *Allocyclops (Psammocyclops) transsaharicus* (Lamoot, Dumont & Pensaerat, 1981) comb. nov.; *A. (P.) silvaticus* Rocha & Bjornberg, 1988.

Key to the species of the subgenus *Psammocyclops*

1. Second endopodite segment of fourth swimming leg with 3 inner setae ..... 2.
– Second endopodite segment of fourth swimming leg with 2 inner setae .... *A. (P.) excellens* (Kiefer, 1955) comb. nov.
2. Spine formula on second exopodite segments of second, third and fourth swimming legs is 3.3.2 ..... *A. (P.) silvaticus* Rocha & Bjornberg, 1988
– Spine formula on second exopodite segments of second, third and fourth swimming legs is 4.4.3 ..... *A. (P.) transsaharicusus* (Lamoot, Dumont & Pensaert, 1981) comb. nov.

Subgenus *Stolonicyclops* Reid & Spooner, 1998

Diagnosis (emended). Antenna without seta representing exopodite. Maxillular palp 2-segmented. Coxae of second, third and fourth swimming legs without seta on their inner-distal corner. Second endopodite segment of fourth swimming leg with 3 inner setae, 1 apical spine, and 1 outer seta. Seta remnant proximal segment of fifth leg relatively long in comparison with somite, but not changing habitus of animal in dorsal view.

Type and single species: *Allocyclops (Stolonicyclops) heggiensis* (Reid & Spponer, 1998) comb. nov.

Discussion

The systematics of the genera included in the subfamily Cyclopinae recently was discussed by many authors (Dussart & Defaye 1985, Reid 1993, 1999, Pesce 1996, Ferrari 1998, Rocha et al. 1998, Reid et al. 1999). Now, like fifty years ago, the most important systematic character at generic level is the morphology of the fifth leg. Until now, only seven genera are known with fifth leg completely fused to somite: *Austriocyclops* Kiefer, 1964; *Bacillocyclops* Lindberg, 1956; *Bryocyclops* Kiefer, 1927; *Allocyclops* Kiefer, 1932; *Haplocyclops* Kiefer, 1952; *Palaeocyclops* Monchenko, 1972; and *Yansacyclops* Reid, 1988. The genera *Austriocyclops* and *Bacillocyclops* have the fifth leg reduced to a single seta or spine. Five other genera have the fifth leg completely fused to the somite, but all three setae remain (two from distal, and one from proximal segment).

The genus *Bryocyclops* differs from the genus *Allocyclops* by the following features: sexual dimorphism in swimming legs; endopodite of the fourth swimming leg always considerably shorter than exopodite (even when it is 2-segmented); distal segment of the fifth leg does not remain as a small protrusion; and anal operculum always produced posteriorly. This genus indeed has confused systematics (Reid 1999), and also needs revision.

The genus *Haplocyclops* is revalidated by Rocha et al. (1998), and differs from *Allocyclops* as follows: genital apertures placed at the second half of the genital double-somite; lateral seta on furcal rami inserted in the first third; antennula without seta on the inner margin of the ultimate segment; distal segment of the fifth leg does not remain as a small protrusion; and endopodite of the fourth swimming leg 1-segmented.

The genus *Palaeocyclops* is monospecific, known from the Kisilkum Desert (Monchenko 1972). It differs from *Allocyclops* by the very long anal operculum, as well as by presence of sexual dimorphism

in swimming legs, and absence of any spine on endopodite of the fourth swimming leg.

The genus *Yansacyclops* is also monospecific, known from Brazil (Reid 1988). It differs from the genus *Allocyclops* by the following features: genital double-somite longer than broad; anal operculum very short, placed in the first half of anal somite; antennula 10-segmented; antenna with very long seta representing exopodite; and second endopodite segment of the fourth swimming leg with one apical spine and one apical seta. This genus is, in our opinion, closest related to the genus *Allocyclops*. Many other genera from the subfamily Cyclopinae have similar segmentation of the swimming legs and antennula (*Speocyclops* Kiefer, 1937; *Muscocyclops* Kiefer, 1937; *Fimbricyclops* Reid, 1993; etc.), but the fusion of their fifth leg to somite is of completely different nature, and it is never total.

We divided the genus *Allocyclops* into 3 subgenera: *Allocyclops* s. str., *Psammocyclops* Kiefer, 1955, and *Stolonicyclops* Reid & Spooner, 1998. Their differential diagnoses, in our opinion, are not sufficient for giveng them generic status. This especially refers to the monospecific subgenus *Stolonicyclops*, which can be separated from the subgenus *Psammocyclops* only by the absence of the coxal setae. All other characteristics are at specific, not at generic level. We already pointed out that Kiefer (1955; 1956) very provisionally described *Psammocyclops excellens* as a new genus and new species. Even Pesce (1996) accepted this, without any particular comments. But if we believe in Kiefer's drawing of the female's fifth leg (which should be one separated article with three setae), how we can explain the drawing of the male's fifth leg (which is completely fused to the somite, and quite exact as the fifth leg in the genus *Allocyclops*)? It seems that Kiefer made an error and drew some cuticular suture or curve as a distinctive membrane of the fifth leg in the female. If we accept this, and after comparison of *Psammocyclops excellens* with *Allocyclops ritae* Dumont & Lamoot, 1978, we see that there are no differential characteristics between these two species. In their description Dumont & Lamoot (1978) wrote that *A. ritae* has the spine formula on exopodites of the swimming legs as 3.3.3.2. But reexamination of the type material (Rocha & Bjornberg 1988) showed that this formula is 2.3.3.2, i.e. the same formula as in *Psammocyclops excallens*. Shape of the fourth swimming leg, as well as dorsal view of the urosome, and other details are the same in both species. Only Dumont & Lamoot (1978) noted that separation of the segments of the fourth leg endopodite is hardly visible, but we already said that this characteristic is known as highly variable in many species. Therefore we consider *Allocyclops ritae* as a synonym of *Psammocyclops excellens*. It is probably trogloxen, or maybe a troglophilous species also in Madagascar, but Kiefer (1955, 1956) there collected only interstitial fauna.

Allocyclops montenegrinus, spec. nov. clearly belongs to the subgenus *Allocyclops*. In fact, in that subgenus there are two well distinguished groups of species. The first group contains three tropical species, having the innermost apical seta of the furcal rami longer than the outermost one. The other group to which *A. montenegrinus* belongs has the innermost apical seta shorter than the outermost one. All species of that group inhabit subterranean waters of Europe, except *A.* (s. str.) *arenicolous* which was known from the interstitial of Lake Nyasa (Africa). From all species in the subgenus *Allocyclops* the new species is easily distinguishable by the shape of furcal rami, anal operculum, and spine and setal formula on swimming legs. Very strong differential characteristics between species, as well as geographical distribution of the genus *Allocyclops*, tell us that this genus had the highest diversity during Tertiary or even before. The genus *Speocyclops*, on the other hand, has very weak differential characteristics between species, and it seems that this genus now has its highest diversity in subterranean waters of Europe. After transferring *Speocyclops transsaharicus* and *Speocyclops orcinus* from that genus to the genus *Allocyclops* (in this paper), many taxonomical and zoogeographical problems in that genus are resolved. The observations of some populations of *Speocyclops demetiensis* from surface waters in Norway by Hessen & Stene (1991) demonstrate that probably we do not need to search ancestors of that genus in African surface waters. Maybe they inhabited mosses and other surface waters on European high mountains before Quaternary major climatic oscillations.

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