

Psammocyclopinidae fam. n., a new monophyletic group of marine Cyclopoida (Copepoda, Crustacea), with the description of *Psammocyclopina georgei* sp. n. from the Magellan Region

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ABSTRACT. *Psammocyclopina georgei* sp. n. is described from submersed sands in the Magellan Strait, South Atlantic Ocean. This is the second species of the genus, previously known only from the Indian Ocean (Mozambique). *Psammocyclopina* Wells, 1967 is the sistergroup of *Metacyclopina* Lindberg, 1953. Psammocyclopinidae fam. n. is accordingly proposed to unify these genera into one monophyletic unit. The sistergroup of the new family is a cluster of cyclopinid genera composed of *Cyclopinodes* Wilson, 1932, *Pseudocyclopina* Lang, 1946, *Parapseudocyclopinodes* Lindberg, 1961, *Hemicyclopina* Herbst, 1952, *Procyclopina* Herbst, 1955, *Heterocyclopina* Plesa, 1968, *Neocyclopina* Herbst, 1952, and an as yet undescribed new genus (Martínez Arbizu, in prep.). Global occurrence of psammocyclopinids is briefly reviewed.

KEY WORDS. Psammocyclopinidae fam. n., Cyclopinidae, Cyclopoida, Copepoda, phylogeny, systematics

Marine Cyclopoida have colonised a great variety of habitats. Most primitive members of the order such as *Cyclopicina* Lindberg, 1953 or *Smirnovipina* Martínez Arbizu, 1997, inhabit the hyperbenthic water layers (MARTÍNEZ ARBIZU 1997a, b), and others like *Mantra* Leigh-Sharpe, 1934 or *Archinotodelphys* Lang, 1949 are associated with molluscs or ascidians (LEIGH-SHARPE 1934; LANG 1949). Most cyclopoids however are epibenthic, i. e. live in close contact to the bottom. This paper deals with one lineage, the Psammocyclopinidae fam. n., which has colonised the interstices of submersed marine sands; one of its members secondarily invaded the coastal groundwaters (HERBST 1974). Like some members of the order Harpacticoida (for instance the Paramesochridae) these cyclopoids display adaptations to interstitial life, with an elongated body shape, reduced number of eggs in an egg sac, shortened antennules, reductions in the armature of swimming legs, etc. One new species of this group collected from the Magellan Region is described here and its phylogenetic relationships discussed.

The species ascribed to the new monophylum were formerly classified in the so-called "Cyclopinidae". However, this family is a classical paraphyletic group, as has been shown repeatedly by HO (1986, 1994) and MARTÍNEZ ARBIZU (1997a). The main task therefore is to dissolve the paraphyletic "Cyclopinidae" into monophyletic

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units using the methods of phylogenetic systematics (HENNIG 1982). As a result of this ongoing revision, two monophyletic units have been previously recognised (MARTÍNEZ ARBIZU 2000a, b), and family rank has been proposed for them. An additional monophyletic group is the new taxon Psammocyclopinidae **fam. n.**

MATERIAL AND METHODS

Meiobenthic samples were taken during the German expedition "Magellan Campaign", on board the RV VICTOR HENSEN using a Minicorer (ARNTZ & GORNY 1996; GEORGE 1999). The first 10 cm of sediment and the overlying bottom water were fixed with buffered formalin at a final concentration of 4%. Meiofauna were extracted by differential flotation and centrifugation using Levasil[®]. Drawings were made using a camera lucida on a Leitz Diaplan[®] interference contrast microscope.

The material is stored in the Copepod Collection of the AG Zoosystematik und Morphologie, University of Oldenburg, Germany.

RESULTS

Order Cyclopoida

Psammocyclopinidae **fam. n.**

Diagnosis (groundpattern). Cyclopoida, body elongated, harpacticoid-like. Tergite of first pedigerous somite free. Antennule short, 11-segmented in female. Antenna 4-segmented, coxa-basis with one inner and one exopodal seta, endopod 3-segmented with 1, 5 and 7 setae. Mandible with basis bearing 1 seta, 2-segmented endopod with 2 and 4 setae, and 4-segmented exopod with 1, 1, 1, 2 setae. Maxillulary praecoxal arthrite with 10 armature elements, coxal epipodite represented by 2 setae, coxal endite, with one seta. Maxilla with praecoxa bearing 3 setae; coxa with 2 well developed endites each produced into a strong claw and bearing 2 setae; and 3-segmented endopod (proximal endopodal segment being a double segment) with 4, 1 and 4 setae. Maxillipedal syncoxa with total of 5 setae; basis with 2 setae; and 4-segmented endopod. Legs 1 to 4 with 3-segmented rami, without inner seta on first exopodal segment. Legs 1 to 3 with only 1 inner seta on middle endopodal segment, leg 4 with 2 setae on this segment. Third exopodal segment of leg 1 with terminal spine transformed into bipinnate seta (arrowed in Fig. 4A). Legs 2 to 4 with only 2 outer spines on third exopodal segment. Leg 5 with distinct coxa and basis in both sexes; coxa with inner seta, basis with outer seta; exopod 1-segmented with 4 armature elements in female; 2-segmented in male, with 1 inner and 1 outer setae on proximal, and 4 elements on distal segment. Leg 6 a plate with 3 well-developed setae in both sexes. Furca with 7 setae.

Type genus: *Psammocyclopina* Wells, 1967.

Other genus: *Metacyclopina* Lindberg, 1953.

Psammocyclopina georgei **sp. n.**

Material. Holotype: one female dissected and mounted on 13 slides (UNIOL collection numbers 1999.004/1 – 1999.004/13).

Type Locality. The type specimen was collected at 79 m depth in the Magellan Strait, Paso Ancho, coordinates 53° 59.7'S 70° 33.0'W, on 31 October 1994. Station VH 954.

Female. Body slender, harpacticoid-like, prosome nearly as long as urosome. Body length from frontal rim of cephalosome to caudal rim of telson 544 μm . Prosome and urosome ornamented with symmetrical pattern of sensilla and pores (Fig. 1A). First pedigerous somite free (Figs 1A-B). Last thoracic and first abdominal somites completely fused to form genital double-somite. Abdominal somites with plain hyaline frills. Anal operculum forming triangular flap (Fig. 6B).

Furca about 1.8 times as long as mean width (Figs 6A-B); with 7 setae. Furcal seta I small, inserting near seta II at about midlength of furca, seta III inserting terminally on small protuberance on outer distal corner, setae IV, V and VI inserting terminally and seta VII inserting on inner dorsal margin.

Antennule short, 11-segmented (Fig. 8A). Armature formula beginning with proximal segment: 5, 9, 9, 4, 2, 2, 1, 1, 4 + aesthetasc, 2 + aesthetasc, 7 + aesthetasc.

Antenna (Fig. 2A) 4-segmented, with small praecoxal sclerite. Coxa and basis fused, with 1 seta on inner margin, and 1 exopodal seta on outer margin; endopod 3-segmented, first segment with 1 seta on inner margin; second segment with 5 setae, 3 of them ornamented with robust spinules, third segment with 7 setae.

Labrum with dense spinulose area ventrally.

Mandible (Fig. 2B) with robust gnathobasis, palp consisting of basis without setae, 2-segmented endopod with 1 and 2 setae; exopod reduced to small protuberance without setae.

Maxillule praecoxal arthrite (Fig. 3A) with 10 armature elements, coxa with 1 seta on endite and 2 setae representing epipodite; basis (Fig. 3B) with 2 basal endites, proximal with 3 setae, distal with 1 seta; 1-segmented endopod with 3 densely spinulose setae and additional naked seta; 1-segmented exopod with dense tuft of spinules on inner margin and armed with 3 densely spinulose setae.

Maxilla (Fig. 3C) with distinct praecoxa and coxa; proximal praecoxal endite with 2 setae of unequal length, distal praecoxal endite with 1 seta; coxal endites (Fig. 3D) each produced into strong claw and armed with 2 setae; basis produced into strong claw armed with 1 robust seta and additional minute seta; endopod 3-segmented, first endopodal segment a double-segment, armed with 1 minute and 1 robust seta proximally and 2 robust setae distally, second segment with 1 seta, distal segment with 2 strong pinnate setae and 2 slender naked setae.

Maxilliped (Fig. 2C) consisting of syncoxa, basis, and 3-segmented endopod; syncoxa partially subdivided into proximal (praecoxal) part bearing 2 slender setae and robust spine, and distal (coxal) portion bearing 2 pinnate setae of unequal length; basis with 2 setae, first endopodal segment with 1 seta, middle endopodal segment produced into strong claw, distal endopodal segment with 4 setae (2 of them geniculate).

Swimming legs 1 to 4 (Figs 4A-B, 5B) with small praecoxal sclerite (not illustrated), coxa, basis and 3-segmented rami.

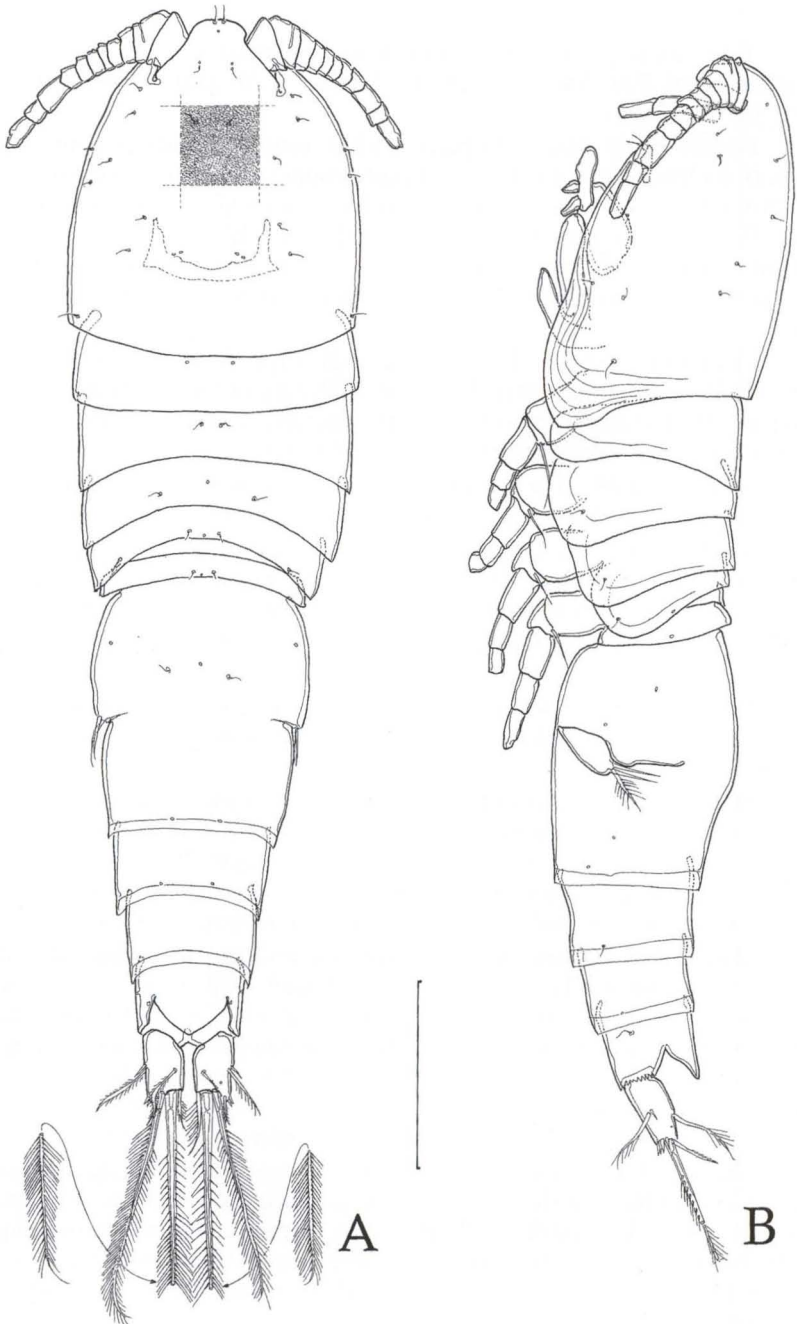


Fig. 1. *Psammocyclopina georgei* sp. n., female habitus. (A) Dorsal view; (B) lateral view. Scale bar 100 μ m.

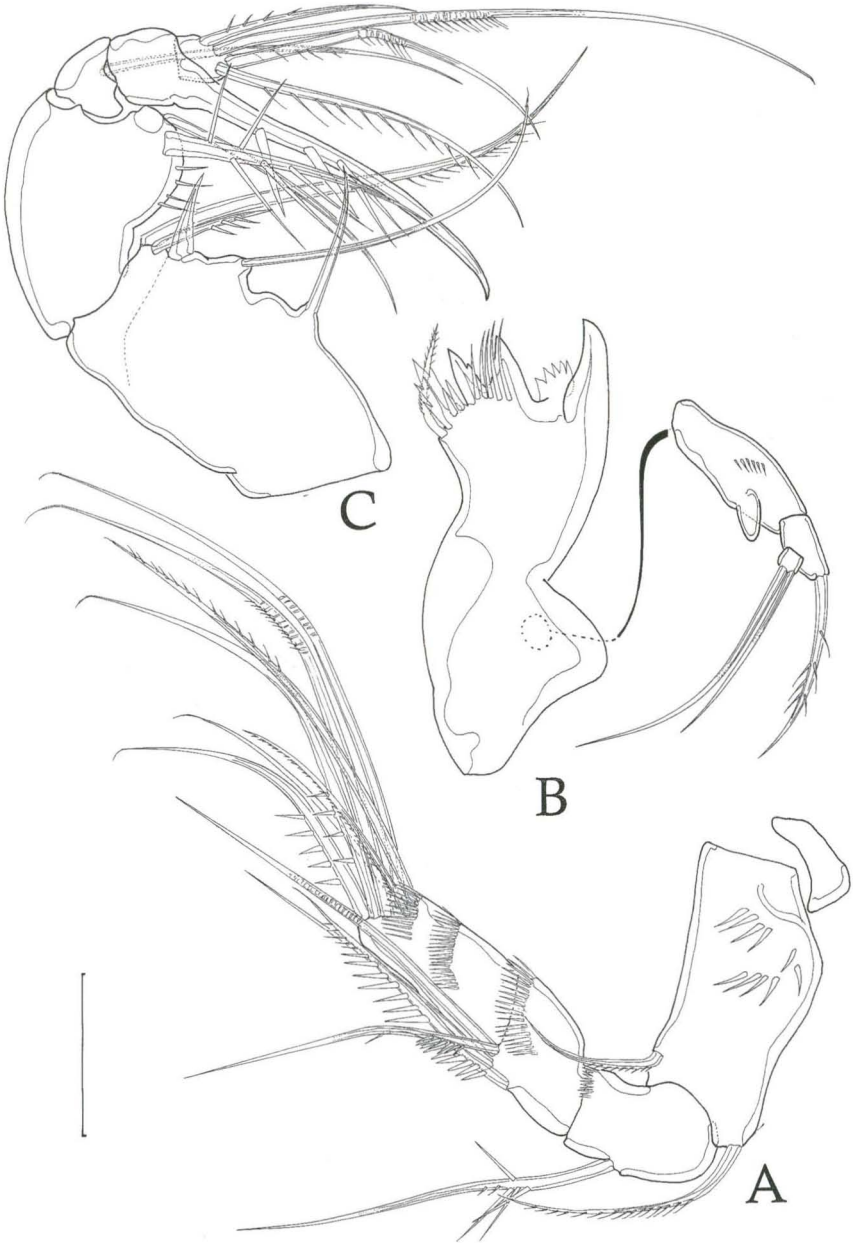


Fig. 2. *Psammocyclopina georgei* sp. n. (A) Antenna; (B) mandible; (C) maxilliped. Scale bar 20 μ m.

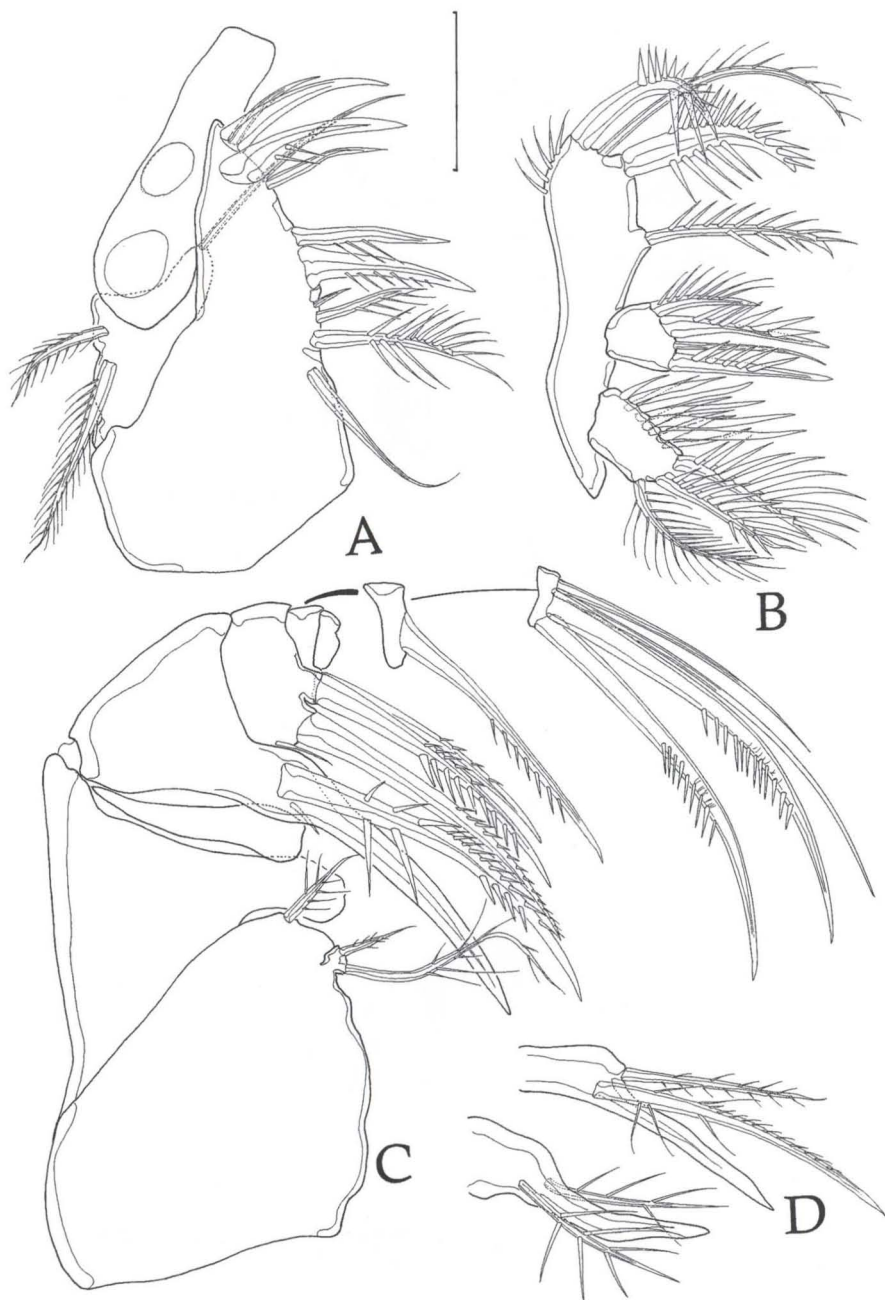


Fig. 3. *Psammocyclopina georgei* sp. n. (A) Maxillule praecoxal arthrite and coxa; (B) maxillule basis and rami; (C) maxilla; (D) proximal and distal maxillary coxal endites. Scale bar 20 μ m.

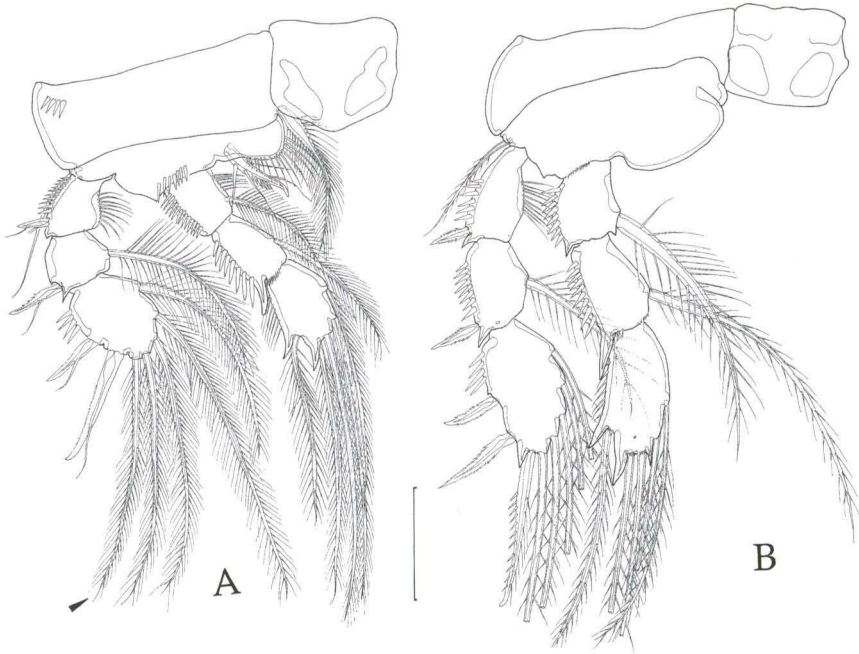


Fig. 4. *Psammocyclopinina georgei* sp. n. (A) Leg 1, terminal element arrowed; (B) leg 2. Scale bar 20 μ m.

Outer terminal element on third exopodal segment of leg 1 a bipinnate seta (arrowed in Fig. 4A). Legs 1 to 4 without inner seta on first exopodal segment. Middle endopodal segment of legs 1 to 3 with 1 inner seta, that of leg 4 with 2 inner setae. Coxae of legs 2 to 4 without inner seta.

Swimming legs armature formula:

	Coxa	Basis	Endopod	Exopod
Leg 1	0-1	1-I	0-1; 0-1; 1,2,2	I-0; I-1; II,1,4
Leg 2	0-0	1-0	0-1; 0-1; 1,2,2	I-0; I-1; II,I,5
Leg 3	0-0	1-0	0-1; 0-1; 1,2,2	I-0; I-1; II,I,5
Leg 4	0-0	1-0	0-1; 0-2; 1,2,2	I-0; I-1; II,I,5

Leg 5 (Fig. 5A), located ventrally, with intercoxal sclerite; coxa with 1 inner seta; basis with 1 slender outer seta; exopod 1-segmented with 3 elongated spines and slender seta.

Sixth legs (Fig 6C) consisting of small operculum covering gonopores and armed with 3 well-developed elements.

Copulatory pore located midventrally on genital double-somite.

Male. Unknown.

Etymology. This species is named after my friend Dr. Kai George, who collected the specimen in the Magellan Strait and kindly place it at my disposal.

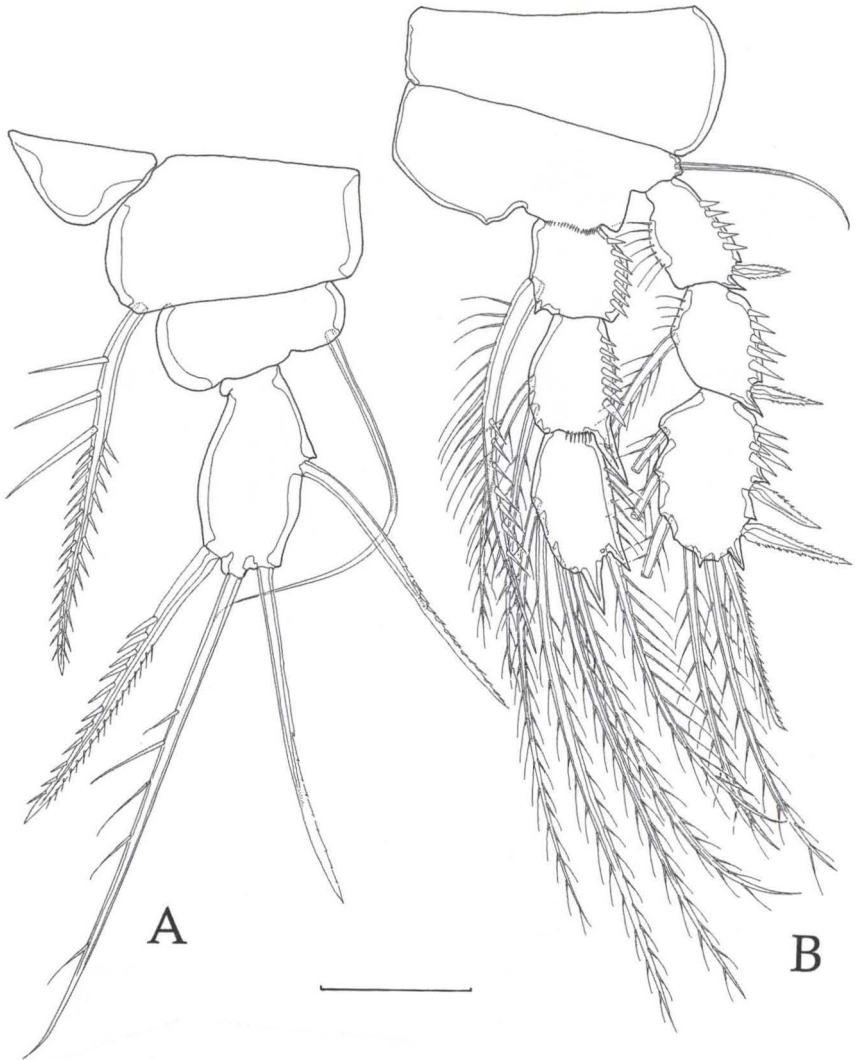


Fig. 5. *Psammocyclopina georgei* sp. n. (A) Leg 5; (B) leg 4. Scale bar 20 μ m.

DISCUSSION

Prior to this study only one species was known in the genus *Psammocyclopina* Wells. The type species, *Psammocyclopina hindleyi* Wells, 1967, is known only from submersed 'clean sands' off Inhaca Island, Mozambique (WELLS 1967). Recently a specimen of *Psammocyclopina* was discovered by me from the top of the Great Meteor Bank, North Atlantic. This specimen, a female, is identified with *P. hindleyi* and therefore will not be considered further. Comparison was made

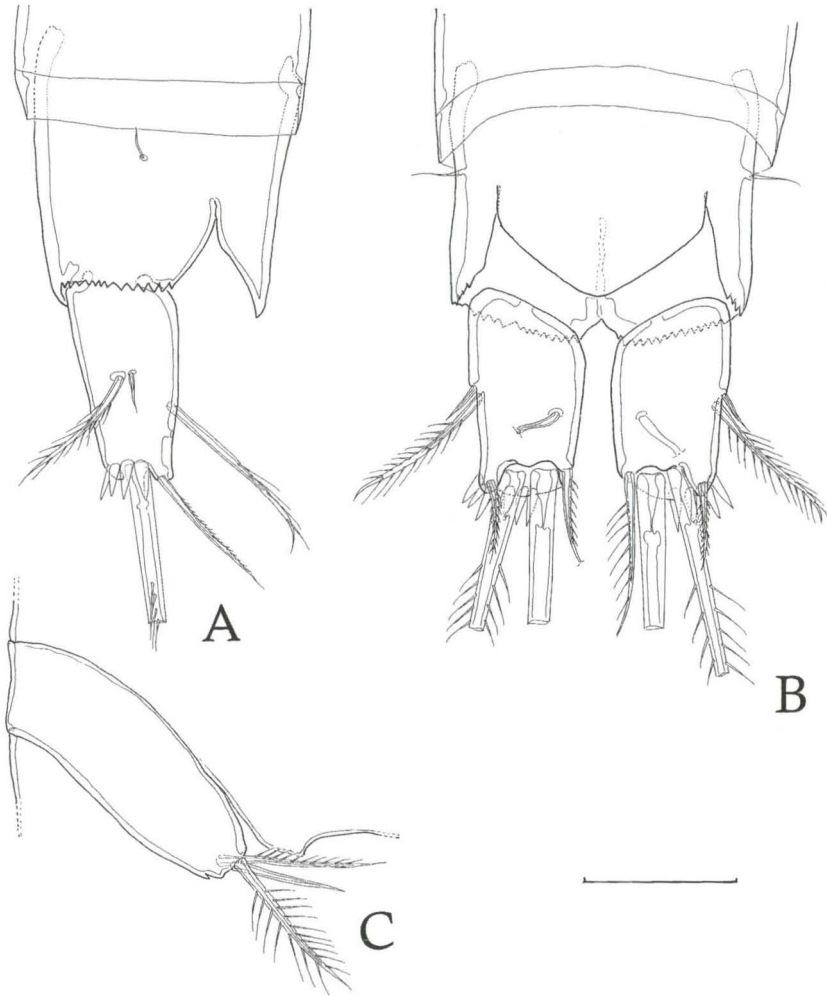


Fig. 6. *Psammocyclopina georgei* sp. n. (A) Telson and furca lateral view; (B) telson and furca dorsal view; (C) leg 6 lateral view. Scale bar 20 μ m.

between the type material of the type species and the new species from the Magellan region. The male allotype labelled as *P. hindleyi* seems to belong to a different species, most probably a new species of *Metacyclopina* Lindberg, 1953. This is evidenced by the dissimilarity of the furca (Figs. 8B-D) with a well-developed seta I (as long as seta II) inserting at a distance from seta II, while in both known species of *Psammocyclopina* the furcal seta I is reduced and is located near seta II; and by the absence of a pointed protuberance on the outer distal corner on which seta III inserts (Fig. 8D), a character present in both species of *Psammocyclopina*. In addition, the mandibular exopod is 4-segmented and not reduced as in *Psammocyclopina*, and the middle endopodal segment of maxilliped is not produced into a

strong claw, as is the case in both species of *Psammocyclopina*. Remarkably, a male psammocyclopinid was also present in the same sample as *P. georgei* sp. n., but again, it seems to belong to an undescribed species of *Metacyclopina*. In this case the differences between the female and male specimens found in the same sample involved not only the shape of the furca and the mouthparts, but also the shape of the anal operculum, the absence of spinules on the labrum, and armature formula of the swimming legs. This greater dissimilarity, if interpreted as sexual dimorphism, would be unique in cyclopinids. I prefer to treat them as two different species.

Study of the holotype of *P. hindleyi* revealed some inaccuracies in the description, emended here. The furca bears seta I (Fig. 8D) in exactly the same position as in *P. georgei*. The antennule seems to be 11-segmented, as in *P. georgei*, not 12-segmented. The antenna displays the same segmentation and armature as *P. georgei*, including a well-developed exopodal seta. The mandibular endopod bears 3 seta rather than 2. The maxillulary praecoxal arthrite seems to be same as in *P. georgei*, and so is the setation and ornamentation of the maxillulary palp (Fig. 7C). The setation on the maxillary praecoxa could not be observed, but the coxal, basal and endopodal setation is the same as in *P. georgei*. Finally, the segmentation and setation of the maxilliped (Fig. 7D) also agree in every detail with *P. georgei*.

The new species from the Magellan region can be easily distinguished from the type species, firstly by its body length: 401 μm long in *P. hindleyi* and 544 μm long in *P. georgei*. The mandibular palp of the new species bears a 2-segmented endopod and a protuberance representing a rudiment of the exopod (Fig. 2B), while *P. hindleyi* has a 1-segmented endopod and no protuberance representing the exopod (Fig. 7B). An additional diagnostic difference is the presence of only 2 outer spines on the third exopodal segment of leg 1 in *P. georgei*. (Fig. 4A), while 3 outer spines are present in *P. hindleyi* (Fig. 7A). Only 1 inner seta on the middle endopodal segment of leg 4 is present in the type species of the genus, while 2 setae are present on this segment in *P. georgei*. (Fig. 5B). The anal operculum is triangular in the new species (Fig. 6B), while it is rounded in *P. hindleyi*. And the distal outer protuberance of the furca is more pronounced in *P. hindleyi* (Fig. 8C-D) than in *P. georgei*. (Fig. 6B).

The sistergroup of *Psammocyclopina* is the genus *Metacyclopina*. Four species of the latter genus have been described, viz. *Metacyclopina harpacticoidea* (Klie, 1949), *M. roscoffensis* Bozic, 1953, *M. brevisetosa* Herbst, 1975 and *M. improvisa* Herbst & Zo, 1981. All were collected in the North Atlantic, three from off Western Europe (Germany, France), and one from the southeastern coast of the United States (South Carolina, Georgia).

Psammocyclopina can be easily distinguished from *Metacyclopina* by the presence of apomorphic states of characters 1 to 4 (plesiomorphic condition in parentheses). *Metacyclopina* is characterised by apomorphic characters 5 to 10 (Fig. 9): 1) Mandibular exopod reduced to a small lobe in the female (well developed, 4-segmented); 2) Middle endopodal segment of maxilliped produced into a strong claw (not produced into a claw); 3) Maxillipedal endopod 3-segmented (4-segmented); 4) Outer distal corner of the furca produced into a claw-like process on which seta III inserts (no such process present); 5) Antennule 10-segmented in female

(11-segmented); 6) Antenna without exopodal setae (with 1 seta); 7) Third endopodal segments of legs 1 to 4 with 4 setae (with 5 setae); 8) Third exopodal segment of leg 1 with 3 inner seta (with 4 inner setae); 9) Middle endopodal segment of leg 4 with 1 inner seta (with 2 inner setae); 10) Terminal furcal setae short and flame-like in female (not transformed).

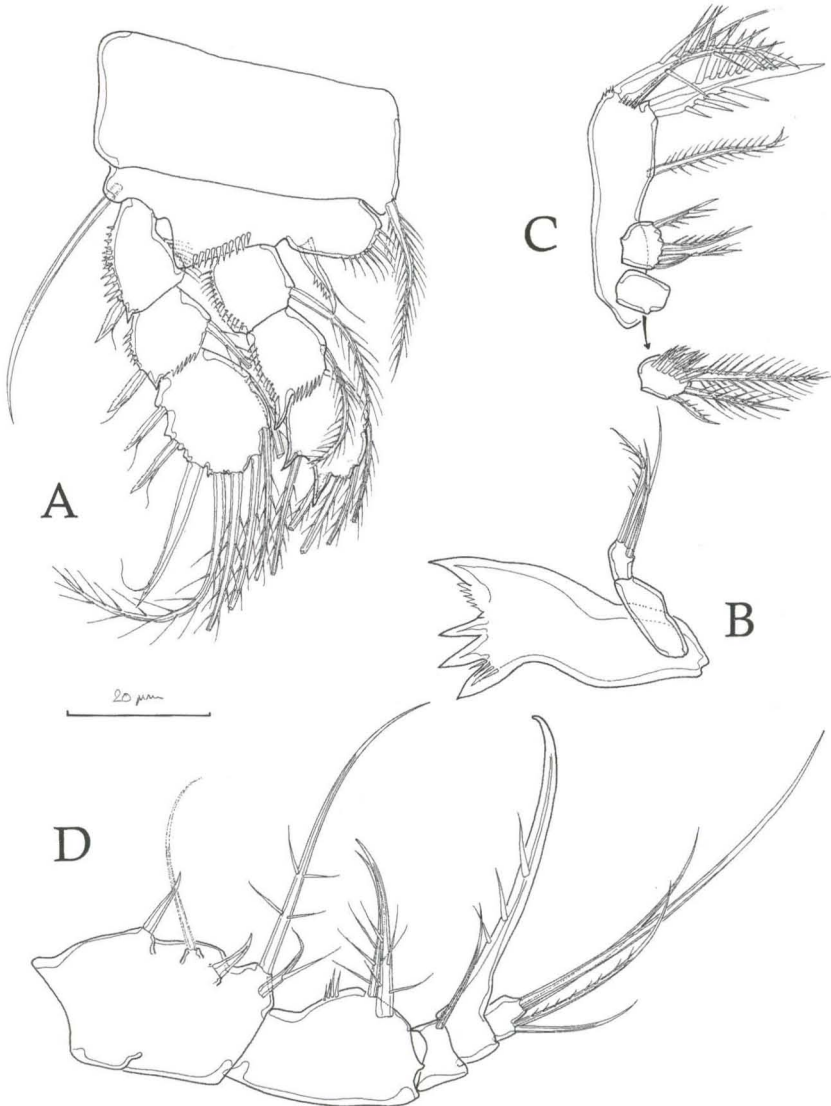


Fig. 7. *Psammocyclopinia hindleyi* Wells, holotype. (A) Leg 1; (B) mandible; (C) maxillule palp; (D) maxilliped. Scale bar 20 μm .

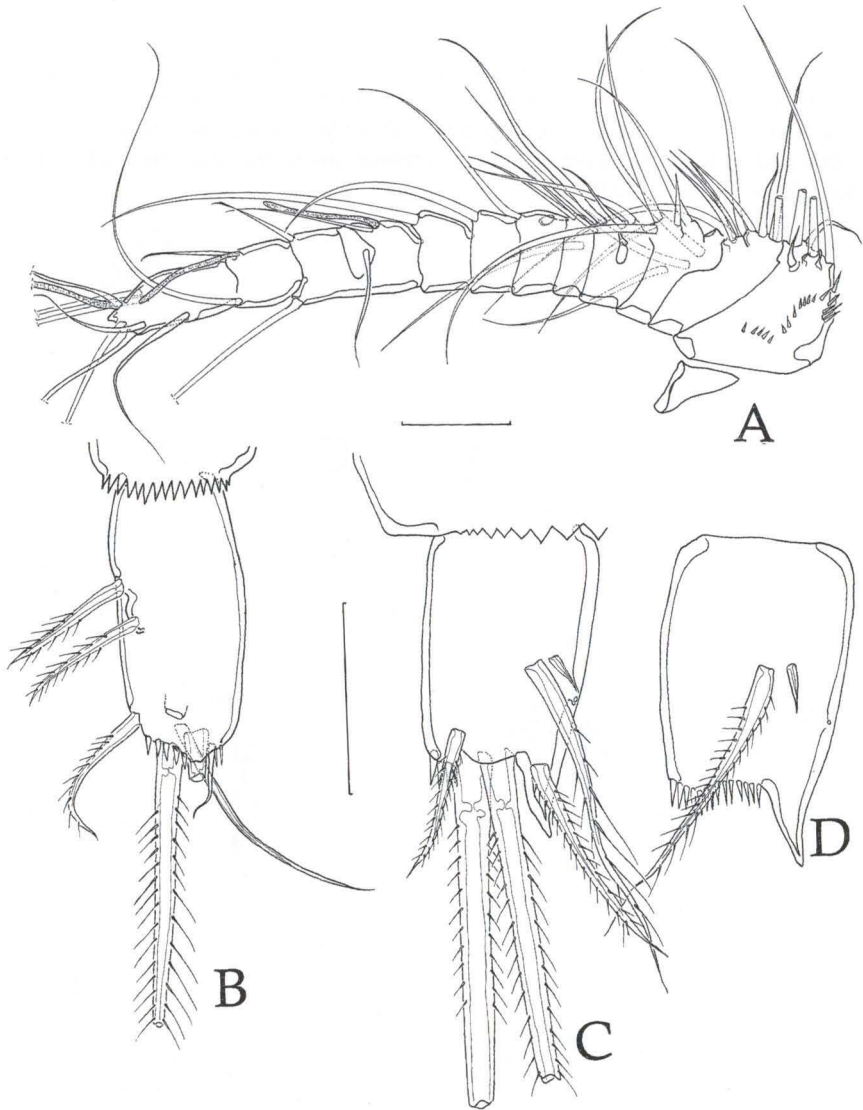


Fig. 8. (A) *Psammocyclopina georgei* sp. n., female antennule; (B) *P. hindleyi* Wells male allotype, furca; (C-D) *P. hindleyi*, female holotype, furca. Scale bars 20 μ m.

The monophyly of a taxon including *Psammocyclopina* and *Metacyclopina* is evidenced by the following apomorphic characters: A) transformation of the body form to an elongated habitus as an adaptation to the interstitial life, and B) by the presence of only 2 outer spines on the third exopodal segments of legs 2 and 3, while 3 outer spines are present in the groundpattern of other monophyletic subunits of cyclopinid Cyclopoida.

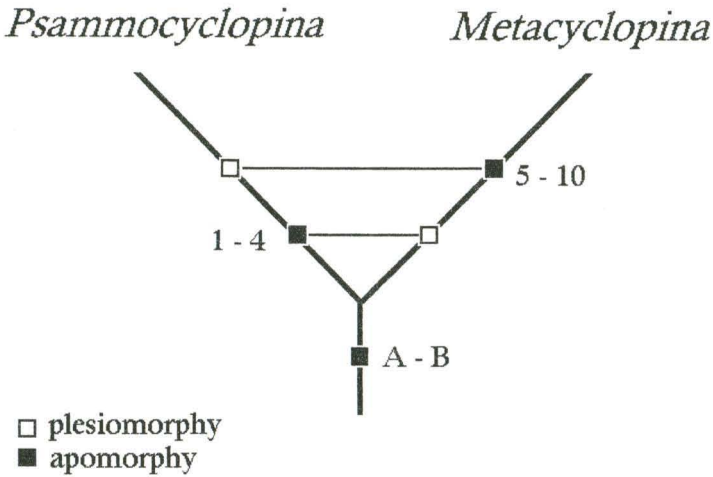


Fig. 9. Phylogenetic relationships within Psammocyclopinidae **fam. n.**. Explanation in text.

Within cyclopinids, the new family belongs to a cluster of genera which have in common the transformation of the terminal lamellopinnate spine on third exopodal segment of leg 1 into a bipinnate seta (this element is arrowed in Fig. 4A). The other genera of cyclopinids belonging to this unnamed monophyletic subunit together with *Psammocyclopinina* and *Metacyclopinina* are: *Cyclopinodes* Wilson, 1932, *Pseudocyclopinina* Lang, 1946, *Parapseudocyclopinodes* Lindberg, 1961, *Hemicyclopinina* Herbst, 1952, *Procylopinina* Herbst, 1955, *Heterocyclopinina* Plesa, 1968, *Neocyclopinina* Herbst, 1952, and an additional as yet undescribed genus. *Psammocyclopinidae fam. n.* differs from a cluster including all other genera mentioned above in having retained 3 well-developed setae on the female sixth legs. All other genera display 2 elements at most.

The new family seems to be widely distributed in submersed sandy habitats of the world oceans. In addition to the new species and the 5 already known species (KLIE 1949, BOZIC 1953, WELLS 1967, HERBST 1974, HERBST & ZO 1981) plus the 2 undescribed species (the species wrongly indicated by WELLS (1967) as the allotype of *P. hindleyi* and the species found co-existing with *P. georgei*), 2 more records of *Psammocyclopinidae* need to be added. One concerns the species mentioned by HUYS & BOXSHALL (1991, figs 2.8.28A and 2.8.42A-C) as an undescribed new genus of Cyclopinidae collected off the southwestern coast of The Netherlands, at 6.5 m depth. The second record of which only the habitus is described (HUYS *et al.* 1994, fig. 3A), is one of the hosts of the tantulocarid *Nippotantulus heteroxenus* Huys, Ohtsuka & Boxshall, 1994, and was collected from sandy deposits off Nagannu Island, Okinawa, Japan, at 52 m depth.

LINDBERG (1952), while proposing the new genus *Metacyclopinina* mentioned a species, *Cyclopinina agilis* C. B. Wilson, 1932, described by WILSON (1932) from the eastern coast of the United States, as a possible representative of this genus. No material of this species has been available to me yet.

These data extend the distribution of the new family to the North and South Atlantic, Indian and western Pacific oceans. Thus the family seems to be distributed worldwide.

NOTE

The volume of the journal "Mikrofauna des Meeresbodens" containing the paper by HERBST (1974) was published early in 1975. Therefore, according to the ICZN the correct spelling of the species described in this paper is *M. brevisetos* Herbst, 1975.

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