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A new species of *Cyclopetta* from the Laptev Sea (Arctic Ocean), with the recognition of Cyclopettidae fam. nov., a new monophylum of free-living Cyclopoida (Copepoda)

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Abstract

Cyclopetta boetiusae sp. nov. is described from the continental shelf in the Arctic Laptev Sea. A phylogenetic analysis shows *Cyclopetta* SARS to be closely related to *Paracyclopetta* WELLS which in the future may even be synonymized with the former genus. The genus *Arctocyclopina* MOHAMMED & NEUHOF is the sister group of the *Cyclopetta-Paracyclopetta* clade. The next relative of these genera is possibly *Paracyclopina* SMIRNOV. However, incompleteness of the descriptions of the species currently ascribed to this genus, makes the polarity of several characters a matter of speculation. A new taxon Cyclopettidae fam. nov. is proposed to include all these genera. It is suggested that oithonid cyclopoids may be closely related to Cyclopettidae fam. nov.
Key words: Copepoda, Arctic Ocean, *Cyclopetta*, taxonomy

Zusammenfassung

Cyclopetta boetiusae sp. nov. wird aus der Laptev See (Arktis) beschrieben. Eine phylogenetische Analyse zeigt, daß *Cyclopetta* SARS eng mit *Paracyclopetta* WELLS verwandt ist, eine zukünftige Synonimisierung wäre sogar möglich. Die Schwestergruppe von *Cyclopetta-Paracyclopetta* ist *Arctocyclopina* MOHAMMED & NEUHOF. Schwestergruppe dieser drei Gattungen zusammen ist möglicherweise *Paracyclopina* SMIRNOV. Die Polarisierung einiger Merkmale wird durch die fragmentarische Beschreibung einiger Arten erschwert. Cyclopettidae fam. nov. wird vorgeschlagen, um diese Gattungen in ein monophyletisches Taxon zu vereinigen. Es wird weiterhin darauf hingewiesen, daß oithoniden möglicherweise eng mit Cyclopettidae verwandt sind.
Schlüsselwörter: Copepoda, Arktis, *Cyclopetta*, Taxonomie

Introduction

The knowledge of marine cyclopoid copepods of boreal and arctic waters was greatly improved by SARS (1913). In his extensive monograph, he described several species in detail. At that time, *Cyclopina* CLAUS 1862 was defined only by symplesiomorphies concerning the relatively primitive condition of the mouthparts. This situation led to a broad generic concept. Several species included by SARS into *Cyclopina*, viz. *C. longicornis* BOECK 1872, *C. elegans* SCOTT 1894, *C. euacantha* SARS 1913 have been removed from this genus by subsequent workers resulting in *Cyclopinoides longicornis*, *Cyclopinodes elegans* and *Cyclopidina euacantha*, respectively (LINDBERG 1952; STEUER 1940; WILSON 1932). Only 2 species were not ascribed by Sars to *Cyclopina* but placed into two separate new genera, viz. *Cyclopinella tumidula* Sars, 1913 and *Cyclopetta difficilis* Sars, 1913. Although not discussed by Sars in detail, he recognised great differences between *Cyclopetta* and other species of free living cyclopoids, which is evidenced by his statement (on p. 18): "This new genus in some respects differs rather conspicuously from the 2 preceding ones, and seems to exhibit a certain approach to the next anomalous genus *Pterinopsyllus*, though it is distinguished also from this genus by several well-marked characters."

After Sars description, *Cyclopetta* had never been found again. During an ongoing investigation on arctic marine copepod biocenoses several benthic samples were taken in the Laptev Sea. Some of these samples contained specimens of a new species of *Cyclopetta* which is described in detail in the present contribution. A phylogenetic analysis will discuss the relationships between *Cyclopetta* and other species currently ascribed to the paraphyletic family "Cyclopinidae".

Material and Methods

Meiobenthic samples were taken during the German expedition ARK IX/4 (August – October 1993), on board of RV *Polarstern* using a Multicorer and a Giant Box Corer. All samples were fixed with buffered formalin at a final concentration of 4%. Meiofauna was 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 at the Copepod Collection of the AG Zoosystematik und Morphologie, University of Oldenburg, Germany.

Description

Ordo Cyclopoida

Cyclopettidae fam. nov.

Diagnosis (groundpattern).

Cyclopoida. First pedigerous somite not incorporated into cephalosome. Furca short (at most 4 times as long as wide) with 7 setae, seta I located on dorsal surface behind insertion of seta II. Antennule 17-segmented in both sexes. Antenna 4-

segmented, with 2 exopodal setae. Mandibular palp consisting of basis with one inner seta, 2-segmented endopod with 3 and 6 setae and 4-segmented exopod with 1, 1, 1, and 2 setae on proximal to distal segments respectively. Maxilliped with distinct praecoxa and coxa, basis and 2-segmented endopod. Legs 1 to 4 with 3-segmented rami. First exopodal segment of legs 1 to 4 with 1 inner seta. Middle endopodal segment of leg 1 with 1, that of legs 2 to 4 with 2 inner setae. Leg 5 displaced laterally, with undivided protopod in both sexes, which is fused to the respective somite; 1-segmented exopod bearing 4 setae in female and 6 setae in male. Copulatory pore (as far as known) not located on ventral margin of genital-double somite, but probably located within gonopores.

Type genus: *Cyclopetta* Sars, 1913.
Other genera: *Paracyclopetta* Wells, 1967, *Arctocyclopina* MOHAMMED & NEUHOF, 1985.
Incerta sedis: Paracyclopina nana SMIRNOV, 1935, *Paracyclopina intermedia* (SEWELL, 1924), *Paracyclopina longifurca* (SEWELL, 1924), and *Paracyclopina minuta* (SEWELL, 1934)

Cyclopetta SARS, 1913

EMENDED DIAGNOSIS
Body cyclopiniform. First pedigerous somite confluent with cephalosome dorsally, but still subdivided laterally. Furca about twice as long as wide, with 7 setae; seta I minute, located on dorsal margin behind insertion point of seta II. Antennule 9-segmented in female. Antenna with fused syncoxa and basis, former basis with 1 inner seta and one seta representing exopod at outer corner, endopod 3-segmented. Mandible with gnathostomous gnathobasis, palp with 2-segmented endopod and 4-segmented exopod. Maxillule with only 1 seta representing coxal epipodite, endopod 1-segmented with 5 setae. Maxilliped with defined praecoxa and coxa, basis and 2-segmented endopod with setal formula 1, 3. Swimming legs with 3-segmented rami. First exopodal segments of legs 1-4 with inner seta. Middle endopodal segment of leg 1 with 1, that of legs 2 to 4 with 2 inner setae; terminal spine on third exopodal segment of leg 1 being of the lamellopinnate type. Leg 5 located laterally lacking an intercoxal sclerite, coxa and basis fused and confluent with the tergite; endopod 1-segmented with 3 long and slender bipinnate setae in female. Last thoracic and first abdominal somites of female completely fused, both dorsally and ventrally to form a genital double somite; without a clearly discernible copulatory pore (which may be incorporated into the gonopores); gonopores located laterally and covered by an operculum derived from leg 6 armed with 2 elements.

Type species: *Cyclopetta difficilis* SARS, 1913.
Other species: *Cyclopetta boetiusae* sp. nov.

Cyclopetta boetiusae sp. nov.

MATERIAL. Holotype: one female dissected and mounted on 4 slides (UNIOL collection number 1999.047/1-1999.047/4), paratype one female mounted on 1 slide (UNIOL collection number 1999.048/1).

LOCUS TYPICUS. The type material was collected using a Giant Box Corer on the continental shelf of the eastern part of the Laptev Sea (Arctic Ocean). Holotype collected on 6.9.1993 at 203 m depth (co-ordinates 77°04N 133°36E), paratype collected 1.9.1993 at 38 m depth (co-ordinates 76°30N 133°21E).

FEMALE. Body cyclopiniform, prosome ellipsoid tapering frontally, urosome narrow about as half as long as prosome (Fig. 1 A-B). Body length (measured form frontal rim of cephalosome to caudal rim of telson) 485 µm. Prosome and urosome showing symmetrical pattern of sensilla and pores (Fig. 1 A). First pedigerous somite fused to cephalosome dorsally, still subdivided on lateral margins (Fig. 1 B). Last thoracic and first abdominal somites completely fused to form a genital double-somite. Well developed pseudosomite located ventrally between fifth leg bearing somite and genital double-somite (Fig. 5 A-B). Abdominal somites with slightly undulate hyaline frills. Furca about twice as long as wide; with 7 setae (Fig 5 A, C). Furcal seta I minute, inserting on dorsal margin behind seta II at midlength of furca, seta III inserting slightly subterminally on outer dorsal corner, setae IV, V and VI inserting terminally and seta VII subterminally on inner dorsal corner. Labrum with a tuft of spinules ventrally.
Antennule short, 7-segmented (2 B). First segment with traces of subdivision. Armature formula beginning with proximal segment: 16, 4, 4, 3, 2, 2, 7 + aesthetasc.
Antenna short, 3-segmented (Fig. 3 A). Syncoxa and basis fused, with one (basal) bipinnate seta on inner distal margin and one (exopodal) bipinnate seta on outer distal corner; endopod 2-segmented with 1, and 5 + 7 setae. Distal endopodal segment compound, traces of original segmentation present on outer margin.
Mandible (Fig. 3 E) with slender gnathostomous gnathobasis, palp consisting of basis bearing one inner seta, 2-segmented endopod with 2, and 6 setae and 4-segmented exopod with 1, 1, 1, and 2 setae.
Maxillule (Fig. 3 C) praecoxal arthrite with 10 armature elements, coxa and basis apparently fused, bearing unisetose coxal epipodite and endite, and 3 basal setae; 1-segmented endopod with 5 setae; 1-segmented exopod with 4 setae.
Maxilla (Fig. 3 B) with distinct praecoxa and coxa; proximal praecoxal endite with 3 long and bipinnate setae and a short pinnate spine, distal praecoxal endite with one long seta, proximal and distal coxal endites with 2 setae each; basis with 2 robust setae; endopod 2-segmented, with 3 and 4 setae.
Maxilliped (Fig. 3 D) with well developed praecoxa and coxa; praecoxa with 2 long and 2 small setae; coxa with 2 setae; basis with 1 robust and 1 small seta; endopod 2-segmented, proximal segment with 1 robust seta, distal segment with 3 setae.
Swimming legs 1 to 4 (Figs. 4 A-B, 2 A) with small praecoxal sclerite, coxa, basis and 3-segmented rami.
Leg 1 (Fig. 4 A) with inner basal spine reaching to half of distal endopodal segment. Middle endopodal segment of leg 1 with one inner seta, that of legs 2 to 4 with 2 inner setae.

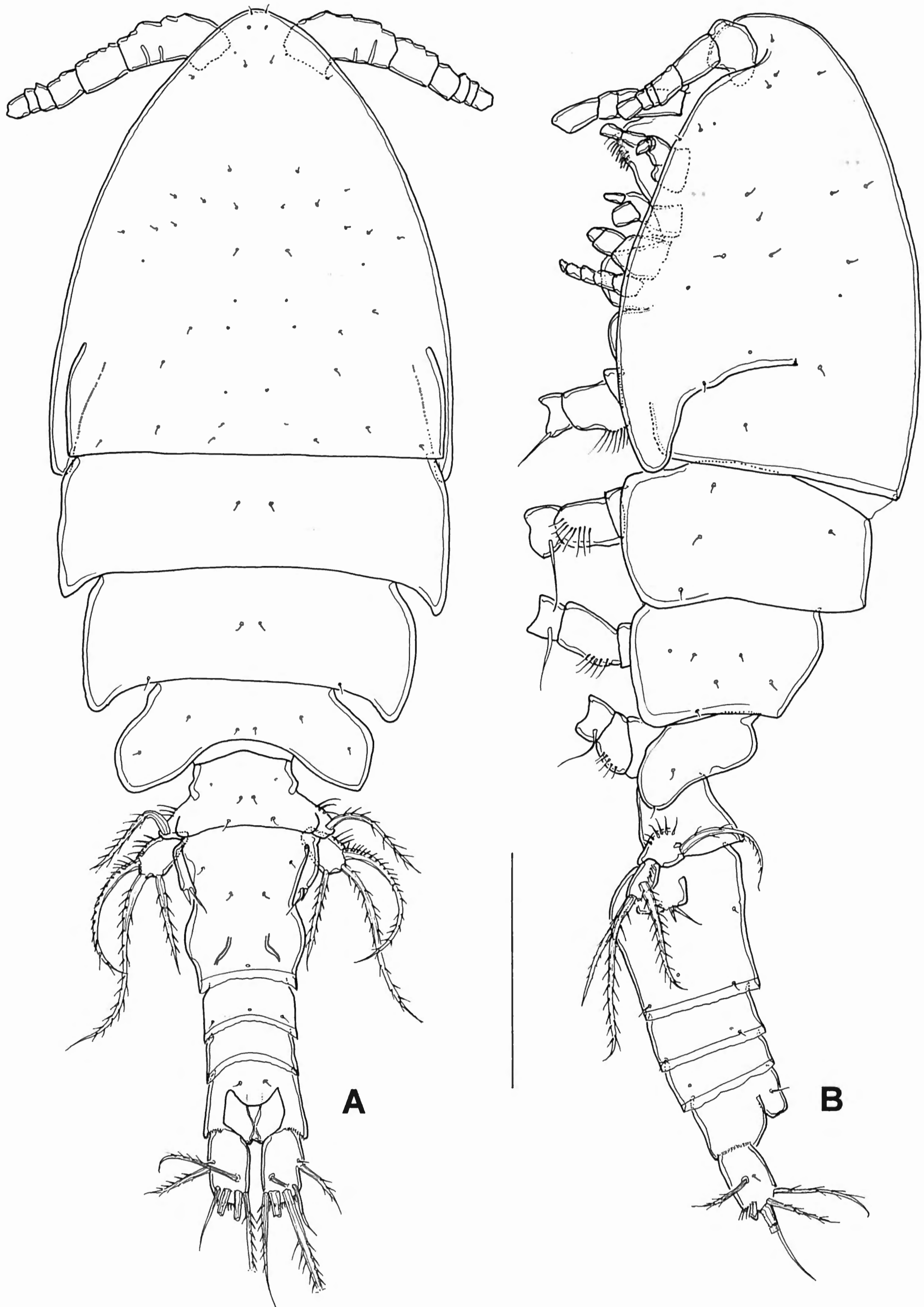

Fig. 1. – *Cyclopetta boetiusae* sp. nov. (female) Habitus. A, dorsal view. B, lateral view. Scale bar 100 µm.

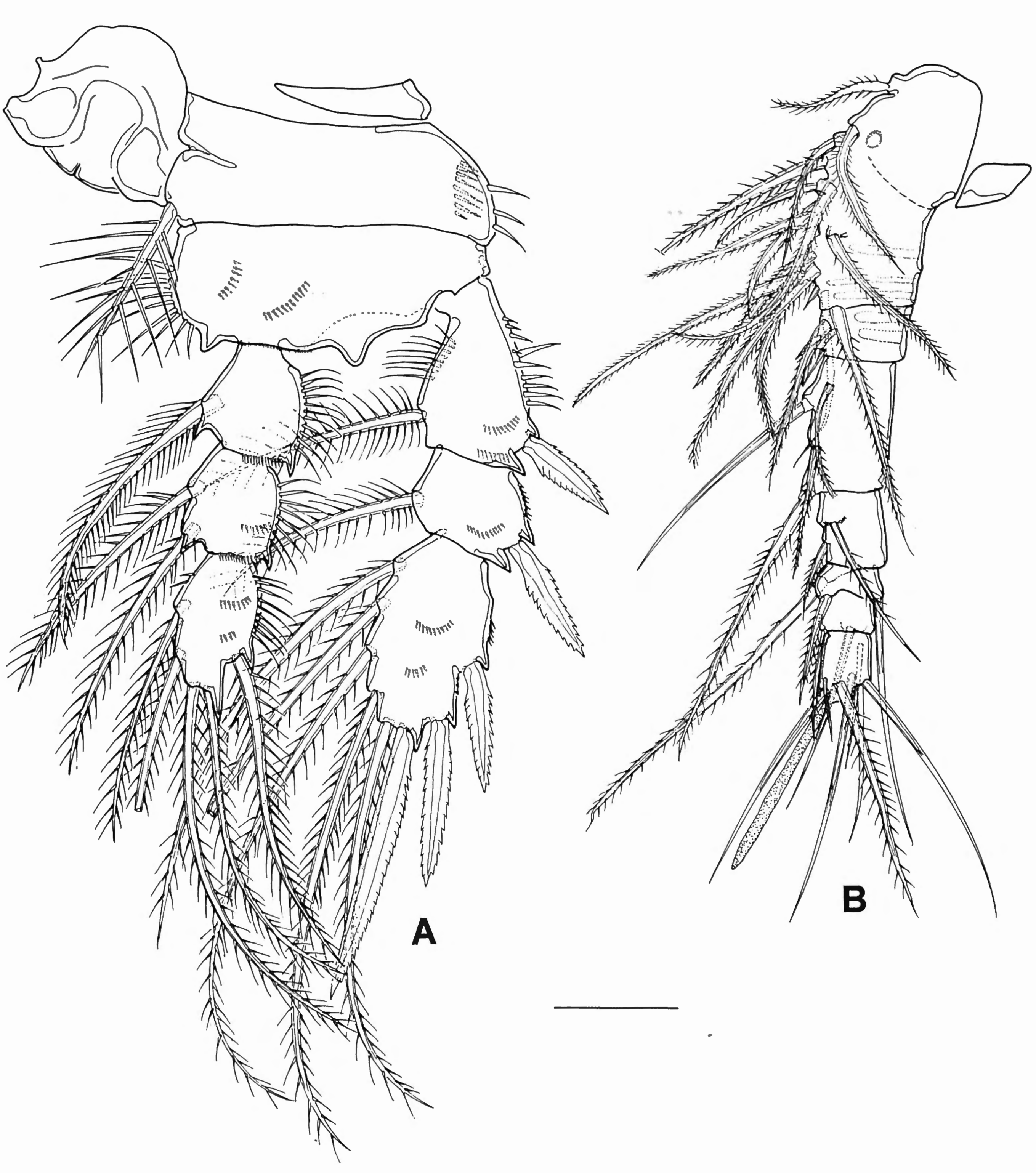

Fig. 2. – *Cyclopetta boetiusae* sp. nov. (female) A, Leg 4. B, Antennule. Scale bar 20 µm.

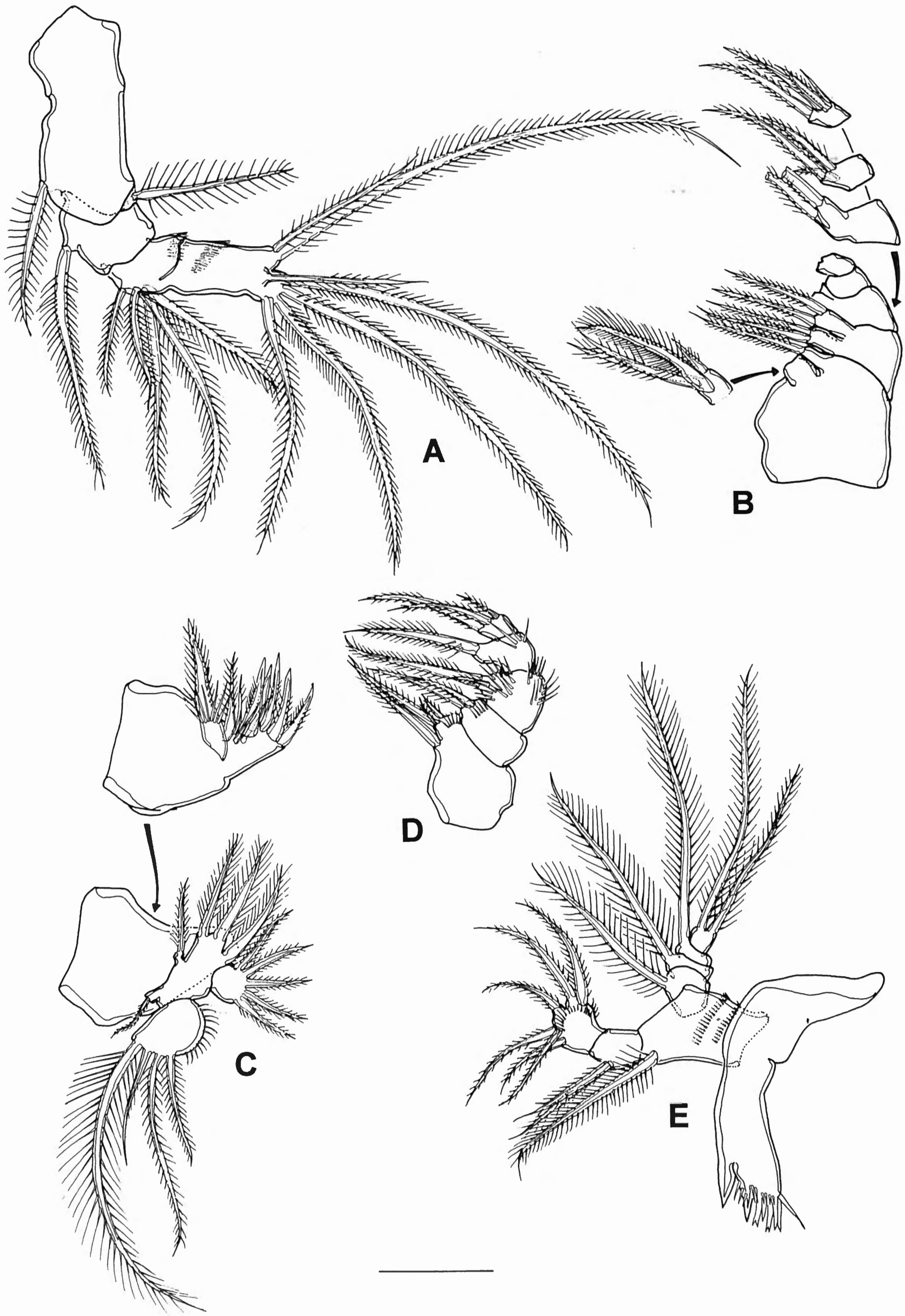

Fig. 3. – *Cyclopetta boetiusae* sp. nov. (female) A, Antenna. B, Maxilla. C, Maxillule. D, Maxilliped. E, Mandible. Scale bar 20 µm.

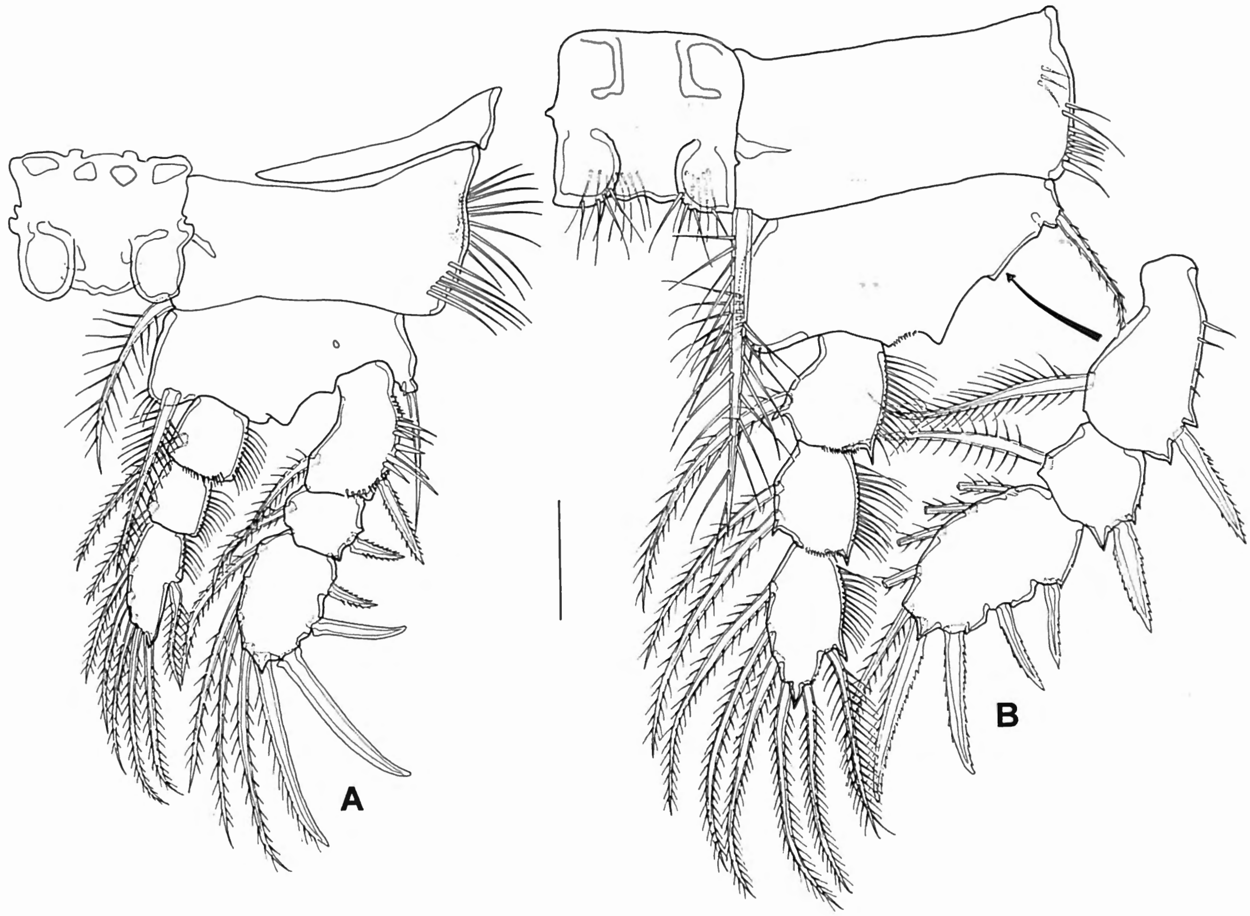

Fig. 4. – *Cyclopetta boetiusae* sp. nov. (female) A, Leg 1. B, Leg 2. Scale bar 20 µm.

Swimming legs armature formula:

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

Leg 5 located laterally (Fig. 5 A-B), without intercoxal sclerite; coxa and basis fused and confluent with somite, outer basal seta arising from a protuberance on dorso-lateral corner of somite, exopod 1-segmented with 3 well developed bipinnate setae.
Sixth legs (Fig. 5 B) a small operculum covering gonopores and armed with 2 spines.
Copulatory pore not discernible on ventral margin (Fig. 5 A), probably located within gonopores.

MALE. Unknown

VARIABILITY. The paratype displays a minute suture line possibly emarcating original division between protopod and fifth legs bearing somite.

ETYMOLOGY. The species is dedicated to my colleague the microbiologist Dr. Antje Boetius, with whom I shared the samples taken with the Multicorer and the Box Corer during ARK-IX/4 in the Arctic Ocean. In recognition of her continuous support and advice.

Discussion

The new species greatly resembles *Cyclopetta difficilis* SARS in many respects. Unfortunately, there is no type material available from the latter, so that comparison has to rely on Sars' description. According to SARS (1913) only 3 specimens of *C. difficilis* were collected off Risør on the south coast of Norway at some 20 m depth. The great geographic

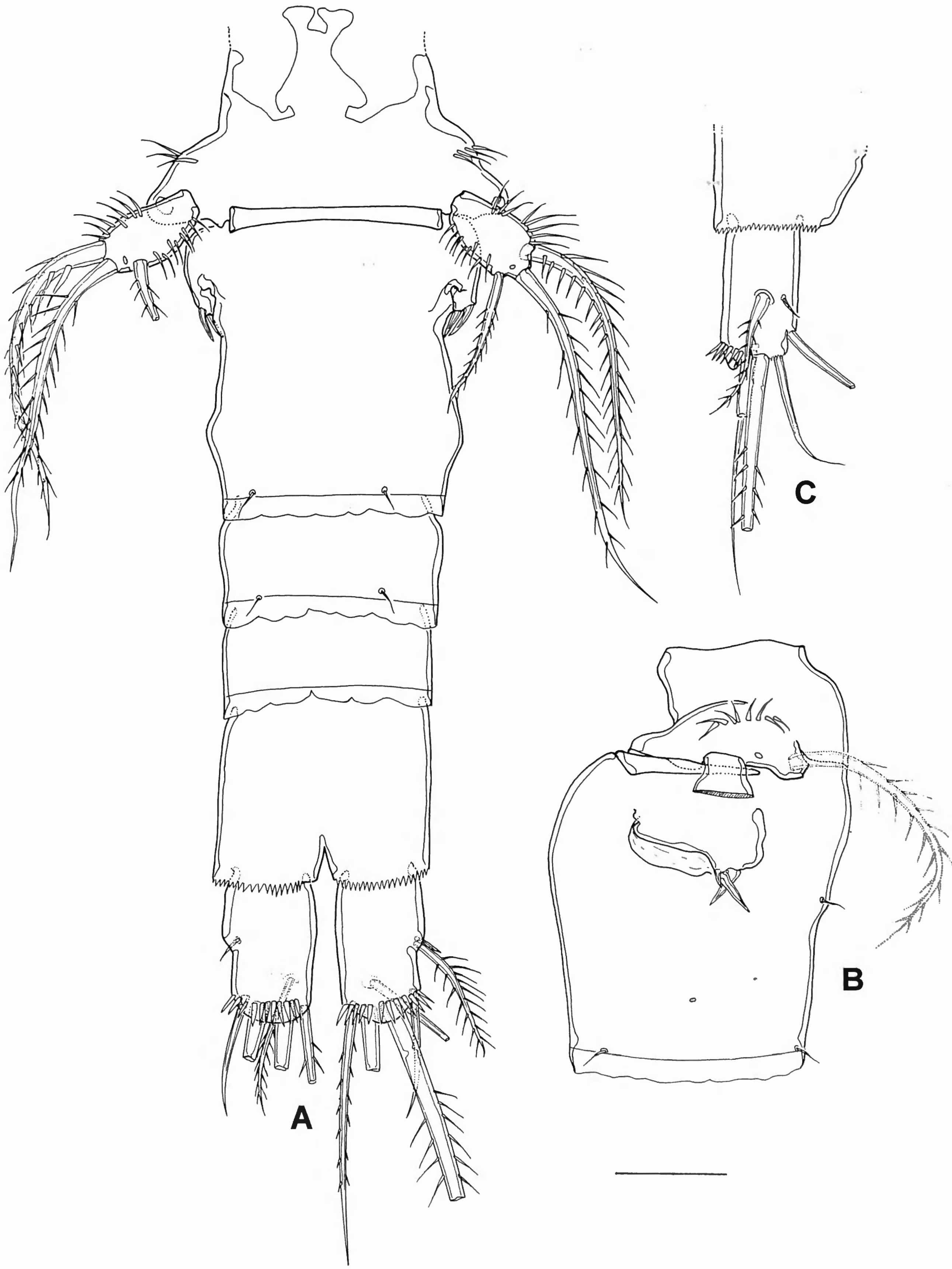

Fig. 5. – *Cyclopetta boetiusae* sp. nov. (female) A, Urosome, ventral view. B, Genital double-somite, lateral view (exopod leg 5 partially drawn). C, furca, lateral view. Scale bar 20 µm.

distance of the new finding together with differences in morphological details, to be discussed below, lead me to propose a new species for the material collected in the Laptev Sea.
Cyclopetta boetiusae sp. nov. agrees with *C. difficilis* in general body shape and prosome-urosome proportions. A median dot described by Sars on the frontal third of the cephalosome of *C. difficilis*, probably representing a nauplius eye, is not present in the specimens from the Laptev Sea. The antenna of the type species of the genus is 9-segmented, while it is 7-segmented in *C. boetiusae* sp. nov. The first segment of the new species is homologous with the first three segments of *C. difficilis*. The lack of separation of the proximal antennulary segments, probably due to a repression of segmentation during ontogeny has to be interpreted as an apomorphic character of the new species. A similar incomplete segmentation occurs between the second and third antennary endopodal segments of *C. boetiusae* sp. nov. resulting in a 2-segmented endopod, while the antennary endopod is 3-segmented in the Norwegian species. In addition, only 4 and 6 setae were depicted by Sars on the second and third endopodal segments, while 5 and 7 setae are present in the equivalent positions in the new species.
Great differences exist in the mandibular palp of both species. SARS' species has a basis with 2 inner setae, a 4-segmented exopod and an unisegmented endopod bearing 3 setae. The new species has a basis with only one inner seta, and a 2-segmented endopod with 2 setae on the proximal and 6 setae on the distal segment (no difference in exopodal segmentation and setation). Within cyclopinids the presence of 2 setae on the mandibular basis is known only from *Cyclopicina longifurcata*, all other cyclopinids having retained only 1 seta, as is the case in *C. boetiusae* sp. nov. This allows to interpret the condition present in *C. difficilis* as the result of a fusion (or lack of separation) of the basis and the proximal endopodal segment to form an allobasis (HUYS & BOXSHALL, 1990).
There are some differences in maxillulary setation. For instance, no coxal epipodite and no coxal endite are depicted in *C. difficilis*, and less armature elements are present on the praecoxal arthrite and basal endites, but this is considered here as being less important, because it may be a result of inaccurate observation, particularly because SARS himself mentioned the great difficulty (specific name!) in studying these minute structures. In the same context, the proximal praecoxal endite, which bears 4 armature elements in *C. boetiusae* sp. nov., is missing in SARS' description, but it cannot been excluded that the proximal portion of the maxilla had been damaged during dissection.
The maxilliped of the new species shows a distinct praecoxa and basis, while a syncoxa seems to be present in SARS' species. In addition, 4 praecoxal setae are present in the species from the Laptev Sea, and only one in the Norwegian species. Segmentation and setation of legs 1 to 4 are identical in both species, despite some minor differences in the relative lengths of some armature elements (inner basal spine leg 1, inner coxal seta leg 2, etc.). The new species also agrees with *C. difficilis* in the setation and condition of leg 5, which has a coxo-basis which is confluent with the respective somite. The fifth legs are displaced laterally and lack an intercoxal sclerite (the sclerite depicted in figures 5 A-B represents a ventrally located pseudosomite as is present at this location in most cyclopinids).
A very remarkable feature is the absence of a ventrally located copulatory pore in *C. boetiusae* sp. nov. The copulatory pore probably is displaced to the lateral margins and is placed within the gonopores. Unfortunately, no drawings of the ventral side of the genital double-somite are provided by Sars.

Phylogenetic considerations

In his extensive study of the Copepoda of Inhaca Island (Mozambique), WELLS (1967) described a new genus and species *Paracyclopetta prima* WELLS, 1967. This remarkable species, as already recognised by WELLS (1967), seems to be closely related to *Cyclopetta*. It shares with *Cyclopetta* a first pedigerous somite which is fused with the cephalosome dorsally but separated laterally; the 9-segmented condition of the antennule; segmentation and setation of maxillule, maxilla and maxilliped; armature of legs 1 to 4; and a 1-segmented leg 5 exopod with 3 setae. It differs from *Cyclopetta* as redefined herein in having a circular prosome, while it is ellipsoid in both species of *Cyclopetta*; in having an asetose antennary syncoxo-basis, and in apparently having retained a distinct protopod of leg 5, the protopod being confluent with the somite in both species of *Cyclopetta*. Unfortunately, the type material of *Paracyclopetta prima* has been lost (personal communication of the crustacean curator of The Natural History Museum in London), so that a detailed comparison and re-evaluation of various characters of phylogenetic importance (whether legs 5 are displaced laterally, position of copulatory pore) have to await the discovery of additional specimens. It has to be noted that suture lines indicating original separation of leg 5 protopod and somite are present in some specimens of *Cyclopetta boetiusae* sp. nov. and *Arctocylopina pagonasta* (see below) so that the 2-segmented condition described for *Paracyclopetta* requires reconfirmation.
Within cyclopinids *Arctocyclopina pagonasta* MOHAMMED & NEUHOF, 1985 described from the annual sea ice in the Arctic Frobisher Bay (Northwest Territories, Canada) shares some potential apomorphies with *Cyclopetta* and *Paracyclopetta*. The following characters have been reconfirmed studying the type material of *Arctocyclopina*: i) endopod of maxilliped only 2-segmented, ii) legs 5 displaced laterally, iii) leg 5 with protopod confluent with somite (some specimens of the type series appear to have a minor suture line indicating original segmentation) and without intercoxal sclerite, iv) no ventrally located copulatory pore discernible on female genital double-somite. The study of the type material of *Arctocyclopina* was rendered difficult by the fact that the specimens were over-clarified by the mounting medium, some were squashed by the coverslip or simply mounted in an unfortunate position for study of the desired characters. For this reason the validity of character iv) should be confirmed by studying wet material of this species, not available in the present context.
The study of the types of *Arctocyclopina* revealed some minor differences from the original description to be mentioned here. The male antennule in my interpretation is not 16-segmented but 17-segmented due to a visible subdivision of the

9th segment; the female antennule is 15-segmented with a setal formula (beginning with the proximal segment) 3/ 5/ 12/ 6/ 1/ 1 + aesthetasc/ 1/ 1/ 1/ 1/ 1 + aesthetasc/ 2/ 1 +1/ 2 + aesthetasc/ 7 + aesthetasc; the maxillule has a coxal endite bearing one seta and one additional seta is present on the dorsal surface of the praecoxal arthrite; the maxilla has a clear subdivision of praecoxa and coxa at least in one of its sides, and its basis bears an additional small seta behind the claw; the maxillipedal syncoxa has three endites with setal formula of 1/ 3/ 2; finally, there is a minute furcal seta I inserting on the dorsal margin behind seta II (exactly the same position as in *Cyclopetta boetiusae* sp. nov.).

In comparison with the *Cyclopetta-Paracyclopetta* clade *Arctocyclopina* has retained several plesiomorphic characters viz. (condition present in the *Cyclopetta-Paracyclopetta* clade in brackets) a 15-segmented female antennule (9-segmented), 2 setae representing the antennary exopod (1 seta), 3 setae on first mandibular endopodal segment (2 setae), 3 and 2 setae on proximal and distal maxillulary basal endites (2 and 1 setae), 7 setae on maxillulary endopod (5 setae), 3 elements on each of the maxillary coxal endites (2 setae on each), 2 and 4 setae on proximal and distal maxillipedal endopodal segments (1 and 3 setae), and 4 setae on female leg 5 exopod (only 3 setae).

There are some badly described and little known cyclopinids from the Asian Pacific and Indian coasts that may belong to the Cyclopettidae fam. nov. as defined herein. These species are *Paracyclopina nana* SMIRNOV, 1935, *Cyclopina intermedia* SEWELL, 1924, *Cyclopina longifurca* SEWELL, 1924 and *Cyclopina minuta* SEWELL, 1934. I have been unable to find the type material of these species; my search rather indicates that no type material is still in existence. Therefore, I propose to include these taxa as *incertae sedis* within Cyclopettidae fam. nov. until the rediscovery of these species.

Paracyclopina nana is known from Jotschichesa, one of the arms of the Suifun delta, near Wladiwostok. This species has been described very incompletely by SMIRNOV (1935). Only the habitus, leg 4, male abdomen and leg 5 of both sexes have been figured. The written description, however, is very informative, allowing comparison with other species of the Cyclopettidae fam. nov. Two-segmented maxillary and maxillipedal endopods together with legs 5, being displaced laterally so that they are clearly visible in dorsal view and having protopods confluent with the segment indicate that this species belongs to the new family. *Paracyclopina nana* is very similar to *Arctocyclopina pagonasta*, especially in the relative proportions and shape of prosome-urosome, and the shape of the furca. It can be distinguished from the latter species in having a 17-segmented female antennule (15-segmented in *Arctocyclopina*), a spine on the inner margin of leg 5 instead of a seta (in *Arctocyclopina*), 3 outer spines on the third exopodal segment of leg 3 (2 in *Arctocyclopina*) and in having 3 outer spines on the third exopodal segment of leg 4 instead of 2. The presence of only 2 outer spines on the third exopodal segment of leg 3 is an autapomorphy of *Arctocyclopina*, because other cyclopinids have 3 spines (this being the condition in the groundpattern of Copepoda). In contrast, the presence of 2 outer spines on the third exopodal segment of leg 4 is an autapomorphic character of the groundpattern of Cyclopoida (i.e. a symplesiomorphy within the group). Should 3 spines at this location be confirmed in the future for *Paracyclopina nana*, this would have to be interpreted as a (secondary) reacquisition of one outer element, i. e. an apomorphy of this species.

The discussion of SEWELL's species is more difficult, because they are so fragmentarily described that one cannot do much else but speculate on their phylogenetic relationships. Some facts, however, can be considered here. Firstly, the similarity between *Paracyclopina nana*, *Cyclopina intermedia* and *Cyclopina longifurca* was recongised already by SMIRNOV (1935), who although frustrated by the lack of detail in SEWELL's descriptions postulated to unify the Indian species with *Paracyclopina nana* in one systematic unit. Smirnov most likely did not know *Cyclopina minuta* which was described by Sewell almost at the same time (SEWELL 1934). The fifth legs of C. *intermedia* and *C. minuta* are clearly visible in the drawings of the dorsal habitus, so that one may conclude that these limbs are displaced laterally as is the case in other members of Cyclopettidae fam. nov. (pending confirmation for *Paracyclopetta*). However, some confusion concerning the segmentation of leg 5 arises from SEWELL's description. According to SEWELL (1924), leg 5 of *C. intermedia* consists of a '...basal portion of two segments and a terminal joint ... the second basal joint bears a single marginal seta ... the distal joint bears three spines...'. It seems that the protopod is divided into a distinct coxa and basis, however, his figure shows an undivided protopod. According to the same author leg 5 of *C. longifurca* consists of a '...basal portion that bears a single external seta and a single free segment...'. One may conclude from this that *C. longifurca* has an undivided protopod and that it is confluent with the somite. Finally SEWELL (1934) describes leg 5 of *C. minuta* as consisting of a '... basal segment that is fused with the thoracic segment and bears a long seta on its outer border... and a free segment...'. STEUER (1940) recognised the similarities between SEWELL's species and *Paracyclopina*, but surprisingly decided to include them into the genus *Cyclopinella*. STEUER's decision was wrong as will be argued elsewhere. These contradictions were recognised by LANG (1946) who compared SEWELL's drawings and concluded that probably leg 5 is 1-segmented in all of the species described by him from India and proposed to include all 3 species into the genus *Paracyclopina*. Finally, HERBST (1953) had the opportunity to study material of *Paracyclopina longifurca* (SEWELL) sent to him by LINDBERG and definitively could confirm that the protopod of leg 5 of this species is fused with the somite, and that the external (basal) seta arises from the outer corner of the somite. The same condition was confirmed by LINDBERG in a letter to HERBST for *Paracyclopina intermedia* (SEWELL). A further similarity of these species with *Paracyclopina nana* and the rest of the Cyclopettidae fam. nov. is the 2-segmented condition of the maxillipedal endopod. All 4 species currently ascribed to *Paracyclopina* live in riverine, brackish or fresh waters. It is therefore interesting to note that *Arctocyclopina* was found in Arctic sea ice (MOHAMMED & NEUHOF, 1985). This is a milieu that potentially develops brackish water conditions. The colonisation of sea ice by *Arctocyclopina* may even be favoured by the input of riverine ice during spring and summer.

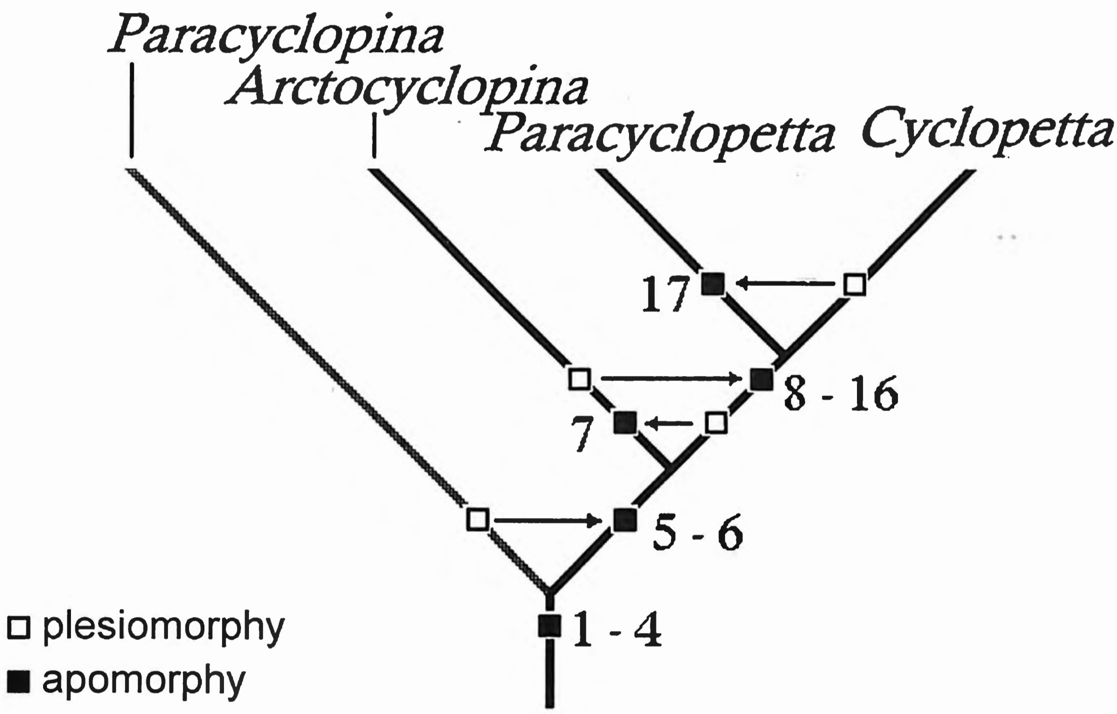

Fig. 6. – Phylogenetic relationships within Cyclopettidae fam. nov.

The nature of the armature elements on leg 5 in the Cyclopettidae fam. nov. deserves special attention. In *Cyclopetta* all elements are bipinnate slender setae. This seems to be the case also in *Paracyclopetta prima* (WELLS 1967). *Arctocyclopina* has bipinnate setae too (MOHAMMED & NEUHOF 1985; and personal observation). However, the innermost element on leg 5 of *Paracyclopina nana* is a strong spine (SMIRNOV 1935). The Indian species *P. longifurca, P. intermedia* and *P. minuta* seem to carry two outer spines, one terminal slender seta and one inner spine (SEWELL 1924, 1934). If *Paracyclopina* is to be included into the Cyclopettidae fam. nov., one has to assume within the family a gradual modification of the spines on leg 5 into setae. The absence of spiniform elements on this leg should then be interpreted as a synapomorphy of *Cyclopetta, Paracyclopetta* and *Arctocyclopina.*

When discussing the phylogenetic relationships of Cyclopettidae fam. nov. within Cyclopoida attention must be paid to the oithonids as a possible sister group. It is clear that oithonids evolved as a specialised lineage within the paraphyletic 'Cyclopinidae' and colonised very successfully the open water column, becoming planktonic. Oithonids show a number of similarities with Cyclopettidae fam. nov., viz. displacement of the fifth legs to a lateral position, loss of its intercoxal sclerite, fusion of its protopod with the somite, and migration of the primitively ventrally located copulatory pores to a lateral position in association with the gonopores. However, an internal analysis of the phylogenetic relationships between *Limnoithona* BURCKHARDT (BURCKHARDT 1912; ZHANG & LI, 1976; FERRARI & ORSI 1984) Oithonidae and Speleoithonidae ROCHA & ILIFFE (ROCHA & ILIFFE 1991) is required, before the phylogenetic position of the oithonid complex within cyclopinids can be assessed.

The phylogenetic relationships within Cyclopettidae fam. nov. as discussed herein can graphically be represented in a phylogenetical argumentation scheme (Fig. 7). Characters used for this analysis are numbered below. Table 1 shows a compilation of the polarity and occurrence of each character in form of a character matrix. This graphical representation shows that no important synapomorphies could be found for the genus *Cyclopetta*, yet a great number of characters supports the monophyly of the *Paracyclopetta-Cyclopetta* clade. This suggests that *Paracyclopetta prima* should rather be included in *Cyclopetta,* since virtually no differences exist between these genera. Due to the lack of type material this step can only be made after examination of new specimens of *Paracyclopetta prima.*

List of characters (plesiomorphic condition in brackets):

1. No ventrally located copulatory pores; (ventrally located).
2. Leg 5 protopod fused with somite; (protopod free, articulating with somite).
3. Leg 5 displaced to lateral position; (ventrally located).
4. Endopod of maxilliped 2-segmented (3-segmented or more).
5. Antennule of female 15-segmented (17-segmented).
6. Innermost armature element of leg 5 being a seta; (a spine).
7. Third exopodal segment of leg 3 with 2 outer spines (3 outer spines).
8. Tergite of first pedigerous somite fused to cephalosome dorsally; (free).
9. Female antennule 9-segmented; (15-segmented or more).

10. Leg 5 with only 3 armature elements; (4 elements).
11. Antennary exopod with 1 seta; (2 setae)
12. First endopodal segment of mandible with 2 setae; (3 setae).
13. Proximal and distal maxillulary basal endites with 2 and 1 setae; (3 and 2 setae).
14. Maxillulary endopod with 5 setae; (7 setae).
15. Maxillary coxal endites with 3 elements each; (3 on each).
16. Proximal and distal maxillipedal endopodal segments with 1 and 3 setae (2 and 4).
17. No antennary exopod; (represented by 1 seta)

Character matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Paracyclopina	?	1	1	1	0	0	0	0	0	0	0	?	?	?	?	?	0
Arctocyclopina	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Paracyclopetta	?	?	?	1	1	1	0	1	1	1	1	1	1	1	1	1	1
Cyclopetta	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0

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