

RESULTS OF THE DIVA-1 EXPEDITION OF RV “METEOR” (CRUISE M48/1)

**A new species of *Paranannopus* Lang, 1936 (Copepoda, Harpacticoida, Pseudotachidiidae) with atrophic mouthparts from the abyssal of the Angola Basin**

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**Abstract**

Within the multicorer deep-sea samples of the DIVA 1 expedition (METEOR cruise M48/1) some male harpacticoid specimens with strongly reduced mouthparts have been collected, each of them representing a hitherto unknown species. Despite their atrophic mouthparts, they can be identified easily as members of the Paranannopinae Por, 1986 because of showing the characteristic swimming-leg sexual dimorphisms of the latter.

In the present paper, a species of Paranannopinae with reduced mouthparts is described for the first time. At the present state of systematic discussion the new species has to be placed within *Paranannopus* Lang, 1936.

Males with atrophic mouthparts have been sporadically described also from other harpacticoid families (such as e.g. Argestidae Por, 1986 and Aegisthidae Giesbrecht, 1892) and the phenomenon is likely to be sexually dimorphic. This kind of sexual dimorphism within harpacticoid copepods combined with enlarged antennular aesthetacs seems to be predominantly a deep-sea phenomenon.

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**Keywords:** Deep sea; *Paranannopus*; Copepoda harpacticoida; Paranannopinae; Atrophic mouthparts; Sexual dimorphism

**Introduction**

During the DIVA-1 campaign of RV “Meteor” in summer 2000 (M48/1) up to 400 species (the total number will be still higher) of harpacticoid copepods have been registered from the abyssal Angola Basin at about 5400 m depth by a first evaluation of the sampled material. The DIVA-1 expedition had, among others, the purpose to investigate the abyssal of the Angola Basin for latitudinal diversity gradients. As for the Copepoda Harpacticoida, Pseudotachidiidae Lang, 1936, Argestidae Por, 1986, Ameiridae Monard, 1927, and Ectinosomatidae Sars, 1903 turned out to be the richest taxa in terms of species and individuals (for

detailed information and data about the project see Rose et al. (2005).

The Pseudotachidiidae are a quite large and successful taxon within the Harpacticoida concerning number of species and subtaxa as well as a worldwide distribution range. Many species are known from the deep sea. Several monophyletic subgroups have already been identified (Hicks 1988, Willen 1996, 1999, 2000), as there are the Paranannopinae Por, 1986, Pseudomesochrinae Willen 1996, Donsiellinae Lang, 1944, *Pseudotachidius* T. Scott, 1898 (compare Hicks 1988; Willen 1996, 1999; Veit-Köhler and Willen 1999). *Idomene* Phillipi, 1843 and *Dactylopodella* Sars, 1905 are not yet or only partly revised (Hicks 1989; Willen 1999). A well-represented pseudotachidiid subtaxon in the DIVA 1 samples are the Paranannopinae. Among them, several male specimens of the genus *Paranannopus* Lang, 1936,

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showing various degrees of mouthpart atrophy, have been encountered. One of these species, *Paranannopus arndwilleni* sp. n., will be described in the present paper. Up to now no explicit description of any paranannopid species with atrophic mouthparts is available in the literature. Two specimens of the new species have been found, interestingly enough, at the northernmost station 346 and the southernmost station 325, respectively, both locations being 300 nm apart.

Station 346 turned out to be much more diverse and show more abundance of harpacticoid copepods than station 325. Differences in food availability over space and time are assumed to be of importance for the different patterns of diversity at both stations (Kröncke and Türkay 2003; Rose et al., 2005).

## Material and methods

Holotype and allotype were preserved in 5% buffered formalin and subsequently transferred to glycerine. Drawings were made with the aid of a camera lucida on a Leica Diaplan microscope equipped with UCA condenser, IC prism and doubler  $\times 15$ . The dissected parts are mounted on several slides. The terminology is adopted from Lang (1948, 1965) except for the segmental composition of mandible, maxilliped and the numbering of the furcal setae, in which cases Huys and Boxshall (1991) have been followed. Abbreviations used in the text: F.R.: furcal rami, Aes: aesthetasc, exp: exopodite, enp: endopodite, “enp1”: first segment of endopodite, Md: mandible, Mxl: maxillula, Mx: maxilla, Mxp: maxilliped, P1–P6: swimming legs 1–6, benp: baseoendopodite of P5. Ro: rostrum, Ceph: Cephalothorax.

The term groundpattern is used in the sense of “Grundmuster” (Ax 1984, p. 156).

### *Paranannopus arndwilleni* sp. n.

Two out of four stations in the Angola Basin were sampled replicatively using a multicorer during the DIVA-1 campaign of the RV “Meteor” M48/1 from 07/06/2000 to 08/08/2000. Station 325 (19°58.291'S, 002°59.682'E; depth: 5494 m) was located 300 nm southwest of station 346 (16°17.024'S, 005°27.021'E; depth: 5433 m). Food availability and sediment structure were different at these stations. The treatment of the samples is described in detail by Rose et al. (2005). Two male specimens were collected: the holotype specimen at station 346 and the paratype specimen at station 325. The type material is stored in the copepod collection UNIOL of the AG Zoosystematik und Morphologie at the C.v.O. Universität Oldenburg, Germany. Catalogue No.:

- Male holotype: UNIOL 2004.001.
- Male paratype: UNIOL 2004.002.

## Etymology

The species is named after my brother Arnd Willen, Bremen, Germany.

### Description of male holotype

Body length (incl. rostrum and without furcal rami): 256  $\mu\text{m}$ .

Maximum body width (measured at rear margin of cephalothorax): 70  $\mu\text{m}$ .

Furcal rami length: 31  $\mu\text{m}$ .

**Rostrum** (Figs. 1A, B, 2): large, not completely demarcated from but medially fused with cephalothorax, tip bifid, with one pair of longer sensilla.

**Body** (Figs. 1A, B, 5A): cephalothorax only slightly longer than broad, cephalic shield dorsally with sensilla, pores and cuticular ridges. Posterior margin of each body somite (excluding anal and penultimate somite) with sensilla. Urosomites ventrally with rows of large spinules on distal margins and smaller ones on surface (Figs. 1A, B, 5A). Dorsal surface with rows of tiny spinules (Fig. 1A, B). Cuticle of whole body dorsally with cuticular ridges, hyaline frills spinulose. Anal somite completely divided with two dorsal sensilla, anal operculum absent, pseudoperculum present (Fig. 1B). Furcal rami (Figs. 1 and 5) 2.7 times longer than broad, furcal setae: I absent, II+III smooth and slender, II located at outer margin, III subapically at outer edge, IV and V slender, slightly displaced towards inner margin, terminal margin ventrally covered by large terminal pore, VI smooth and slender, located at inner edge, VII biarticulated, on dorsal surface.

**Antennule** (Fig. 2): subchirocer, 7-segmented, setal armature as follows:

I(1); II(1); III(8); IV(6); V(9+aes); VI(1); VII(9+aes). Segments short, broader than long, except for VII, aesthetasc on V enlarged, segment V only slightly swollen, of almost square shape, with basal sclerite.

**Antenna** (Fig. 3D): allobasis with long abexopodal pinnate seta in proximal half; exp three-segmented, with 2–1–(1+2) setae, one apical seta much shorter than the other; enp with spinule row along abexopodal margin, another spinule row on apical margin; subapical armature consisting of one strong pinnate spine, one smaller geniculate seta and one slender spine; apically with five setae: two slender spines, three geniculate setae, the outermost of which large and pinnate.

**Mouthparts** (Fig. 3A): completely absent, labrum consisting of slightly atrophic lobe with spinules on anterior margin and pores.

**Maxilliped** (Fig. 3A): consisting only of small rectangular lobe with pinnate seta (probably representing syncoxal seta) and another seta of hyaline appearance being basically fused (probably representing basal claw).



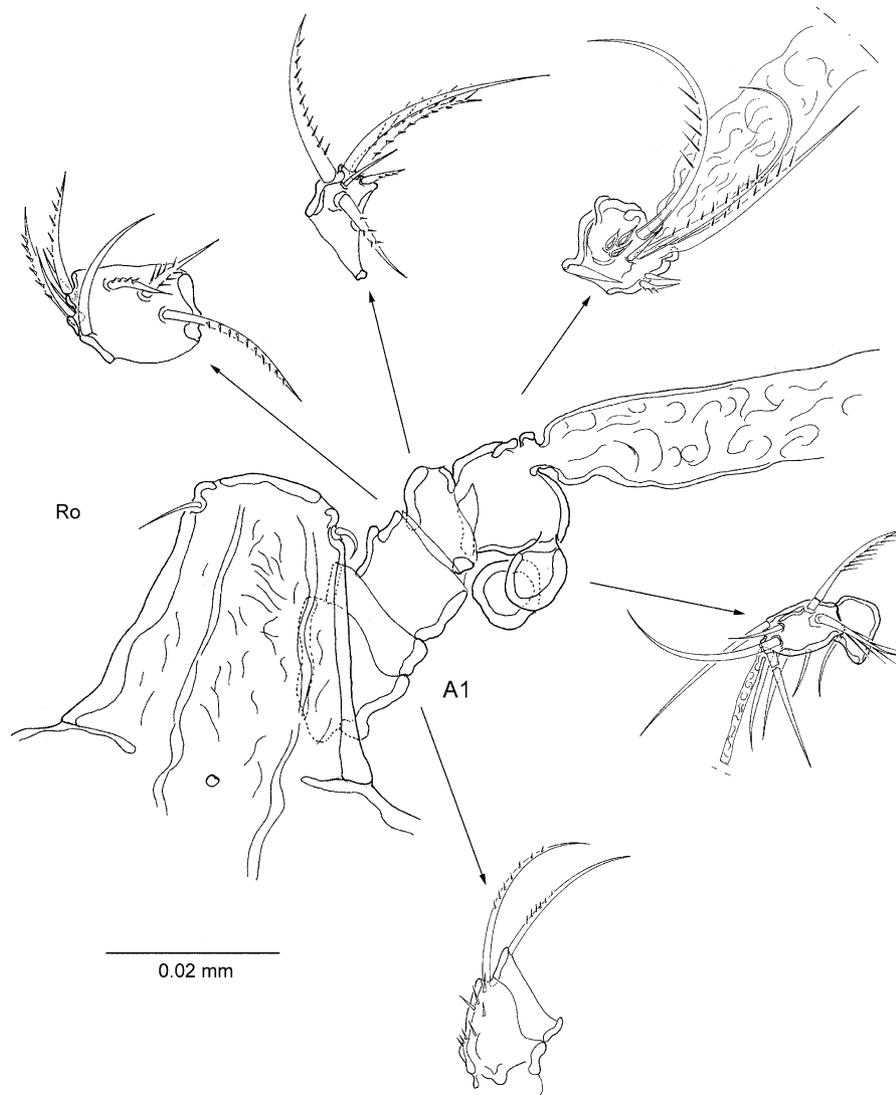
**Fig. 1.** *P. arndwilleni* sp. n., male holotype: (A) habitus from lateral view, (B) habitus from dorsal view.

**P1** (Fig. 3B): coxa of rectangular shape with spinule rows on outer margin and on anterior surface. Basis with pinnate outer and large pinnate inner spine with rounded tip; terminal margin, anterior surface and base of inner spine with spinule rows. Exp three-segmented, outer margins with spinules; exp1 and 2 each with one outer pinnate spine, exp1 slightly longer than exp2 and 3, exp2 with plumose inner seta; exp3 with two outer pinnate spines and two long plumose terminal setae; enp2-segmented, enp1 and enp2 of almost equal length, with spinules along outer and distal margin of enp2, enp1 with one short inner plumose seta, enp2 with two long, plumose terminal setae and one outer pinnate spine.

**P2–P4** (Figs. 4A–C, 5B). Exps and enps 3-segmented, except for P4 enp being 2-segmented. Coxa of P2 with spinule rows on distal margin. Basis with small pinnate outer seta and a spinule rows at distal margin. Exopodites of P3 and P4 are damaged in both specimens but setal formulae still ascertainable:

Setal formulae (after Lang 1948)

	Exp	Enp
P2	0–1–2, 2, 1	1–1–3, 1, 0
P3	0–1–3, 2, 1	1–1–0, 2, 1
P4	0–1–3, 2, 1	1–1, 2, 0



**Fig. 2.** *P. arndwilleni* sp. n., male antennule and rostrum.

P2 and P3 showing the characteristic paranannopid sexual dimorphism: outer segmental apophysis on P2enp2 long and pinnate, enp3 slightly deformed, modified terminal seta inserting on segmental process, being thickened, smooth and rounded. P3enp2 with outer segmental apophysis of slightly hook-like shape.

**P5 (Fig. 4D):** pair of legs including respective exp and benp fused to a single plate, basal/exopodal part with pinnate outer seta and two smaller inner setae, endopodal setation consisting of one smooth seta inserting medially.

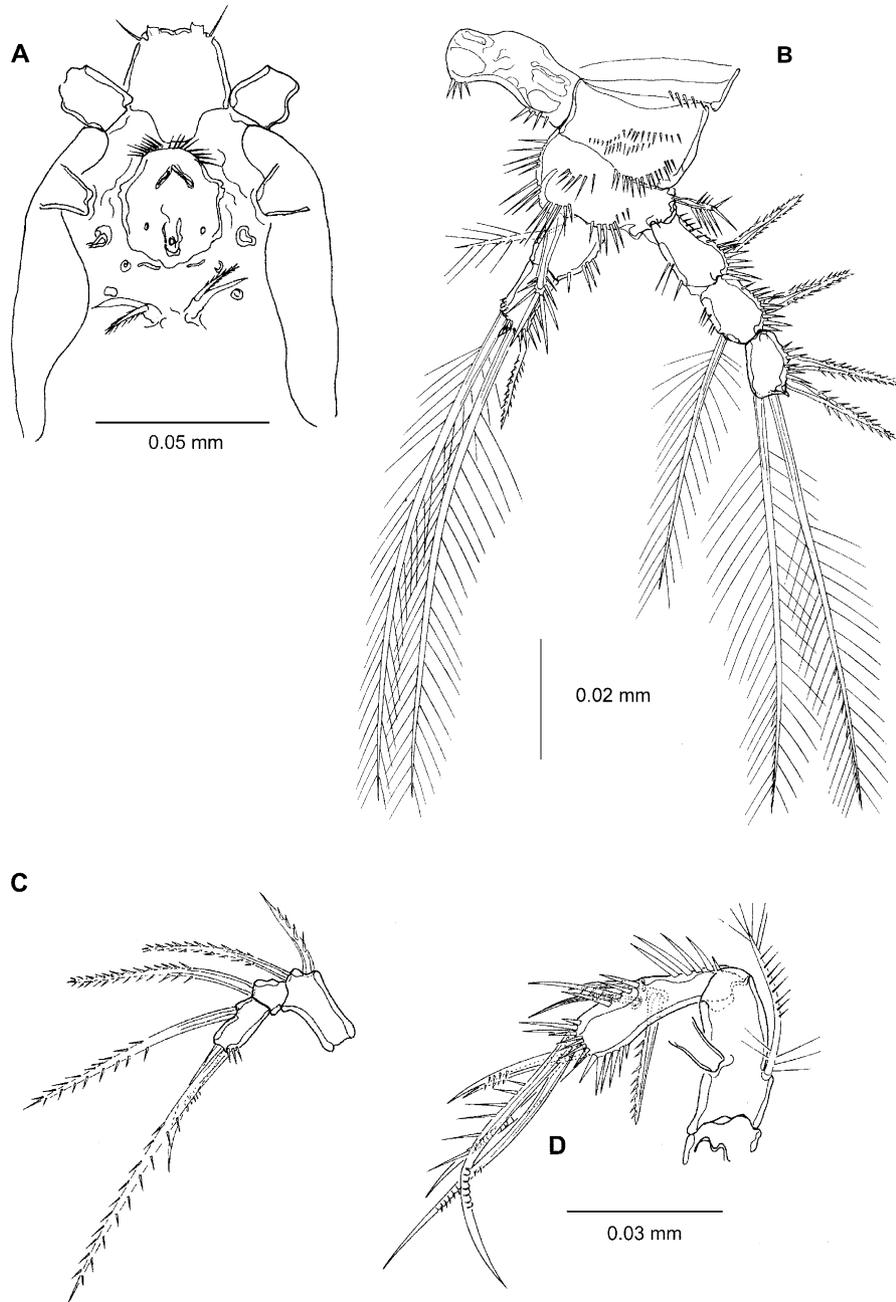
**P6 (Fig. 4D):** pair of legs fused medially, P6 consisting of small lobe with two setae.

## Discussion

The Paranannopinae have been thoroughly revised in the past decade by [Gee and Huys \(1990, 1991, 1994\)](#) and

[Huys and Gee \(1992, 1993, 1996a, b\)](#) including re-descriptions of old material, establishment of several new genera and discussion of phylogenetic lineages within the taxon. One of these lineages, e.g., comprising *Leptotachidia* [Becker, 1974](#), *Micropsammis* [Mielke, 1975](#), *Telopsammis* [Gee and Huys, 1991](#), *Paradanielsenia* [Soyer, 1970](#), *Jonesiella* [Brady, 1880](#), *Sentiropsis* [Huys and Gee, 1996](#), *Peltisenia* [Huys and Gee, 1996](#) (compare [Huys and Gee, 1996b](#)), is convincingly characterised by the presence of mouthpart aesthetascs which are always located on homologous setae on Md, Mxl and Mx.

On the other hand, the “paranannopid branch” according to [Huys and Gee \(1996b\)](#) is linked by a typically enlarged and modified subapical seta of A2 enp, the distal outer spine of P1exp3 shorter than middle one, P5benp and exp fused. The genera placed into this group by [Huys and Gee \(1996b\)](#) are *Paranannopus* [Lang, 1936](#), *Cylindronannopus* [Coull, 1973](#), *Fladenia* [Gee](#)



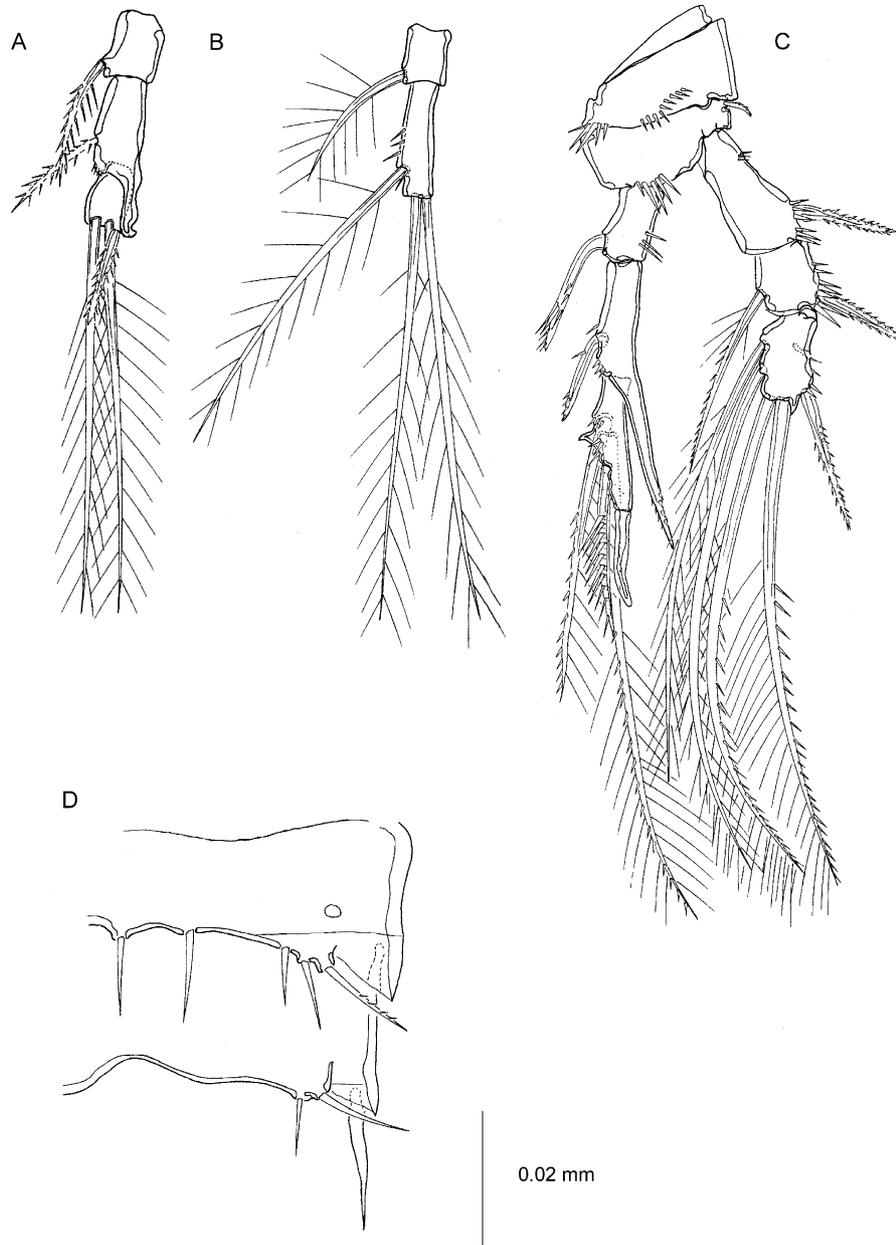
**Fig. 3.** *P. arndwilleni* sp. n., male holotype: (A) atrophic mouthparts from ventral view; (B) P1; (C) exopod of Antenna; (D) Antenna.

and Huys, 1990, *Bathypsammis* Huys and Gee, 1993, *Anapophysia* Huys and Gee, 1996.

At present 22 species of *Paranannopus* Lang, 1936, mainly from the deep sea, are described. The deepest reported location (Becker and Schriever 1979) is the Peru Trench (*P. reductus* and *P. truncatus* Becker and Schriever, 1979, from 6100 m depth), which is also the only one known from the Pacific.

The monophyly of the taxon has yet to be verified. Obvious characters as an in some aspects modified female A1 and a modified terminal seta on A2 exp, seem

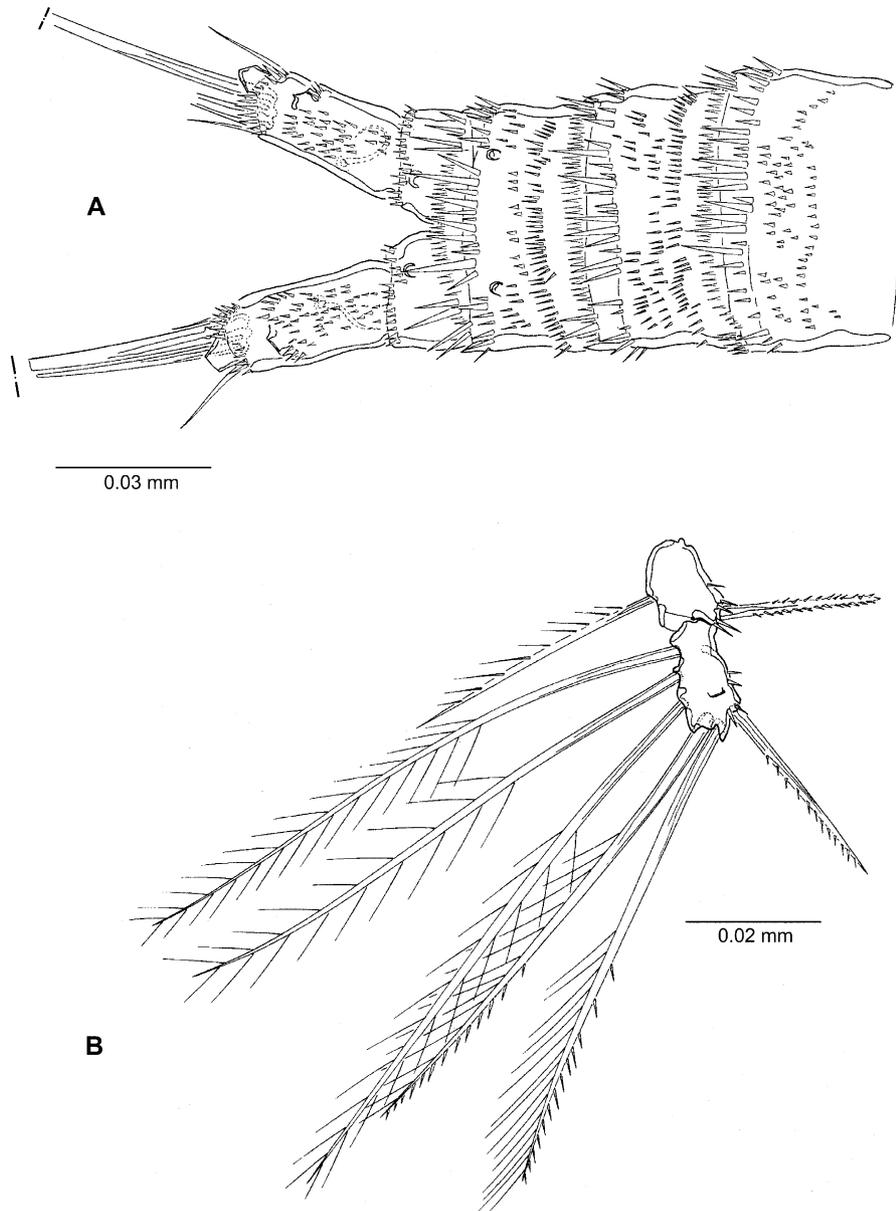
also to be present in e.g. *Fladenia* and/or *Bathypsammis*. However, although a thorough systematic analysis goes beyond the scope of this paper, some aspects will be discussed in the following in order to place the new species within the current state of discussion. *P. arndwilleni* sp. n. is closely related to *P. variabilis* Schriever, 1985, of which also a female specimen has been described. Males of these species share a certain pattern — comprising both plesiomorphic and apomorphic characters — of shape, setation and segmentation of P2–P4, compared to the paranannopid



**Fig. 4.** *P. arndwilleni* sp. n.: (A) endopod of P3; (B) endopod of P4; (C) P2; (D) P5 and P6.

groundpattern and other species (including other specimens from the DIVA 1 samples) of *Paranannopus*: the endopods of P2 and P3 are 3-segmented, the endopod of P4 is 2-segmented, P4 endopod-2 is lacking the outer seta, the exopods-3 of P2–P4 are slightly deformed (compare Figs. 4A–C, 5B) bearing only 1 outer spine (except for P4exp3 showing two outer spines in *P. variabilis*) and carrying the complete set (referred to the harpacticoid and paranannopid groundpattern) of strongly developed and elongated inner setae. The P5 consists of a single, not prominent plate with exo- and baseoendopodal parts represented by setae. Differences can be found among others in the shape of the sexual

dimorphism of P2 and P3 being more elaborate in *P. variabilis*. The state of its mouthparts is not described at all by Schriever (1985) but the maxilliped of *P. variabilis* still possesses a separated syncoxa and basis as well as a developed basal claw. No statement about the female mouthparts has been made either. The shape of the furcal rami with slightly reduced furcal setae IV and V “displaced” by a large terminal pore (compare Fig. 5A) and the P1 endopod-2 lacking terminal setae (as in *P. variabilis*) are present also in several other species of *Paranannopus* (compare, e.g., *P. bahusiense* Por, 1964, *P. triarticulatus* Wells, 1965, own observations in other DIVA species) as well as the



**Fig. 5.** *P. arndwilleni* sp. n.: (A) urosome and furcal rami from ventral view; (B) exopod2 and exopod3 of P4.

reduced P1 setation also in *Cylindronannopus*. Other species sharing the presence of well-developed elongate inner setae on the swimming-leg exopods combined with the shape of P5 are *P. hicksi* Schriever, 1985 and *P. kunzi* Schriever, 1985. These species together with *P. arndwilleni* sp. n. and *P. variabilis* will be in the following referred to as “*variabilis*-group”. For the former two species mouthparts have been described.

A majority of species within *Paranannopus* including the type species *P. abyssi* Sars, 1920, shows an opposite “morphological trend” by having the inner setae of swimming-leg exopods reduced in number and size and the endopods either completely lost or reduced in

number of segments (referred to in the following as “*abyssi*-group”). However, many species are insufficiently described, making up a set of a detailed character matrix and character analysis almost impossible at present. The above species grouping is only provisional in order to facilitate the following discussion.

From almost all described species, except for *P. langi* Wells, 1965 and *P. variabilis* Schriever, 1985, only either male or female has been described. The species from which only the male is known — almost all of which (except for *P. langi* Wells, 1965) belonging to the “*variabilis*-group” — show more setae on the swimming-leg exopod-3 and more segments in the endopods

than the species where only the female is described and almost all of which show the characteristics of the “abyssi-group”.

This phenomenon led Gee and Huys (1990) to the assumption that it could be a general kind of sexual dimorphism in *Paranannopus*. For also this reason, *P. tricarticulatus* Wells, 1965 has been synonymised with the male of *P. langi* Wells, 1965 by Huys et al. (1996).

However, there are some arguments against this explanation. Such an extreme kind of sexual dimorphism would be a very strong autapomorphy for *Paranannopus*. On the other hand its monophyly is not verified yet at all by other characters. This has also been stated by Huys et al. (1996, p. 244): “This genus is badly in need of revision and is almost certainly an amalgam of a number of genera”. Moreover, in the closely related and derived taxon *Cylindronannopus*, which probably branches off from a yet to define subtaxon within *Paranannopus*, males and females do not show these extreme differences in segmentation and setation of swimming-legs (e.g., *C. primus* Coull, 1973, *C. bispinosus* Schriever, 1985, own observations). Finally, in *P. variabilis* (compare Schriever 1985), despite the incomplete and insufficient description and the doubtful assignment of the female specimen to the same species as the male specimen, the former seems to share at least the shape and setation of the swimming-legs (except for asymmetrical segmentation of P2 endopod and, according to the drawings of Schriever, the inner setae of at least P3 exopod being shorter than in the male) of the male. Therefore, female specimens with the peculiar swimming-leg morphology of the “*variabilis*-group” do exist. However, obviously more data and a detailed phylogenetic analysis are necessary to find a final explanation.

Data on the worldwide distribution of species of *Paranannopus* are only sporadically available. A large percentage of the species including the members of the “*variabilis*-group” as closest relatives of *P. arndwilleni* sp. n. have been described from the Iceland-Faroe Ridge by Schriever (1983, 1985), shedding only a small “spotlight” on the really existing distribution pattern of *Paranannopus* species. At least, *P. arndwilleni* sp. n. extends this known range of occurrence of this group to the southern Atlantic.

Males with reduced mouthparts have been sporadically described also from other harpacticoid families (such as e.g. Argostidae Por, 1986 and Aegisthidae Giesbrecht, 1892) and the phenomenon is likely to be sexually dimorphic. However, literature on this subject is almost non-existent (except for very few publications, e.g. Huys 1988; Lee and Huys 2000).

This kind of sexual dimorphism within harpacticoid copepods combined with enlarged antennular aesthetascs seems to be predominantly a deep-sea phenomenon. It was also observed in males of Huntemaniidae,

Ectinosomatidae and Neobryidae from the DIVA samples (Seifried, Drewes, pers. comm.). Generally reductions in setation and segmentation are useful characters for phylogenetic analysis (Willen 1996, 2000), but in this case they are either present to a differing degree or absent in male specimens of close systematic relationship (in this case *Paranannopus*). Mouthpart atrophy has developed several times independently within the Harpacticoida, presumably as an adaptation to deep-sea conditions, which obviously require an increased effort to find mates of the matching species.

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