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PRIMARY RESEARCH PAPER

A new pelagic *Alteutha* (Copepoda: Harpacticoida) from Potter Cove, King George Island, Antarctica—description, ecology and information on its year round distribution

Gritta Veit-Köhler · Verónica Fuentes

Abstract A new harpacticoid copepod species was found during a year round plankton survey in a shallow Antarctic bay. Both the dominant Calanoida and Cyclopoida and the often neglected Harpacticoida, their abundances in relation to sea-ice formation and decline in presence of *Euphausia superba* are regarded, in this study. *Alteutha potter* sp. n. (Peltidiidae) was collected in Potter Cove, King George Island, Antarctica. While its geographical region occurrence and planktonic life style are comparable to many of its congeners, morphological characters such as shape and setation of the maxilliped and the almost complete fusion of the baseoendopod and the exopod of the fifth leg in the female are described for the first time for this genus. Morphological peculiarities such as the lack, the deformation or fusion of setae on only one body side have been detected in several specimens. This copepod species is obviously sea-ice related. Its abundances in the plankton reached a maximum under the winter sea-ice. The year round population structure did not show very high variability whereas ovigerous females mostly occurred in spring and summer. Assuming different possible ecological strategies and environmental temperatures generation times between 46 and 77 days are calculated for *A. potter* sp. n.

Keywords Plankton survey · Shallow water · Sea ice · Taxonomy · Ecology · Peltidiidae · Generation time

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Introduction

The antarctic zooplankton is usually dominated by copepods of different orders (Chojnacki & Weglenska, 1984; Pane et al., 2004; Walkusz et al., 2004). In plankton surveys detailed investigations mostly focus only on the orders Calanoida and Cyclopoida (Elwers & Dahms, 1998; Tanimura et al., 1986; Walkusz et al., 2004). Due to the lower abundances and an apparent lack of suitable descriptions Harpacticoida are frequently neglected and only few studies on species level have been carried out (Dahms et al., 1990; Günther et al., 1999).

Here we present a new planktonic species of harpacticoid copepods from a shallow antarctic bay, which frequently appeared in year round vertical and horizontal zooplankton samples collected with hand nets. *Alteutha potter* sp. n. is a new member of the Peltidiidae, a world-wide distributed family of harpacticoid copepods. Peltidiidae have regularly been reported from the plankton (Table 1), although their body shape seems to characterize them as an exclusively substrate-associated family (Hicks, 1986). The genus *Alteutha* is commonly found in antarctic and subantarctic waters, and 10 out of 16 valid species known to date are reported from the southern hemisphere (Table 1).

Year round plankton studies in the shallow coastal Antarctic environment are very scarce (Elwers & Dahms, 1998; Menshenina & Rakusa-Suszczewski, 1992) as most of the Antarctic zooplankton studies are only carried out during the summer season. In this study, we describe the seasonal variability of abundances of copepod orders in general and the population dynamics of *A. potter* sp. n. in detail. Moreover, the data presented here are from the first 12 months zooplankton study carried out in Potter Cove, King George Island, South Shetland Islands.

Materials and methods

Sampling of plankton material was carried out on a weekly basis (February 2002–December 2002) in Potter Cove, King George Island, Antarctica (Fig. 1) in front of the Argentinian Jubany Station and the German Dallmann Laboratory. The sampling station (named St. 1; Fig. 1) was located in the inner part of the cove, where depths range between 10 and 40 m (62°13′50″ S, 58°38′59″ W).

Qualitative and quantitative surface samples from the upper water column were obtained by means of a hand net of 200 μm mesh size (40 cm diameter of aperture and 100 cm length of the cone) equipped with a calibrated flowmeter mounted midway between the net rims and the mouth center, and towed by an inflatable dinghy. During summer, autumn and end of spring horizontal tows were carried out for about

10 min over a distance of 500 m (measured with GPS). When Potter Cove was frozen (approximately from July to September) samples were taken through a hole in the ice. The sampling hole was cut through the 40 cm ice cover above a water depth of 12 m and vertical hauls (20) taken from 5 m depth to the surface using the same hand net (200 μm mesh size). Different quantities of sea water were filtered in summer (50–70 m^3) and winter (2–15 m^3, with 15 m^3 in the majority of the hauls). The samples were preserved in a 4% solution of buffered formalin. Zooplankton was sorted using a Leica Mz 12.5 stereomicroscope, counted and classified either to higher taxon or species level, depending on the taxon. The abundances were expressed as Ind./100 m^3.

Specimens of *Alteutha potter* sp. n. selected for description were drawn from the dorsal side prior to dissection. The dissected parts were mounted in glycerine on slides. Drawings were made with the aid of a camera lucida on a Leica DMR microscope equipped with differential interference contrast (DIC) at 1000× magnification. Abbreviations used in the text: Exp = exopod, enp = endopod, benp = baseoendopod, P1–P6 = swimming legs 1–6, ''enp1 P2'' = the proximal segment of the endopod of P2.

Calculations of the generation time of *A. potter* sp. n. were carried out after Veit-Köhler & Brey (unpubl. data) on the base of their artificial neural network model: An extensive collection of literature data on generation times of benthic and pelagic copepods at given temperatures was the base for the artificial neural networks (ANN) of the backpropagation type (Hagan et al., 1996). Each data set consisted of the independent variables egg mass, female body mass, temperature and habitat as well as the dependent variable generation time. The data were split randomly in 80% training data and 20% test data. The ANN ''learned'' the relation between dependent and independent variables from the training data. Ten ANN, each trained on a different set of data, were pooled into a composite prediction model, i.e. the predicted value is the average of the predictions made by 10 ANN.

Microscopic measurements of adult females and eggs of *Alteutha potter* sp. n. allowed us to estimate female body mass and egg mass: Female

Table 1 Locations, habitat, sampling depth, and body size of all valid species of *Alteutha* (Baird, 1837).

Species	Body size		Location	Habitat and depth	Record
Alteutha depressa (Baird, 1837)	Female 0.8–1.3 mm	Male 0.53–0.7 mm	Norway, British Isles, European coast from Scotland to France. Tunesia, Algeria, Italy, Mediterranean Sea. Romania, Black Sea. South Africa, St. Croix Island, Algoa Bay. Patagonia, Puerto Deseado, Isla de los Estados. Tierra del Fuego. South Orkneys, Scotia Bay. Kerguelen. Circum southern, cool temperate.	Associated to algae and stones, sandy and gravelly. 0–29 m. Benthonic. Phytal. Planktonic.	Sars (1904) Scott (1912) Monard (1928) Nicholls (1941) Lang (1948) Wiborg (1964) Pallares (1968) Pallares (1979) Hicks (1982)
	0.46–0.51 mm	0.45–0.46 mm			
Alteutha dubia Scott, 1912	Female 1.4 mm		South Orkneys, Scotia Bay.	Dredged. Benthonic.	Scott (1912)
Alteutha interrupta (Goodsir, 1845)	Female 1–1.2 mm		Baltic. Helgoland, coast of Germany, south and west coast of Norway, Northern Sea. Coast of France. British Isles. Mediterranean Sea. Red Sea.	Associated to algae and oysterbeds. 2 - 20 m Benthonic 100 m. Planktonic.	Goodsir (1845) Sars (1904) Monard (1928) Vos (1945) Lang (1948)
Alteutha langi Monk, 1941	Female 0.68–0.80 mm	Male 0.60–0.64 mm	Californian coast, USA.	Associated to algae. Planktonic.	Monk (1941)
Alteutha novae-zealandiae (Brady, 1899)	Female 0.85 mm		New Zealand, Port Chalmers and Otago.	Surface. Planktonic.	Brady (1899)
Alteutha oblonga (Goodsir, 1845)	Female 1.30 mm	Male 0.8–0.9 mm	Franz Josephs Land, Norway, Sweden, Germany, British Isles, Ireland, France (Atlantic), North America (Atlantic). Tierra del Fuego.	Sandy or gravelly bottom. Associated to algae. Benthonic. Planktonic.	Goodsir (1845) Lang (1948) Klie (1927) Pallares (1979)
	0.9–1.34 mm				
Alteutha polarsternae Dahms, 1992	Female 1.1 mm	Male 0.98 mm	Weddell Sea.	450 m. Benthonic.	Dahms (1992)
Alteutha rara Jakobi, 1954	Male 0.7–0.8 mm		Brazil, Baía de Paranaguá	Associated to algae.	Jakobi (1954)

Table 1 continued

| Species	Body size	Location	Habitat and depth	Record
Alteutha roeae Hicks, 1982	Female 0.56 mm Male 0.44 mm	St Croix Island, Algoa Bay, South Africa.	Associated to algae. Benthonic. Planktonic.	Hicks (1982)
Alteutha sarsi Monrad, 1924	Female 0.6 mm	South Africa. Algeria. France, Banyuls.	Associated to algae.	Monard (1928) Lang (1948) Hicks (1982)
Alteutha sewelli Krishnaswamy, 1952	Female 0.679 mm Male 0.75 mm	India		Krishnaswamy (1952)
Alteutha signata Brady, 1910	Female 0.6 mm	Kerguelen, Observatory Bay.	Dredged. Benthonic.	Nicholls (1941) Lang (1948)
Alteutha trisetosa Lang, 1936	Female 1.2 mm	South Georgia	Associated to algae. 16 m. Benthonic.	Lang (1936) Lang (1948)
Alteutha typica Czerniavski, 1868	Female 0.73 mm Male 0.68 mm	Romanian coasts, Agigea, Constanta, Eforie. Bulgaria, Mitschourine, Black Sea.	Associated to algae. 1.5 m. Benthonic.	Por (1960) Apostolov (1973)
Alteutha potter sp.n.	Female 1.71 mm Male 1.24 mm	Potter Cove, King George Island, South Shetland Islands, Antarctica.	Associated to sea ice. Surface layer. Planktonic.	this work
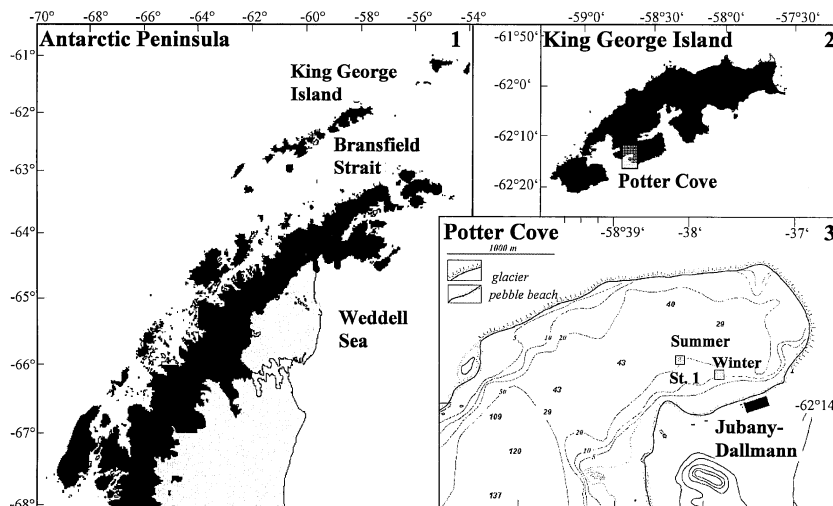
Fig. 1 Map showing the year round sampling station (St. 1) in summer and winter 2002 in Potter Cove, South Shetland Islands, Antarctica (**1**) King George Island (**2**), Potter Cove (**3**)

body volume was calculated after Warwick & Gee (1984) using a conversion factor of 230 for scutelliform harpacticoids. Transformations of body volume into carbon content [µg C] were made using the equations given by Feller & Warwick (1988) and Kiørboe & Sabatini (1994). Egg weight was calculated via the spheric volume of an egg and the formula of Kiørboe & Sabatini (1994).

Results

Systematics

Material

The examined specimens are registered in the collection of the University of Oldenburg (=UNIOL-collection), Department of Zoosystematics and Morphology and kept at the German Centre for Marine Biodiversity Research (DZMB), Senckenberg Research Institute (FIS) in Wilhelmshaven, Germany.

Female holotype: No. 2005.001/1–12 (12 slides), 03-15-02, Station 1 (inner cove; 62°13′50″ S, 58°38′59″ W), surface net (200 µm). Male allotype: No. 2005.002/1–1 (1 slide), 06-05-02, Station 1 (inner cove; 62°13′50 S, 58°38′59″ W), surface net (200 µm). Female paratype 1:

2005.003/1–10 (10 slides), 03-05-02, Station 3 (outer cove; 62°15′14 S, 58°42′34 W), surface net (200 µm). Female paratype 2: 2005.004/1–4 (4 slides), 03-11-02, Station 3 (outer cove; 62°15′14″ S, 58°42′34″ W), surface net (200 µm). Male paratype 3: 2005.005/1–11 (11 slides), 03-11-02, Station 2 (middle cove; 62°14′12″ S, 58°40′52″ W), surface net (200 µm).

Etymology

The species name *potter* refers to Potter Cove, a small inlet in Maxwell Bay, King George Island, Antarctica, where numerous specimens have been found during the plankton survey carried out by the second author in 2002 and 2003.

Description

Female

Habitus (Fig. 2a, holotype). Total body length measured from anterior tip of rostrum to posterior margin of telson: 1.71 mm (holotype).

Body bright amber-coloured, strongly chitinized, dorsoventrally depressed, seen dorsally oval in form, gradually tapering towards posterior end. Whole surface covered with more or less round depressions placed close to each other. Many of these depressions, especially on cepha-
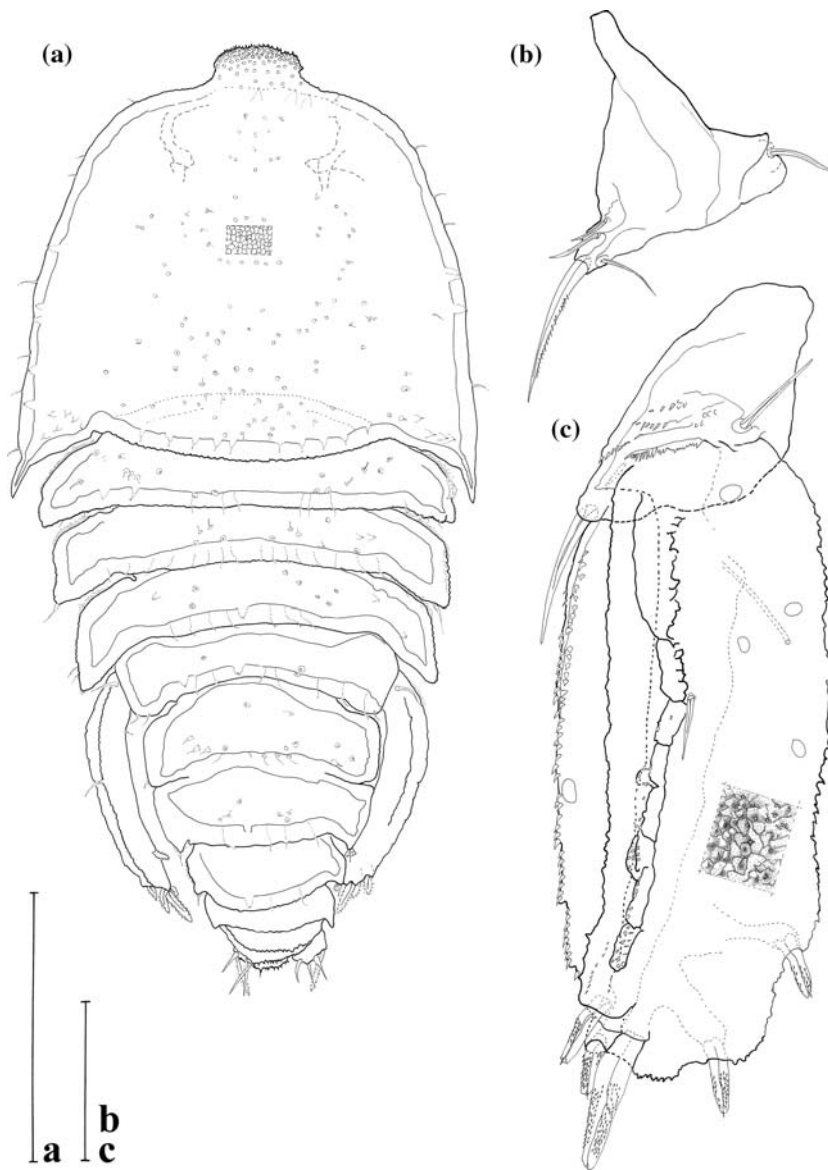
Fig. 2 *Alteutha potter* sp. n. (**a**) Female habitus, dorsal (Holotype). (**b**) Female baseoendopod of P5, inner view (Paratype 2). (**c**) Female P5 (Paratype 2). Scale bars: *a*, 0.5 mm; *b*, *c*, 0.1 mm

lothorax, bear pores, others tiny sensilla. Rows of sensilla also at posterior margins of segments. Cephalothorax with several stronger sensilla, at frontal and lateral edges. Rim of cephalothorax inwardly drawn, thus forming a groove for retracting the antennula when animal rolls into a ball. First three free segments laterally with fields of tiny spinules, fifth and sixth free segments partly fused to form genital double somite, eighth

free somite carrying a small, thin pseudoperculum. Telson very short. Furcal rami short and stout (Fig. 4e, paratype 2), with several rows of stout spinules and scales, furnished with seven elements: seta I naked, slender; seta II developed as stout, hirsute spine; seta III slender, hirsute; seta IV long, slender and hirsute; seta V as seta IV but longer and stronger; seta VI small, naked; seta VII small, naked, dorsally displaced.

Rostrum (Fig. 2a). Strong, stout, completely fused with cephalothorax, ventrally supported by triangular base.

Antennule (Fig. 3a, paratype 1). Nine-segmented, ornamented with more or less round cuticular depressions on surface of first four segments, segment I with spinule rows and field of tiny spinules. All setae slender and naked.

Setal ornamentation: I (1), II (12), III (9), IV (4 + aesthetasc, fused at base with seta), V (2), VI (4), VII (2), VIII (2), IX (7 + aesthetasc, fused at base with seta).

Antenna (Figs. 4a, b, holotype). Basis with one pinnate seta and a field of stout spinules. Endopod two-segmented. Enp1 with one small, pinnate abexopodal seta. Enp2 with fields of stout spinules and a row of more slender spinules apically, subapically with four setae, one of which naked, two with short and one with longer spinules. Apical margin with seven setae, four of which
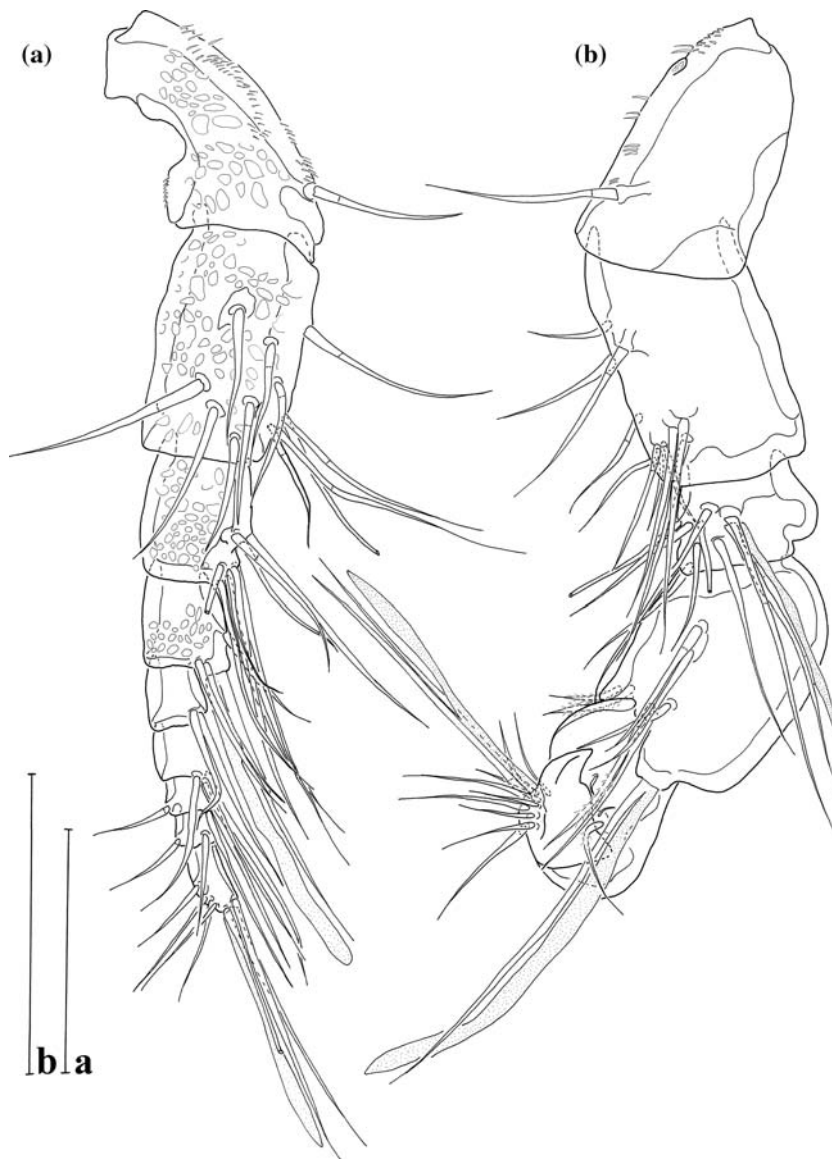

Fig. 3 *Alteutha potter* sp. n. (**a**) Female antennule (Paratype 1). (**b**) Male antennule (Paratype 3). Scale bars: *a*, 0.1 mm; *b*, 0.1 mm
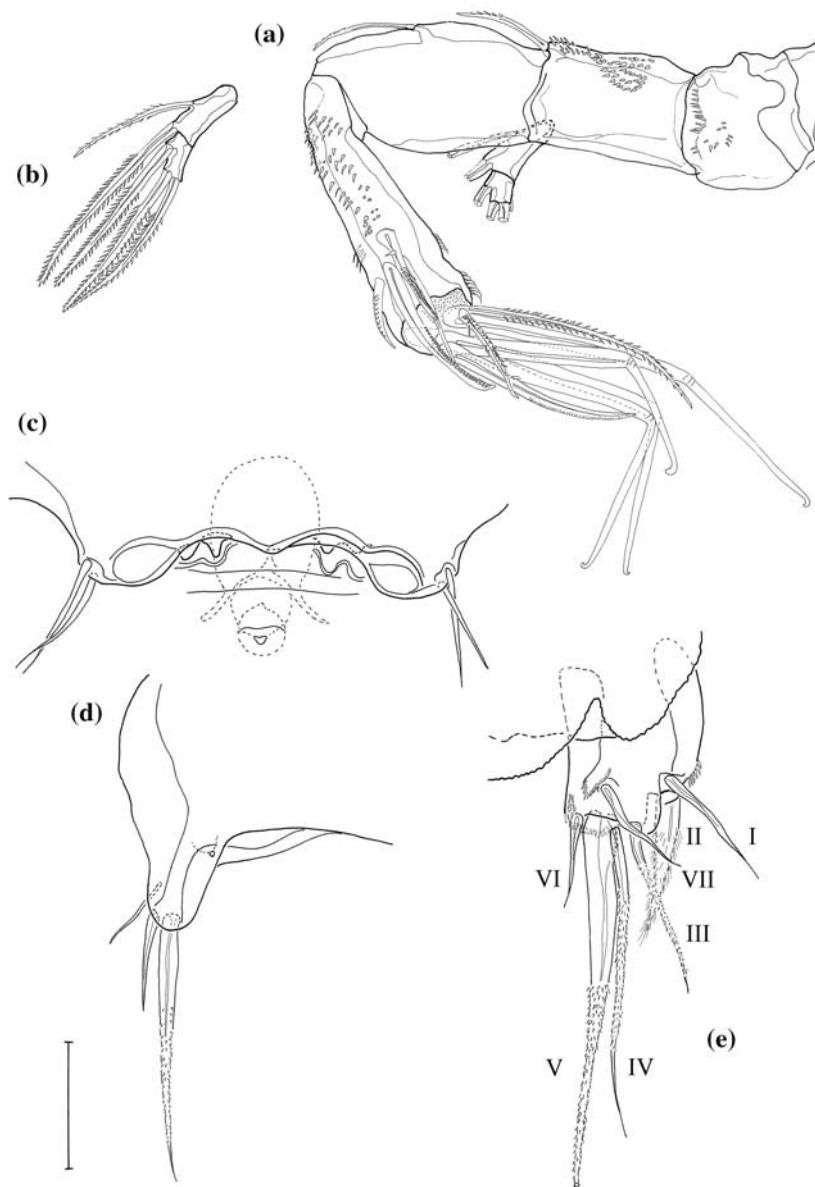
Fig. 4 *Alteutha potter* sp. n. (**a**) Female antenna (Holotype). (**b**) Exopod of female antenna (Holotype). (**c**) Female P6 and genital field (Paratype 2). (**d**) Male P6 (Paratype 3). (**e**) Female furcal ramus, right (Paratype 2). Scale bar: 0.05 mm

naked, geniculate, one with very small scales, one large and one small bipinnate seta. Exp two-segmented, first segment with two lateral setae, second with one lateral and two apical setae, all of which bipinnate with short spinules.

Mandible (Fig. 5g, holotype). Coxa with slender, elongated gnathobasis. Cutting edge with several strong teeth and a pinnate spine. Basis of palp with two bipinnate setae. Enp one-segmented with altogether six setae, five on distal end (four naked, one pinnate) and one bipinnate midlength at inner edge. Exp small, one-segmented with altogether three setae, one naked, one pinnate and one bipinnate.

Maxillule (Figs. 5a, c, holotype; Fig. 5b, paratype 1). Praecoxal arthrite with two juxtaposed
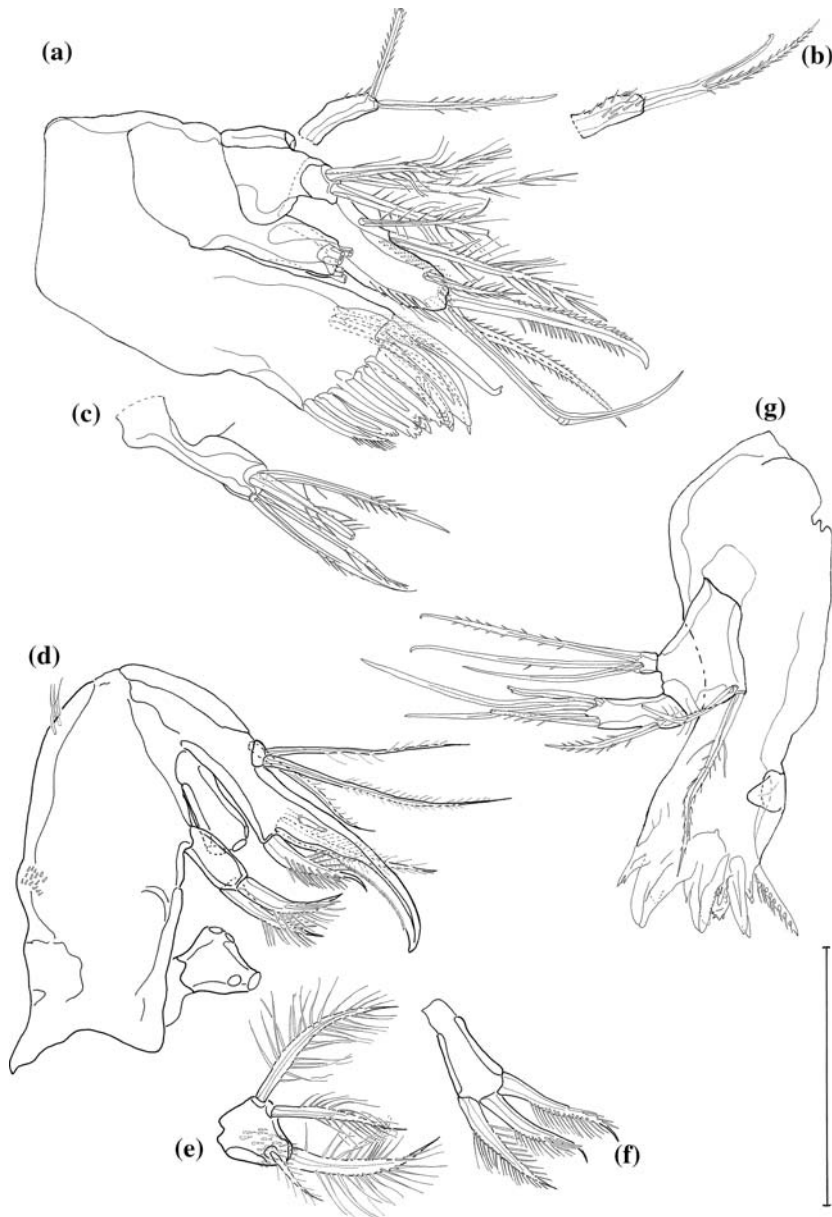
Fig. 5 *Alteutha potter* sp. n. Female maxillule. (**a**) complete view (Holotype) with exp (Paratype 1). (**b**) exp (Paratype 1), other body side. (**c**) basis (Holotype). Female maxilla (Holotype). (**d**) complete view. (**e**) proximal endite. (**f**) distal endite. (**g**) Female mandible (Holotype). Scale bar: 0.1 mm

setae on posterior surface, one of which bipinnate. Inner margin of arthrite with eight strong, stout spines, each of characteristic shape and two strong setae, one of which pinnate. Coxal endite with four pinnate and bipinnate setae (Fig. 5c). Basis with three apical setae: One geniculate, one bipinnate with strong, short spinules and one tripinnate with short spinules. Additionally, there is a row of long spinules along the margins of the basis and three bipinnate setae of different sizes descending along the outer part of the basis. Enp with three bipinnate setae with long spinules and exp with two slender pinnate setae with short spinules. Exp broken in holotype therefore
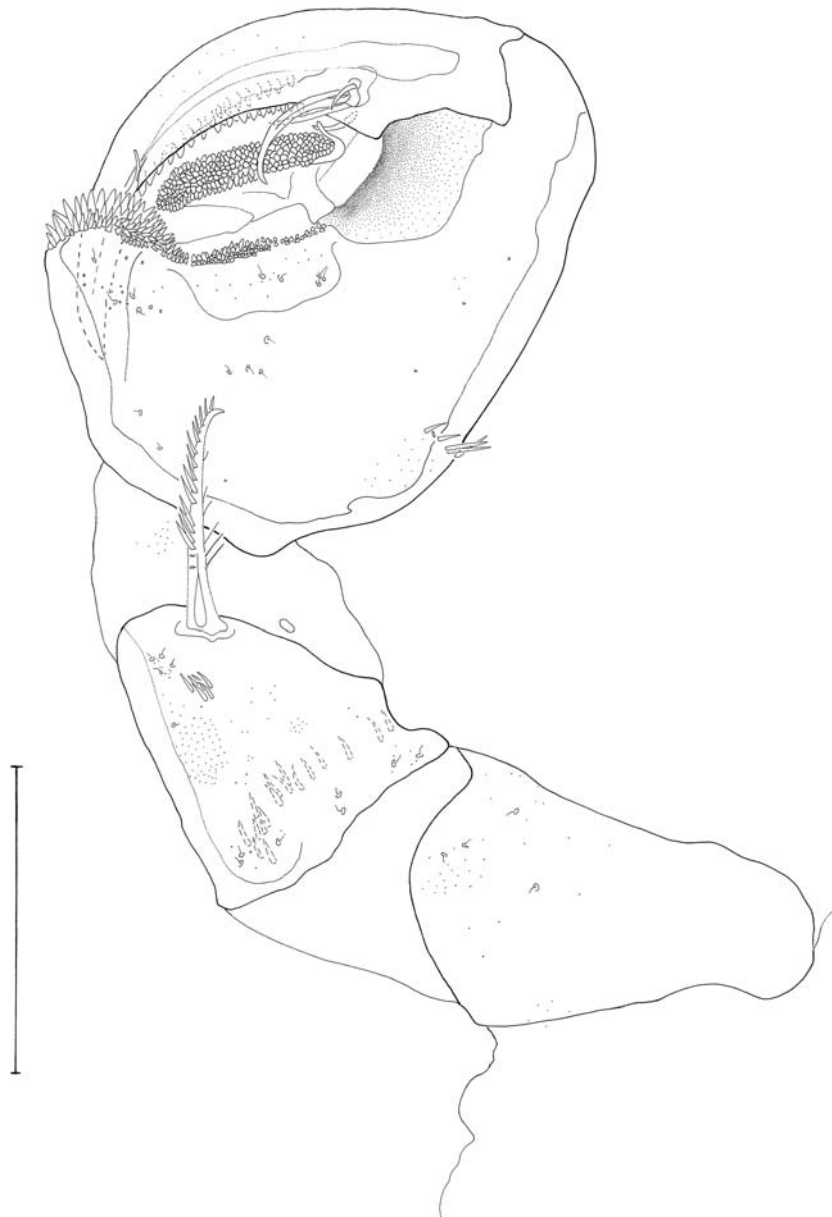
Fig. 6 *Alteutha potter* sp. n. Female maxilliped (Holotype). Scale bar: 0.1 mm

described from paratype 1 (see section ''Irregularities'').

Maxilla (Figs. 5d–f, holotype). Praecoxa and coxa mostly fused to form syncoxa bearing three endites. Separation towards basis visible. Proximal endite slightly bilobed, armed with field of spinules and three strong bipinnate setae and one small bipinnate seta (Fig. 5e). Middle endite with two (Fig. 5d), distal endite three bipinnate spines

(Fig. 5f). Basis drawn out to form strong finely serrated claw with a tube pore on anterior surface, claw accompanied by two strong bipinnate spines. One slender seta arises from basis at the base of a small enp, which is one-segmented and armed with two slender pinnate setae.

Maxilliped (Fig. 6, holotype). Strong, large appendage, prehensile. Pedestal well developed ornamented with few tiny sensilla. Syncoxa with

some tiny sensilla, some spinules on anterior and a spinule row on posterior surface, and only one strong spinulouse seta. Basis (palm) nearly round and bulbous. Endopod fused with strong claw. Basis with a row of spinules, several small sensilla, and, underneath the claw, a pistil-like rising with scale-covered surface and a small tongue-like structure. Numerous rows of scales of different sizes accompany the rising and cover a marked elevation on the palm opposite to the insertion-point of enp. From this elevation a tiny seta arises. Enp with two small and one tiny seta on anterior surface, representing the enp2, and one small seta on posterior surface. A large section of the distal part of the claw overlaps with the basis.

Swimming legs (Fig 7; Fig. 8; Table 2). P1–P4 with naked intercoxal sclerites and robust, large coxae with spinule rows, partly with pores. Outwardly drawn bases bring appendages into a laterally displaced position.

P1 (Fig. 7a, holotype). Basis with one inner and one outer bipinnate seta and tube pore accompanying outer seta. Enp slightly shorter than exp, three-segmented with rows of well
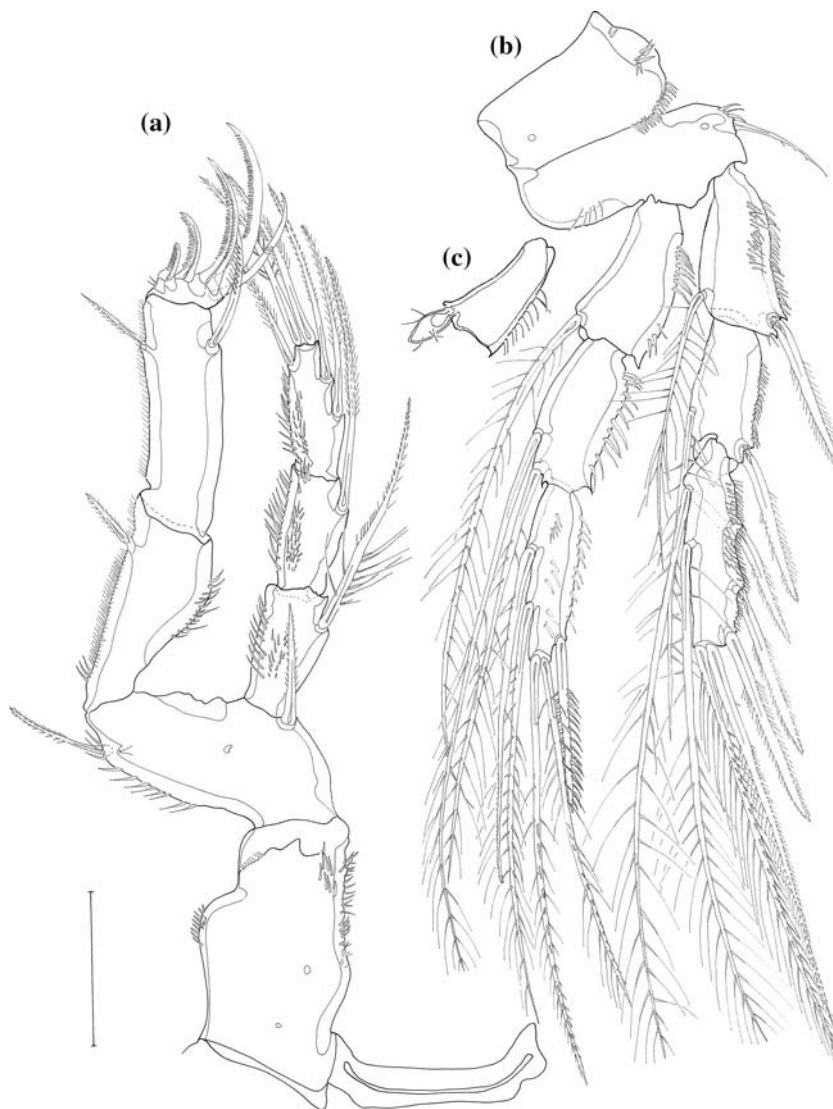

Fig. 7 *Alteutha potter* sp. n. (**a**) Female P1 (Holotype). (**b**) Female P2 (Holotype). (**c**) aberrant male enp1 P2 (only in one leg, Paratype 3). Scale bar: 0.1 mm

Fig. 8 *Alteutha potter* sp. n. (**a**) Female P3 (Holotype). (**b**) Female P4 (Holotype) with aberrant exp3. (**c**) normal exp3 P4 (Holotype), other leg. Scale bar: 0.1 mm

developed spinules along outer margins and fields of spinules on surface of segments. Enp1 with one inner bipinnate seta with long spinules at the

Table 2. Seta and spine formula of swimming legs of *Alteutha potter* sp. n.

	Basis	Exopod	Endopod
P1	1.1	0.1.5	1.1.221
P2	0.1	1.1.223	1.2.221
P3	0.1	1.1.323	1.2.321
P4	0.1	1.1.323 (322)	1.2.221

beginning and short spinules towards the tip, enp2 with one inner seta with short spinules in the second half, enp3 two inner, two terminal and one outer seta, all of which bipinnate. Exp three-segmented, with exp1 and exp2 carrying a row of very fine spinules on the outer margin. Exp1 additionally with inner field of longer spinules and bipinnate outer spine. Exp2 elongated, with similar outer spine and inner pinnate seta. Exp3 short with one naked, geniculated seta and four strong, outwardly curved, toothed claws of increasing length from proximalmost to distal-

most. The three outer claws show two parallel rows of teeth.

P2–P4 (Fig. 7b, holotype; Figs. 8a–c, holotype). Bases with outer setae accompanied by row of spinules, seta only in P2 pinnate. Basis of P2 with pore and some additional larger thin spinules on inner side (Fig. 7b). Basis of P4 with elevation carrying a sensillum near outer seta (Fig. 8b). Exp and enp of P2–P4 three-segmented, with rows of spinules of different sizes along outer rims of segments, sometimes additional rows or fields of spinules on surface. Enp P2–P4 with differing numbers of long, bipinnate, slender inner and terminal setae with spinules of distinct sizes and inner bipinnate spine on enp3. Terminal setae of enp3 P2 tripinnate. Exp P2–P4 with differing numbers of inner bipinnate setae, always two terminal setae, the outermost of which always with shorter spinules. Inner terminal seta of exp P2 tripinnate (Fig. 7b). Exopodal segments normally furnished with bipinnate outer spines (exp1: one outer spine; exp2: one outer spine; exp3: three outer spines).

Certain irregularities in the exopodal armature of the holotype could be observed (see section "Irregularities").

P5 (Figs. 2b, c, paratype 2). Enp and basis fused to form benp ornamented with several rows of scales and one naked outer seta (Fig. 2b). One robust, inner seta with very small spinules and three small naked accompanying setae represent the remnants of the enp. Suture between benp and exp only clearly visible on the inner side of the leg. Exp elongated (Fig 2c), with medially elevated ridge, flattened towards outer and inner margin. Innerwards uniformly plain region is formed with relatively thinner cuticle and armed with rows of scales at its margin. Whole surface covered with distinct patterns of cuticle structures. Exp armed with small, slender seta on surface near middle rim and five stout spines of different sizes covered with tiny thorns at the lateral and distal part of the exp. Except from the largest, each spine carries a sensillum at its slightly opened top.

Genital complex and P6 (Fig. 4c, paratype 2). Genital field as shown in Fig. 4c. Sixth leg represented by lateral elevation with two slender naked setae and an ovally shaped thin chitinuous

structure leading towards two small outgrowths which correspond to depressions of the same shape in the cuticle underneath these structures.

Male

Habitus (Fig. 9a, allotype). Total body length measured from anterior tip of rostrum to posterior margin of telson: 1.24 mm (allotype). Body resembling that of female with similar ornamentation and strongly developed cuticle.

Antennule (Fig. 3b, paratype 3). Six-segmented, no surface ornamentation visible. Segment I with irregularly distributed small spinules. Almost all setae slender and naked, with the exception of three setae at the fourth and one seta at the fifth segment.

Setal ornamentation: I (1), II (11), III (9 + aesthetasc), IV (8 + aesthetasc, fused at base with seta), V (3), VI (11 + aesthetasc, fused at base with seta).

P5 (Fig. 9b, c, paratype 3). Enp and basis fused to form benp with one naked outer and two naked inner setae, one of which small. Exp elongated, with medially elevated ridge, flattened towards outer and inner margin. Whole surface covered with distinct patterns of cuticle structures, but not as expressed as in female. Exp with scale-like spinules at its outer rim, armed with small, hirsute seta in upper third and five stout spines of different sizes covered with tiny spinules at the lateral and apical part of the exp. Three spines carry a sensillum at their slightly opened tops.

P6 (Fig. 4d, paratype 3). Represented by outgrowths situated laterally on the segment. With one pore on the surface and three setae inserting on the rear side (two of which small, naked, one strong and slightly hirsute).

Irregularities

During the description process several irregularities between the two body sides of the same animals have been detected:

The main parts of the maxillule have been drawn from the holotype (Fig. 5a). The exp has been added from paratype 1, but this animal had two normal setae on the exp in one body side (Fig. 5a) and two fused setae in the other
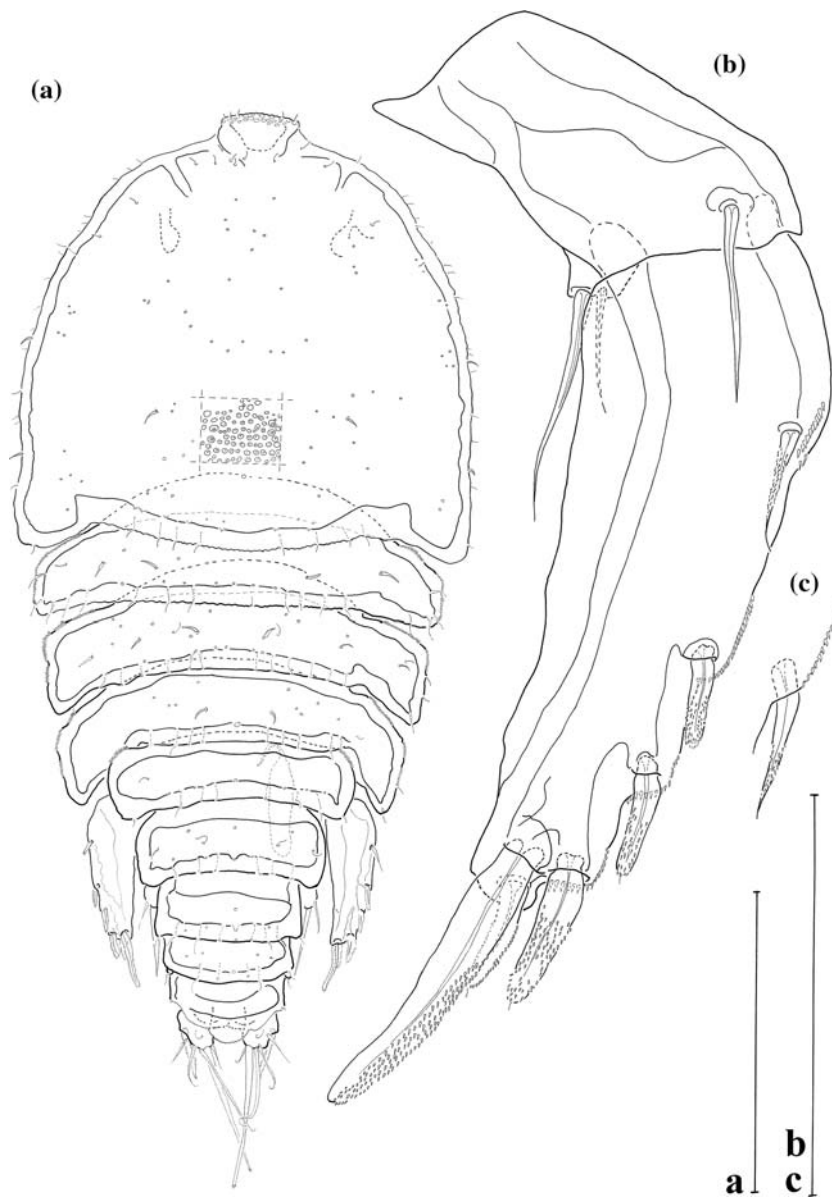
Fig. 9 *Alteutha potter* sp. n. (**a**) Male habitus, dorsal (Allotype). (**b**) Male P5 (Paratype 3). (**c**) proximalmost outer spine P5 (Paratype 3), other leg. Scale bars: *a*, 0.4 mm; *b*, *c*, 0.1 mm

(Fig. 5b). Concerning the maxilliped, some individuals of the non-type material have been detected with this appendage at one body side being smaller than at the other and having a less pronounced elevation opposite to the insertion point of the claw. Another particular feature is the aberrant form of the inner seta of a male P2 enp1 on one body side (Fig. 7c, paratype 3), which has been detected to be shortened and

inflated but was still carrying some spinules. In the P4 the holotype had only two outer spines at the exp3 of one body side (no damage visible, Fig. 8b), but the full set of three spines in the other (Fig. 8c). A difference between the left and the right P5 of the male paratype 3 has been detected concerning the uppermost of the spines, which in one leg did not show a round but a pointed tip (Fig. 9c).

Ecological results

Abundances of copepods

Copepods were the dominant zooplankton group throughout the year 2002 in Potter Cove, with the exception of some weeks during summer and spring when the Antarctic krill *Euphausia superba* Dana, 1852 was very abundant (data not shown). The abundance of the different groups of copepods (Harpacticoida, Cyclopoida and Calanoida) fluctuated evidently throughout the year (Fig. 10).

The contribution of Harpacticoida to the total individual numbers of copepods also varied clearly, fluctuating between 2% (3-Apr. and 18-May) and more than 90% (6-Nov. and 18-Dec.) while the relative abundance of Harpacticoida ranged between 10 and 20% for the rest of the year.

All three copepod groups reached highest densities under the ice during the winter. *A. potter* sp. n. followed the same pattern as Harpacticoida in general (Fig. 11). The under-ice community of the Calanoida was mainly represented by copepodits of the three species *Ctenocalanus citer* Heron & Bowman, 1971, *Metridia gerlachei* Giesbrecht, 1902 and *Calanus propinquus* Brady, 1883, whereas Cyclopoida were represented mainly by copepodids of *Oithona similis* Claus, 1863. The other species of

Harpactioida, with the exception of *A. potter* sp. n., remain to be identified.

Abundances and population structure of Alteutha potter sp. n.

A. potter n. sp. was always present in the year-round surface plankton samples from the inner Potter Cove (St. 1) and rose to a maximun of 687 Ind./100 m^3 in July (Fig. 11). In general, the species reached its maximum densities in Potter Cove under the winter sea-ice, which was present from July to beginning of September 2002 (3-Aug.: 154 Ind./100 m^3; 8-Aug.: 77 Ind./100 m^3 and 7-Sep. 63 Ind./100 m^3). During the rest of the year the values were lower, between 2–4 Ind./100 m^3 (October, November and December 2002) and 10–20 Ind./100 m^3 (summer season).

The relative abundance of *A. potter* sp. n. in relation to the total abundance of Harpacticoida fluctuated between 2 and 100%. The lowest values were found in the summer months, the highest in winter and spring time.

The year round population structure does not show very high variability (Fig. 12). Adult females were present, in different proportions, during the whole year. Adult males were present in almost all the samples from February to beginning of September and were absent in many
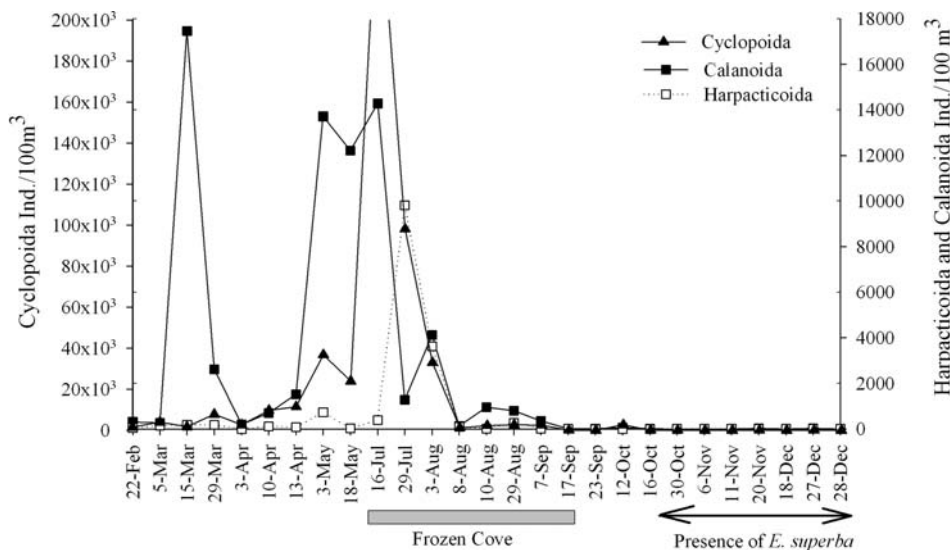

Fig. 10 Copepod abundances [Ind./100 m^3] in Potter Cove, St. 1 during the sampling period in 2002: Calanoida, Cyclopoida and Harpacticoida. Out of scale: Cyclopoida 16-Jul 269.011 Ind./100 m^3
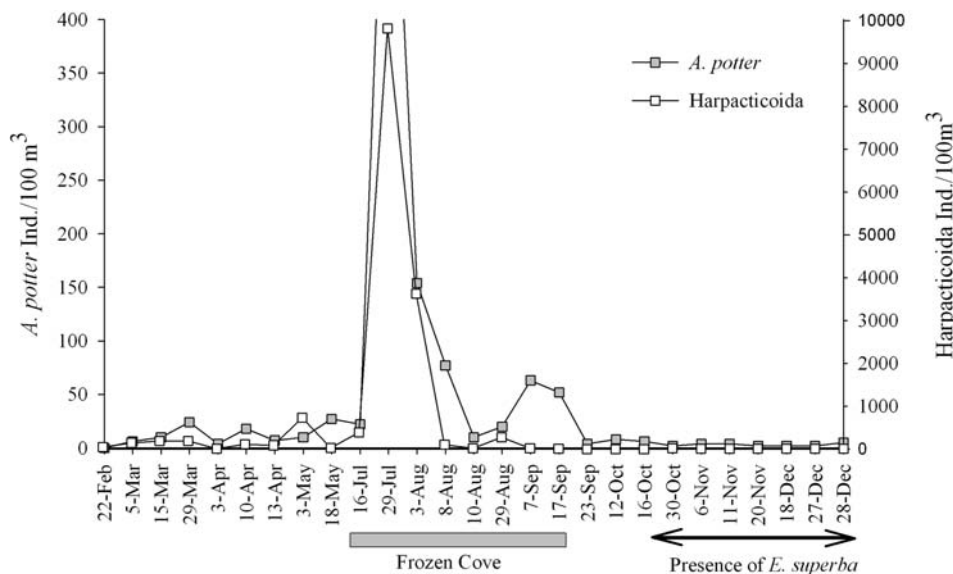
Fig. 11 Abundances [Ind./100 m³] of harpacticoid copepods (without *A. potter* sp. n.) and *Alteutha potter* sp. n. in 2002, Potter Cove, St. 1. Out of scale: *A. potter* sp. n. 29-Jul 687 Ind./100 m³
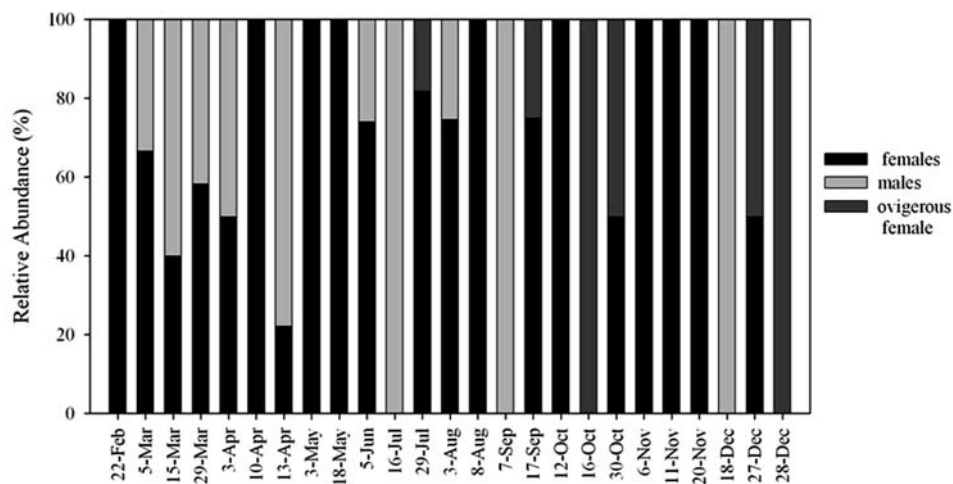

Fig. 12 Relative abundances of females, males and ovigerous females of *Alteutha potter* sp. n. in 2002, Potter Cove, St. 1

samples in the second half of the year (end of September to end of December), with the exception of one sample in December when only males were present. Ovigerous females mostly came up in spring and summer.

Reproduction: seasonality and predicted generation time

A rise in the number of specimens could be detected in samples that had been taken from

underneath a stable ice-cover during winter time. Although few egg-sac carrying females could be detected in winter, and more in spring and summer, reproductive stages were absent in all samples.

For applying the artificial neural network model for the calculation of generation times in sac spawning copepods by Veit-Köhler & Brey (unpubl.) 12 females from the samples 07-29-02 and 06-05-02 collected at St. 1 were measured. With a mean body volume of 238.77 nl

(±24.57 nl) a content of organic carbon of 26.98 μg (±2.78 μg) was calculated. The average diameter of 12 eggs of a female from the 09-17-02, St. 1 was 53.0 μm (±3.6 μm) which lead to an egg weight of 0.011 μg C (±0.002 μg). The total clutch size of this female was 43.

The model was run for two possible development strategies:

Assuming a purely pelagic development with environmental temperatures between –2°C (July) and 0°C (December) a generation time for *A. potter* sp. n. of 46–55 days is probable. With a purely benthic or algae bound life style for the same temperatures 65–77 days of generation time are calculated.

Discussion

Systematic discussion

Characterization of Alteutha *Baird, 1845 within the Peltidiidae*

The genus *Alteutha* has been erected by Baird in 1845 (Lang, 1948). The genus consists of 16 valid species, three additional species remain uncertain. After Hicks (1986) among other outstanding characteristics such as the lateral parts of the cephalic shield being inflexed ventrally, all *Alteutha* species share a simple body architecture, a seven- to nine-segmented antennule, a two-segmented antenna exp, maxilliped with an inflated or elongated palm and an elongate claw, enp P1 three-segmented, exp3 P1 with four claw-like and one geniculate seta, exp1 P2–P4 with inner seta (only *Alteutha trisetosa* Lang, 1936, *Alteutha rara* Jakobi, 1954, *Alteutha austrina* (synonymized under *Alteutha depressa* (Baird, 1837) by Hicks (1982) and *Alteutha oblonga* Goodsir, 1845 are lacking this character), exp3 P2–P4 with three outer spines, P5 two-segmented, posterior abdominal somites free, and caudal rami broad with distinct principal terminal setae.

Hicks (1986) states that, apart from one character in *Neopeltopsis* Hicks, 1976, no single character is unique to just one genus. Only specific combinations of several characteristics describe the genera diagnostically. Obviously the Peltidiidae seem to contain genera which are sharing plesiomorphic characteristics. The three-segmented exp P1 for example is reported for *Alteutha* as well as for *Alteuthella* A. Scott, 1909 and *Alteuthoides* Hicks, 1986 and the armature of exp3 P1 with four claw-like setae and a generally present geniculated seta can be found in *Alteutha* as well as in *Eupelte* Claus, 1863.

Because of these plesiomorphies and the fact that the mouthparts are not adequately described for most of the known Peltidiidae, the diagnosis given for the known *Alteutha* species can only be a working diagnosis.

Placement of Alteutha potter *sp. n. and differentiation from congeners*

A. potter sp. n. coincides with the genus diagnosis in all parts. The only slight difference to Hicks' (1986) diagnosis is that the benp and the exp P5 of the female do not seem to be absolutely separated when regarded from the outer side. However, *A. potter* is the largest member of the genus described so far (Table 1).

The maxilliped of *Alteutha potter* sp. n. differs greatly in shape and setation from almost all other *Alteutha*-species. The spinules observed in other species along the basis (palm) are reduced and replaced by numerous rows of scales of different sizes. Only *Alteutha depressa* (Baird, 1837) (Pallares, 1968; Hicks, 1982), *Alteutha sarsi* Monard, 1924, *Alteutha typica* Czerniarski, 1868, *Alteutha langi* Monk, 1941, *Alteutha dubia* Scott, 1912, and *Alteutha signata* Brady, 1910, have a somewhat similar maxilliped with a nearly round bulbous basis and a pistil-like rising underneath the endopod with the claw. In contrary to *A. potter* sp. n., none of them shows the marked elevation on the palm opposite to the insertion-point of the endopod. In most of the drawings the closed claw is always only put against the basis. Thus an overlapping of a great section of the distal part of the claw with this segment has only been described for *A. potter* sp. n. Moreover, the syncoxa of the maxilliped of *A. potter* sp. n. carries only one strong spinulouse seta. This is in contrary to all other *Alteutha* species with round bulbous palms.

A. potter sp. n., as well as *Alteutha polarsternae* Dahms, 1992, belongs to the species group which

still carries an inner seta at the exp1 P2–P4. The description of *A. polarsternae* is one of the most detailed in the genus *Alteutha*, so most of the comparisons have to be made with this species, although there are contradictions in Dahms' (1992) description (mandibular palp, P1). Unfortunately, the type material of *A. polarsternae* from the Weddell Sea was not accessable.

A description or drawing of the maxilla are not given by Dahms and other descriptions are not as clear in order to compare the armature of the endopod of the maxilla. However, the fact that a seta arises from the basis at the base of the endopod and not from the endopod itself, is remarkable. This character might be variable between species or it might have been overlooked formerly. As far as the other genera of Peltidiidae are concerned, Dahms' (1992) redescription of *Eupelte villosa* (Brady, 1910) mentions that the endopod carries three setae, although according to his drawing one of these setae seems to stem from the basis of the maxilla, as well.

According to Seifried (2003) the maxillule of *A. polarsternae* is lacking the enp and not the exp, as stated by Dahms in the description, and the complete coxa is absent. As variations between the animals of a single species and even within the same animal as shown for *A. potter* sp. n. are known, it is possible that the mouthpart drawn by Dahms was not a typical but an aberrant maxillula of *A. polarsternae*. Nevertheless it can be stated, that *A. potter* sp. n. has one seta less at its maxillular exp. Considering the drawings, the mandibles of *A. polarsternae* and *A. potter* sp. n. show the same armature, whereas the antenna of *A. polarsternae* carries one more seta at the basis and one seta less subapically at enp2. Dahms describes the P1 exp3 with five claws, non of them geniculate, and he states that this character is as in other representatives of the Peltidiidae. In fact, his drawing indicates a geniculation of the innermost claw, which, despite being armed with short spinules shows some grooves midlength. *A. potter* sp. n. has a seta as innermost element, which is obviously geniculate and has one tiny hair indicating a possible spinulation. This character shared by both species coincides with the genus diagnosis given by Hicks (1986).

Morphological peculiarities

Krishnaswamy (1952) detected for *Alteutha sewelli* Krishnaswamy, 1952 a characteristic which later has been discussed by Hicks (1986): The exp3 P4 of this species carries only two outer spines while exp3 P2 and P3 show the full set of three outer spines. It is not only the reduction of the number of outer spines in exp3 P4 of *A. sewelli* that worried Hicks, but it is the discontinuity between the three swimming legs concerned. He stated that the appendage in question of the specimen Krishnaswamy described was deformed or that Krishnaswamy was in error.

Aberrant developments in maxillipeds and swimming legs (P2, P4, P5) in the same animal (holotype, paratype 3, several other individuals) obviously occur regulary in *A. potter* sp. n.. So it seems that a certain amount of variety is possible among these animals, as for example the exp3 P4 which lacks a spine in the holotype without showing any hint of damage. Therefore Krishnaswamy most surely was not wrong when he observed this rare feature in *A. sewelli*.

Distribution and habitat of related species

The family Peltidiidae is a world wide distributed family with several species being reported from the southern hemisphere (Table 1). Of 16 valid species of *Alteutha* (15 species in Table 1; *Alteutha armatus* (Goodsir, 1845) not shown because no location is given) 10 are reported from the southern hemisphere. Although the discovery of several northern hemisphere species even in higher southern latitudes is reported, this information should still be handled with care, as firstly the descriptions are often insufficient and secondly because a number of species have been synonymized in the past.

Nevertheless, the records from South Africa, the South Orkneys, South Georgia, Patagonia, Tierra del Fuego, the Weddell Sea, the Kerguelen, New Zealand and the new species from the South Shetland Islands clearly show that *Alteutha* has to be regarded as a genus which has successfully populated the Southern ocean. Besides other factors, a lifestyle not unalterably sediment- or

algal-bound and the habit of, at least occasionally, emerging into the water column and leading a planktonic life, might have contributed to this wide distribution range.

Ecological discussion

Habitat and ecological features of Alteutha potter *sp. n.*

Alteutha potter sp. n. belongs to the Peltidiidae, a family of pelagic, phytal and benthic harpacticoids. Although their typical dorso-ventrally depressed body shape seems to characterize the Peltidiidae as a mainly substrate-associated family (Hicks & Coull, 1983; for *Alteutha*-species see Table 1), many species, including the new one, are described from the plankton such as *Alteutha novae-zealandiae* (Brady, 1899) or were found in plankton and benthos samples such as *Alteutha depressa* (Baird, 1837), *Alteutha interrupta* (Goodsir, 1845), and *A. oblonga* (Goodsir, 1845). However, as already observed by several authors, meiofauna species can either actively enter the water column or passively be eroded from the sediment (Rodriguez, 2004; Suderman & Thistle, 1998; Thistle et al., 1995; Thistle & Sedlacek, 2004). *A. potter* sp. n., to date, could not be detected in sediment samples from Potter Cove (Veit-Köhler, unpubl. data), but still remains a possibility that individuals are emerging from the macroalgal stocks at the northern rocky part of Potter Cove. Harpacticoida associated with those macroalgae have not yet been investigated.

A. potter sp. n. is a bright amber-coloured, strongly chitinized animal. Although its colour makes it relatively conspicuous for potential predators, observations of the new species and of the closely related species *Alteutha interrupta* (Goodsir, 1845) from the North Sea indicate, that these animals are very fast and agile swimmers. Their very well developed and robust cuticle might contribute an additional protection against predation, but whether living in the water column or in association with a substrate, harpacticoid copepods can be an important prey for invertebrate species and fish larvae (Alheit & Scheibel, 1982; Coull, 1990; Coull & Palmer, 1984; Feller & Kaczynski, 1975; Gee, 1987).

On the other hand harpacticoids are an important component of the meiofauna preying on microalgae and bacteria, thus contributing to the recycling of bacterial and other living material (Giere, 1993) and, due to their emerging behaviour, to bentho-pelagic coupling (Marcus & Boero, 1998). As the harpacticoid fraction is always well represented in plankton samples, they may play an important role in this habitat, as well. However, they are normally referred to at order-level and most plankton studies, especially in the Antarctic (Chiba et al., 2001; Tanimura et al., 1986), do not give details on species composition and taxonomy of harpacticoids.

Reproduction: seasonality and predicted generation time

The absence of reproductive stages of *A. potter* sp. n. despite the presence of gravid females in winter, spring and summer, gives rise to the assumption, that the offspring must be living in a habitat other than the pelagic or ice-bound realm.

The calculations carried out by means of the model for the prediction of generation times in sac spawning copepods (Veit-Köhler & Brey, unpubl.) indicate that despite the low temperatures a relatively short generation time has to be expected for the case that the offspring and the species in general including the gravid females lead a substrate associated life and animals only incidentally emerge into the water column. With a purely pelagic life style an even shorter generation time of about 30% less is probable. Lang (1948) cites Klie (1927), who reports that *A. oblonga* has the habit of ''swarming'' in autumn and winter and he thinks of this habit as being associated with reproduction events. Considering this, we can state that the higher abundances of *A. potter* sp. n. during winter might be related both to a swarming event and to the ephemeral existence of an additional habitat, the sea ice. The presence of gravid females in spring and summer seems to support this swarming hypothesis.

So the true generation times must lay somewhere in between the purely pelagic and the purely substrate-bound predictions and cannot be

determined until the habitat of the offspring is discovered.

Year round surveys and comparison with other environments

Most plankton sampling programs in the Southern Ocean are limited to short intervals in summer, although year round studies are very important in order to understand life cycles and ecology of species. The relative abundances of the three copepod orders found in the Potter Cove plankton are comparable to other Antarctic shallow water environments. Kittel et al. (2001) found that about 90% of the entire Admiralty Bay (King George Island) zooplankton community between February 1992 and January 1993 was comprised of commonly occurring copepods such as *O. similis* (50% of the collected animals), *C. citer* and *M. gerlachei.* Menshenina & Rakusa-Suszcewski (1992) and Freire et al. (1993) also observed similar patterns of abundances in Admiralty Bay. In our study the above mentioned species were also the dominant copepods during most of the year. Concerning previous zooplankton studies in Potter Cove, Elwers & Dahms (1998) studied the seasonal population structure of *O. similis* in 1996 and 1997. They found *O. similis* to be the most abundant species with a proportion of more than 80% of the total amount of copepods. Unfortunately, they did not consider other zooplankton groups and did not mention harpacticoid copepods at all.

In this study, harpacticoids contributed between 2 and 20% to the total copepod number (with the exception of two samples in October and November when they represented more than 90%) and they were present throughout the year. This is in accordance with the year round observation of Kittel et al. (2001) and Freire et al. (1993) for Admiralty Bay and Sicinski et al. (1996) for Herve Cove, King George Island.

Seasonal distribution

Elwers & Dahms (1998) and Metz (1995) found that the total abundance of *O. similis* in Potter Cove and the Weddell Sea, respectively, was generally

low in October and November. In the present study not only was *O. similis* less abundant at this time of the year but also all other copepod species. In the October–November samples harpacticoids were the only copepods present, albeit in very low numbers (6 Ind./m³). Other authors discussed the seasonal copepod fluctuations considering, among other factors (Elwers & Dahms, 1998; Metz, 1995; Atkinson & Peck, 1988), mainly hydrographic characteristics and food abundance and quality. In future studies, the fact of seasonally declining copepod stocks will be related to the presence of high numbers of *E. superba* in the Cove (data not shown in this work), which is known to predate considerably on copepods, especially when they are very abundant (Atkinson & Snyder, 1997; Atkinson et al., 1999).

The highest copepod abundances throughout the year 2002 were registered during the winter months and the beginning of spring. This coincides with the presence of a consolidated ice cover in Potter Cove. *A. potter* sp. n. followed the same pattern, performing a peak of abundance in the samples taken under the sea ice. Due to the presence of the ice sheet at this time of the year only vertical hauls could be carried out. Although the abundance of zooplankton was very high during winter, it even could have been underestimated by the method used. Therefore, we hypothesize that the actual abundances of copepods under the ice could be higher than indicated here. Indeed, during the beginning of the year 2002, we observed that in vertical hauls the quantity of animals per sample was very low. Therefore, we decided to increase the sample volume for a better resolution of species with low abundances. Horizontal tows contributing three or four times more volume of sampled water (an average of 50 m³ in our studies) were therefore additionally performed during summer.

Sea ice as a habitat

It is well known that sea ice provides a suitable habitat for different species of heterotrophic metazoans (Horner et al., 1992). The under-ice surface is highly structured and can contain three-dimensional macrostructures such as caves, holes, etc., and as ice algae may accumulate a high

biomass in the sea ice, forming the base of the sea-ice food web, a high abundance of sea-ice bound metazoans can be sustained (Gradinger, 2001).

The presence of harpacticoids within the sea ice or directly underneath is reported in several studies (Günther et al., 1999; Knox et al., 1996; Dahms et al., 1990; Fukuchi & Tanimura, 1980). However, this is the first time a member of the family Peltidiidae was found to be ice-related. It is known that migrations of copepods between different environments might occur. Particularly, adult benthic harpacticoids can seasonally migrate into the ice (Gradinger, 2001). Nevertheless, data on the diversity of sea-ice bound harpacticoid species are still scarce. However, in many Weddell Sea studies the harpacticoid *Drescheriella glacialis* Dahms & Dieckmann, 1987 was found to be an ice-associated copepod (Schnack-Schiel et al., 2001a; Schnack-Schiel et al., 2001b). With the exception of *D. glacialis* and the studies of Dahms et al. (1990) and Günther et al. (1999), harpacticoids have not been identified to species level in the majority of the studies including this one. Therefore the description of the planktonic and ice-bound harpacticoid community from Potter Cove is left as one of the aims for future investigations.

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