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Astacilla boreaphilis sp. nov. (Crustacea: Isopoda: Valvifera) from shallow and deep North Atlantic waters

BENTE STRANSKY[1] & JÖRUNDUR SVAVARSSON[2]

[1]*University of Hamburg, Biocenter Grindel and Zoological Museum, Martin-Luther-King Platz 3, 20146 Hamburg, Germany. E-mail: bente.stransky@uni-hamburg.de*

[2]*Institute of Biology, University of Iceland, Askja–Natural Science Building, Sturlugata 7, 101 Reykjavík, Iceland. E-mail: jorundur@hi.is*

Abstract

Astacilla boreaphilis **sp. nov.** is described from shallow and deep waters off Iceland and Greenland. *A. boreaphilis* **sp. nov.** is easily distinguished from all but one of the *Astacilla* species recorded from the North Atlantic by the absence of eyes and from all other *Astacilla* species by the pattern of the spines on the body. The species shows pronounced sexual dimorphism. The species occurs at depths between 219 and 1809 m and at temperatures between 2.4°C and 7.2°C. The species is therefore restricted to Atlantic Water (AW), characterizing the area south of the Greenland–Iceland–Færoe Ridge and to Atlantic Water presumably diluted by cold water masses from the Nordic Seas. The depth range in the area differs locally and may be limited by cold water currents crossing the Ridge.

Key words: Isopoda, Arcturidae, *Astacilla*, Iceland, Greenland

Introduction

The Arcturidae Dana, 1849 (Crustacea, Isopoda, Valvifera) are a bizarre group of filter-feeding benthic isopods (Poore 2001). *Astacilla* Cordiner, 1793 is a cosmopolitan genus, with 32 species described worldwide. Seven species are known from the North East Atlantic, these being *A. arietina* Sars, 1882, *A. bocagei* Nobre, 1903, *A. granulata* (Sars, 1877), *A. caeca* Benedict, 1898, *A. intermedia* (Goodsir, 1842), *A. longicornis* (Sowerby, 1806) and *A. pusilla* (Sars, 1873). These species are widely distributed from the shelf down to the deep-sea, except *A. caeca*, which has only been found from depths between 2790–3340 m (Kussakin 1982).

One of the northernmost distribution areas of *Astacilla* is the continental slope around

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Iceland and southeastern Greenland, providing characteristic topographic and hydrographic features. The submarine Greenland–Iceland–Færoe Ridge (GIF—Ridge) constrains the exchange of water masses from the North Atlantic to the seas north of the ridge (Weisshappel & Svavarsson 1998; Hansen & Østerhus 2000; Weisshappel 2000, 2001). While most of the water masses enterning the Nordic Seas flow over the eastern part of the ridge, i.e. the Iceland–Færoe Ridge (Hansen & Østerhus 2000), the water masses from the north return southwards through surface layers along the East Greenland coast and several overflows along the ridge. From the North Atlantic Current, the Irminger Current branches off and is again divided into the North Icelandic Irminger Current (Stefánsson 1962) flowing northwards through the Denmark Strait along the Icelandic coast, while the other part turns westwards and then flows parallel to the East Greenland Current southwards (Stefánsson 1962; Malmberg & Briem 1993; Hansen & Østerhus 2000). These very different water masses, showing distinctive patterns in temperature and salinity, make this region highly interesting for faunal investigations. Several authors found evidence of hydrographic influences on the distribution of peracarid crustaceans (Svavarsson *et al*. 1990, 1993; Svavarsson 1997; Negoescu & Svavarsson 1997; Weisshappel & Svavarsson 1998; Weisshappel 2000, 2001).

During a large-scale exploration of benthic invertebrates in Icelandic waters (BIOICE project) and extensive studies in the waters off South Greenland, an undescribed species of the genus *Astacilla* was found. In the present study this new species is described. In light of pronounced sexual dimorphism and substantial changes in habitus during development, notes on the developmental stages are given.

Materials and methods

During the BIOICE (Benthic Invertebrates of Icelandic waters) project from 1991–2004, the benthic fauna in Icelandic waters was thoroughly investigated. In all, 1050 samples (each given a BIOICE station number) were taken of benthic invertebrates were taken at 579 locations using a variety of sampling gear during cruises on the research vessels *Bjarni Sæmundsson*, *Håkon Mosby* and *Magnus Heinason*. Samples were taken with a modified Rothlisberg-Pearcy epibenthic sledge (RP sled; Rothlisberg & Pearcy 1976; Brattegard & Fosså 1991) with 0.5 mm mesh in the cod end, a Sneli sled (Sneli 1998), an Agassiz trawl and a triangular dredge. Samples from the RP sled were decanted through a series of sieves, the smallest mesh size being 0.5 mm. The Sneli sled samples were sieved through 1 mm sieve. The specimens were then preserved in 10% buffered formalin and later transferred to 80% ethanol.

Additional material was collected off South Greenland in 2001. In all, 10 samples were taken with an epibenthic dredge (Stransky, in prep.), having 0.5 mm mesh. The samples were decanted through a series of sieves, the smallest mesh size being 0.5 mm and were preserved directly in 96% cooled ethanol.

Over 6000 specimens were found in 64 of the samples from Iceland (from 919 BIOICE samples fully sorted for isopods) and four specimens were collected from Greenland.

The material is deposited at the Icelandic Museum of Natural History, Reykjavík (IMNH), the Zoological Museum of Hamburg (ZMH) and the Zoological Museum of Copenhagen (ZMUC).

The description was produced using the DELTA software (Dallwitz *et al*. 1997), but was edited afterwards.

Taxonomy

Valvifera Sars, 1882

Arcturidae Dana, 1849

***Astacilla* Cordiner, 1793**

***Astacilla boreaphilis* sp. nov.**
(Figs 1–10)

Material examined

Holotype. ♀ (7.4 mm), BIOICE stn 2475, 63°04.20’N, 21°34.90’W, 842 m, 5.5°C, 5 July 1993, RP sled, IMNH 2006.06.01.1.

Paratypes. Allotype, ♂ (7.0 mm), same data as holotype, IMNH 2006.06.01.2; ♀ (7.5 mm), BIOICE stn 3069, 62°28.80’N, 14°29.94’W, 1602 m, 3.24°C, 11 July 1997, RP sled, IMNH 2006.06.01.3; ♀ (7.4 mm, IMNH 2006.06.01.4), preparatory ♀ (6.4 mm, IMNH 2006.06.01.5), ♂ (8.7 mm, IMNH 2006.06.01.6), precopulatory ♂ (5.8 mm, IMNH 2006.06.01.7), juvenile (manca 3) (4.9 mm, IMNH 2006.06.01.8), juvenile (manca 2) (3.2 mm, IMNH 2006.06.01.9), all same data as holotype; BIOICE stn 2257, 63°14.61’N, 26°29.14’W, 1209 m, 4.09°C, 5 September 1992, RP sled, 30 specimens, IMNH 2006.06.01.10; BIOICE stn 2427, 63°09.90’N, 20°03.69’W, 778 m, 5.5°C, 3 July 1993, RP sled, 185 specimens, IMNH 2006.06.01.11; BIOICE stn 2472, 63°06.70’N, 21°37.60’W, 666 m, 6.09°C, 5 July 1993, RP sled, 37 specimens, IMNH 2006.06.01.12, 2 specimens (1 ♀, 1 ♂), ZMH 41184, 2 specimens (1 ♀, 1 ♂), ZMUC-CRU-9892; BIOICE stn 2475, 63°04.20’N, 21°34.90’W, 842 m, 5.5°C, 5 July 1993, RP sled, 341 specimens, IMNH 2006.06.01.13, 28 specimens (11 ♀, 12 ♂, 5 mancas), ZMH 41185, 30 specimens (14 ♀, 9 ♂, 7 mancas), ZMUC-CRU-9893.

Greenland material: WH233 stn 1016, 63°33.69’N, 39°18.18’W, 219 m, 4.37°C, 25 October 2001, epibenthic dredge, 4 specimens (1 brooding ♀, 1 ♂, 2 manca 3), ZMH 41183.

Other non-catalogued material (deposited at IMNH)

BIOICE stn 2254, 63°14.61'N, 26°03.43'W, 999 m, 4.88°C, 5 September 1992, Sneli sled, 1 specimen; BIOICE stn 2293, 62°27.86'N, 22°40.24'W, 1203 m, 3.91°C, 9 September 1992, RP sled, 7 specimens; BIOICE stn 2299, 63°00.10'N, 22°39.61'W, 775 m, 5.53°C, 10 September 1992, RP sled, 28 specimens; BIOICE stn 2303, 63°03.88'N, 22°41.22'W, 600 m, 6.75°C, 10 September 1992, RP sled, 1 specimen; BIOICE stn 2340, 62°08.00'N, 13°20.00'W, 1302 m, 5 May 1993, RP sled, 26 specimens; BIOICE stn 2403, 63°02.90'N, 21°49.60'W, 838 m, 5.49°C, 1 July 1993, RP sled, 448 specimens; BIOICE stn 2404, 63°02.30'N, 21°50.80'W, 802 m, 5.49°C, 1 July 1993, Sneli sled, 12 specimens; BIOICE stn 2406, 62°59.20'N, 21°47.00'W, 934 m, 4.57°C, 1 July 1993, RP sled, 106 specimens; BIOICE stn 2407, 62°58.60'N, 21°49.30'W, 917 m, 4.57°C, 1 July 1993, Sneli sled, 47 specimens; BIOICE stn 2409, 62°52.37'N, 21°43.42'W, 1060 m, 4.0°C, 2 July 1993, Sneli sled, 1 specimen; BIOICE stn 2410, 62°51.60'N, 21°44.10'W, 1074 m, 4.0°C, 2 July 1993, RP sled, 168 specimens; BIOICE stn 2418, 63°09.93'N, 21°12.08'W, 256 m, 7.08°C, 2 July 1993, RP sled, 4 specimens; BIOICE stn 2424, 63°10.27'N, 20°09.54'W, 495 m, 6.46°C, 3 July 1993, RP sled, 2 specimens; BIOICE stn 2426, 63°10.30'N, 20°03.80'W, 800 m, 5.5°C, 3 July 1993, Sneli sled, 4 specimens; BIOICE stn 2430, 63°07.90'N, 19°57.20'W, 1016 m, 4.8°C, 3 July 1993, RP sled, 3 specimens; BIOICE stn 2435, 63°13.80'N, 19°31.70'W, 965 m, 5.48°C, 3 July 1993, RP sled, 2 specimens; BIOICE stn 2691, 64°26.10'N, 28°14.20'W, 1162 m, 3.72°C, 31 August 1994, Sneli sled, 7 specimens; BIOICE stn 2692, 64°26.60'N, 28°15.50'W, 1162 m, 3.72°C, 31 August 1994, RP sled, 10 specimens; BIOICE stn 2697, 64°10.20'N, 27°43.10'W, 1042 m, 4.2°C, 2 September 1994, RP sled, 364 specimens; BIOICE stn 2698, 64°10.50'N, 27°42.60'W, 1038 m, 4.2°C, 2 September 1994, Sneli sled, 2 specimens; BIOICE stn 2700, 64°05.60'N, 27°50.00'W, 1105 m, 3.84°C, 2 September 1994, Sneli sled, 39 specimens; BIOICE stn 2701, 64°05.50'N, 27°49.70'W, 1121 m, 3.84°C, 2 September 1994, RP sled, 173 specimens; BIOICE stn 2704, 63°50.50'N, 27°42.80'W, 1295 m, 3.8°C, 2 September 1994, RP sled, 114 specimens; BIOICE stn 2706, 63°55.80'N, 28°16.30'W, 1406 m, 3.71°C, 3 September 1994, Sneli sled, 1 specimen; BIOICE stn 2707, 63°55.30'N, 28°16.80'W, 1407 m, 3.71°C, 3 September 1994, RP sled, 6 specimens; BIOICE stn 2811, 62°39.84'N, 19°45.36'W, 1695 m, 3.31°C, 23 August 1995, RP sled, 11 specimens; BIOICE stn 2844, 63°05.40'N, 17°21.10'W, 1085 m, 4.48°C, 27 August 1995, RP sled, 1601 specimens; BIOICE stn 2846, 62°59.00'N, 17°50.10'W, 947 m, 3.48°C, 27 August 1995, RP sled, 43 specimens; BIOICE stn 2864, 62°04.21'N, 20°35.55'W, 1681 m, 2.67°C, 31 August 1995, RP sled, 315 specimens; BIOICE stn 2900, 65°25.48'N, 27°52.62'W, 855 m, 5.18°C, 24 August 1996, Sneli sled, 2 specimens; BIOICE stn 2901, 65°25.76'N, 27°53.60'W, 854 m, 5.18°C, 24 August 1996, RP sled, 47 specimens; BIOICE stn 2904, 65°23.27'N, 28°21.27'W, 1057 m, 4.78°C, 24 August 1996, RP sled, 1 specimen; BIOICE stn 2907, 65°15.95'N, 28°50.36'W, 1311 m, 3.96°C, 25 August 1996, Sneli sled, 6 specimens; BIOICE stn 2909, 65°15.61'N, 28°50.15'W, 1300 m, 3.96°C, 25

August 1996, RP sled, 28 specimens; BIOICE stn 2912, 65°11.01’N, 29°04.18’W, 1456 m, 3.9°C, 25 August 1996, RP sled, 77 specimens; BIOICE stn 2918, 65°12.57’N, 29°14.55’W, 1539 m, 3.22°C, 26 August 1996, Sneli sled, 2 specimens; BIOICE stn 3069, 62°28.80’N, 14°29.94’W, 1602 m, 3.24°C, 11 July 1997, RP sled, 13 specimens; BIOICE stn 3183, 61°14.25’N, 27°54.98’W, 1005 m, 4.6°C, 31 July 2000, triangle dredge, 1 specimen; BIOICE stn 3189, 62°08.63’N, 26°38.17’W, 950 m, 5.21°C, 10 August 2000, Agassiz trawl, 21 specimens; BIOICE stn 3259, 62°59.50’N, 19°11.10’W, 1311 m, 3.72°C, 11 September 2001, Sneli sled, 58 specimens; BIOICE stn 3260, 62°59.40’N, 19°10.90’W, 1308 m, 3.72°C, 12 September 2001, RP sled, >1000 specimens; BIOICE stn 3261, 62°59.70’N, 19°11.10’W, 1301 m, 3.72°C, 12 September 2001, Agassiz trawl, 23 specimens; BIOICE stn 3263, 62°31.50’N, 19°39.50’W, 1682 m, 3.3°C, 13 September 2001, RP sled, 81 specimens; BIOICE stn 3280, 62°53.50’N, 15°55.60’W, 1692 m, 2.85°C, 16 September 2001, RP sled, 18 specimens; BIOICE stn 3500, 62°59.90’N, 20°30.30’W, 814 m, 5.82°C, 31 August 2002, Sneli sled, 4 specimens; BIOICE stn 3501, 62°59.84’N, 20°30.25’W, 829 m, 5.82°C, 31 August 2002, RP sled, 373 specimens; BIOICE stn 3504, 62°01.46’N, 19°49.15’W, 1733 m, 3.09°C, 2 September 2002, RP sled, 1 specimen; BIOICE stn 3505, 61°46.53’N, 19°44.45’W, 1809 m, 2.55°C, 2 September 2002, RP sled, 2 specimens; BIOICE stn 3509, 62°02.40’N, 19°38.71’W, 1678 m, 2.7°C, 3 September 2002, RP sled, 5 specimens; BIOICE stn 3510, 62°14.41’N, 19°28.62’W, 1605 m, 2.67°C, 3 September 2002, RP sled, 178 specimens; BIOICE stn 3512, 62°14.34’N, 19°28.78’W, 1607 m, 2.67°C, 4 September 2002, Agassiz trawl, 33 specimens; BIOICE stn 3514, 62°25.59’N, 19°46.15’W, 1780 m, 2.93°C, 4 September 2002, RP sled, fragment; BIOICE stn 3515, 62°22.20’N, 18°23.35’W, 1331 m, 3.77°C, 4 September 2002, RP sled, 1 specimen; BIOICE stn 3527, 62°47.19’N, 17°20.37’W, 1662 m, 3.36°C, 8 September 2002, RP sled, 64 specimens; BIOICE stn 3528, 62°47.28’N, 17°07.67’W, 1749 m, 2.95°C, 8 September 2002, RP sled, 7 specimens; BIOICE stn 3535, 62°38.52’N, 14°15.11’W, 1596 m, 2.64°C, 9 September 2002, Sneli sled, 1 specimen; BIOICE stn 3536, 62°23.93’N, 14°13.20’W, 1514 m, 2.57°C, 10 September 2002, Sneli sled, 3 specimens; BIOICE stn 3537, 62°24.68’N, 14°13.23’W, 1511 m, 2.57°C, 10 September 2002, Agassiz trawl, 1 specimen; BIOICE stn 3539, 61°59.63’N, 13°33.09’W, 1377 m, 2.41°C, 10 September 2002, RP sled, 57 specimens; BIOICE stn 3547, 62°59.04’N, 18°09.23’W, 1233 m, 12 September 2002, RP sled, 1 specimen; BIOICE stn 3554, 64°16.74’N, 25°41.58’W, 304 m, 7.19°C, 2 September 2003, RP sled, 3 specimens.

Diagnosis

Eyes absent. Adult body strongly sexual dimorphic, with heavy spination. Anterolateral margins of head rounded in lateral view, with medial indentation, small rostral point evident in fully developed specimens. Fusion of head and pereonite 1 indicated by dorsolateral suture incised laterally; head and pereonite 1 with one small medial spine anteriorly, two dorsal spines medially and two dorsolateral spines distally.

Pereonites 2–7 with heavy spination. Pleotelson with dorsolateral posterior wings, a pair of dorsolateral spines and a small dorsal tubercle/spine at mid-length. Oostegites 2–4 oval-triangular shaped, tapering distally; oostegites 2 and 3 simple, laminar-like; oostegite 4 approximately three times longer than wide, with strong ridge and tubercles/spines laterally, outer side strong.

Males with similar spination pattern, except on pereonite 4. Pereonite 4 without spines, only insignificant tubercles anteriorly. Pleotelson without dorsal tubercle/spine at mid-length.

Description of female holotype

Body 7.44 mm in length, elongate, strongly geniculate between pereonites 4 and 5, cylindrical. Anterolateral margins of head rounded in lateral view, with medial indentation, small rostral point evident in fully developed specimens. Head and pereonite 1 fused, laterally sinuate, with one small medial spine anteriorly, two dorsal spines medially and two dorsolateral spines distally; pereonites 2–4 all of different width; pereonite 2 with one dorsal spine and two dorsolateral tubercles; pereonite 3 with one dorsal spine and two dorsolateral spines; pereonite 4 elongate, being 1.6 times longer than head and pereonites 1–3 together and about 0.58 times the total body length, with five dorsal pairs of spines and up to four lateral spines; oostegites 2–4 oval-triangular shaped, tapering distally; oostegites 2 and 3 simple, laminar-like; oostegite 4 approximately three times longer than wide, with strong ridge and tubercles/spines laterally, outer side strong; pereonites 5–7 similar in spination pattern, with single dorsal spine and two dorsolateral spines, at pereonite 7 developed as tubercles. Pleotelson with dorsolateral posterior wings, two dorsolateral spines and a small dorsal tubercle/spine at mid-length.

Antenna 1 shorter than 0.3 of third peduncular article of antenna 2; flagellum with group of three sensory setae and with two aesthetascs, aesthetascs two-segmented.

Antenna 2 slender, more than 0.7 of body length, with many fine setae and several groups of three sensory setae; flagellum with two articles, with medial spines on middle and distal part of first article and few on second flagellar article, with distal claw.

Mandibles symmetrical but not identical. Spine row of right mandible with one dentate spine, left mandible with two spines; incisor with four lobes; lacinia mobilis with two major lobes and one small indication of third lobe.

Maxilla 1 inner lobe with three terminal setae and few simple setae on outer margin; outer lobe with 10 stout apical setae and 4–5 simple setae, with several simple setae over entire surface.

Maxilla 2 inner lobe with eight robust denticulate setae in apical row, three stout setae in second row and five setose setae proximal to middle lobe; inner surface proximally with several long fine setae and several small simple setae; middle lobe with three progressively longer setae, all pectinate; outer lobe with three long setae, all pectinate and finely setulate, proximal margin with fine setae.

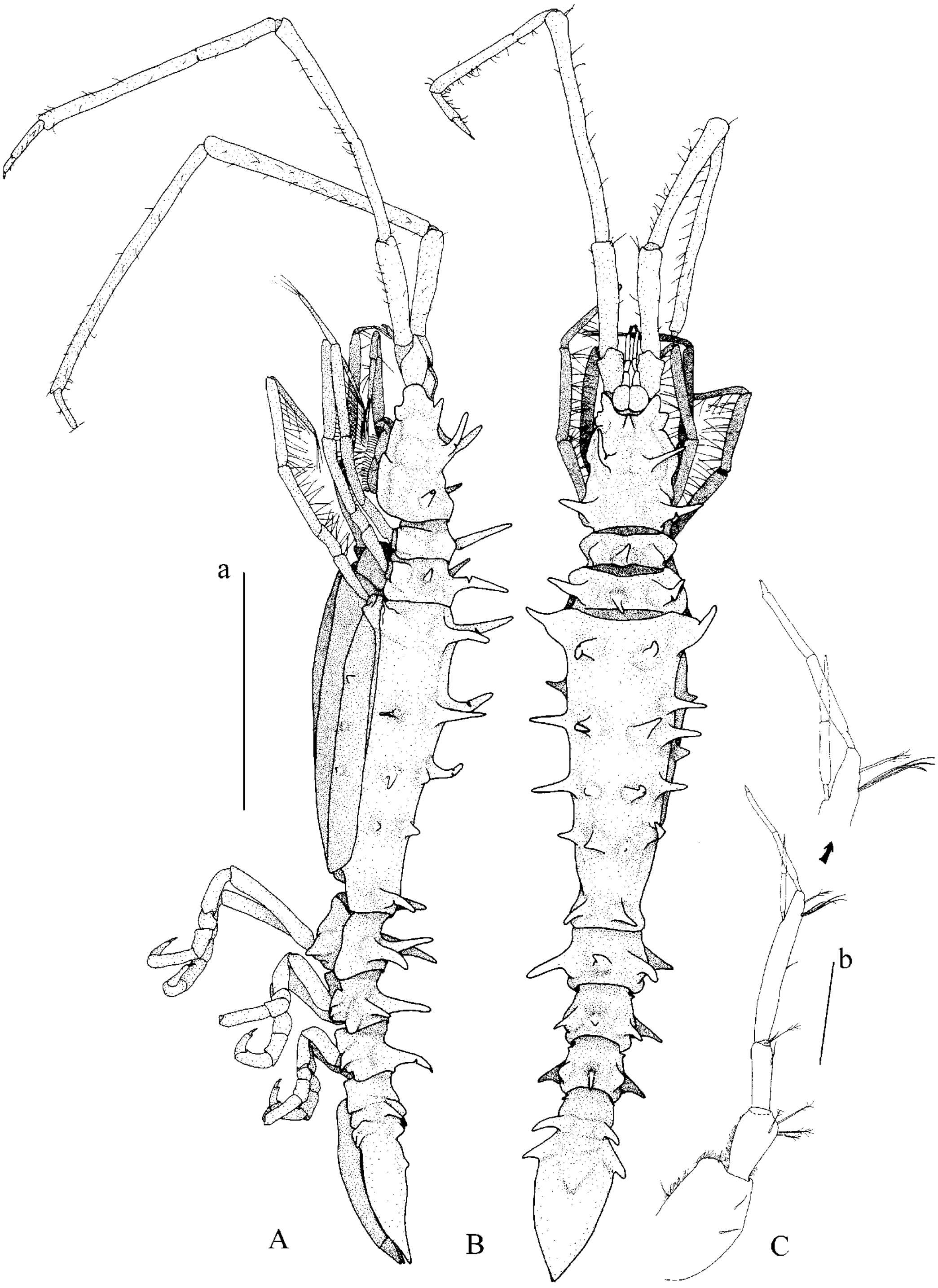

FIGURE 1. *Astacilla boreaphilis* **sp. nov.**, holotype ♀, 7.4 mm, (IMNH 2006.06.01.1). A, habitus, lateral view. B, habitus, dorsal view. C, antenna 1. Scales: a = 2 mm, b = 0.2 mm.

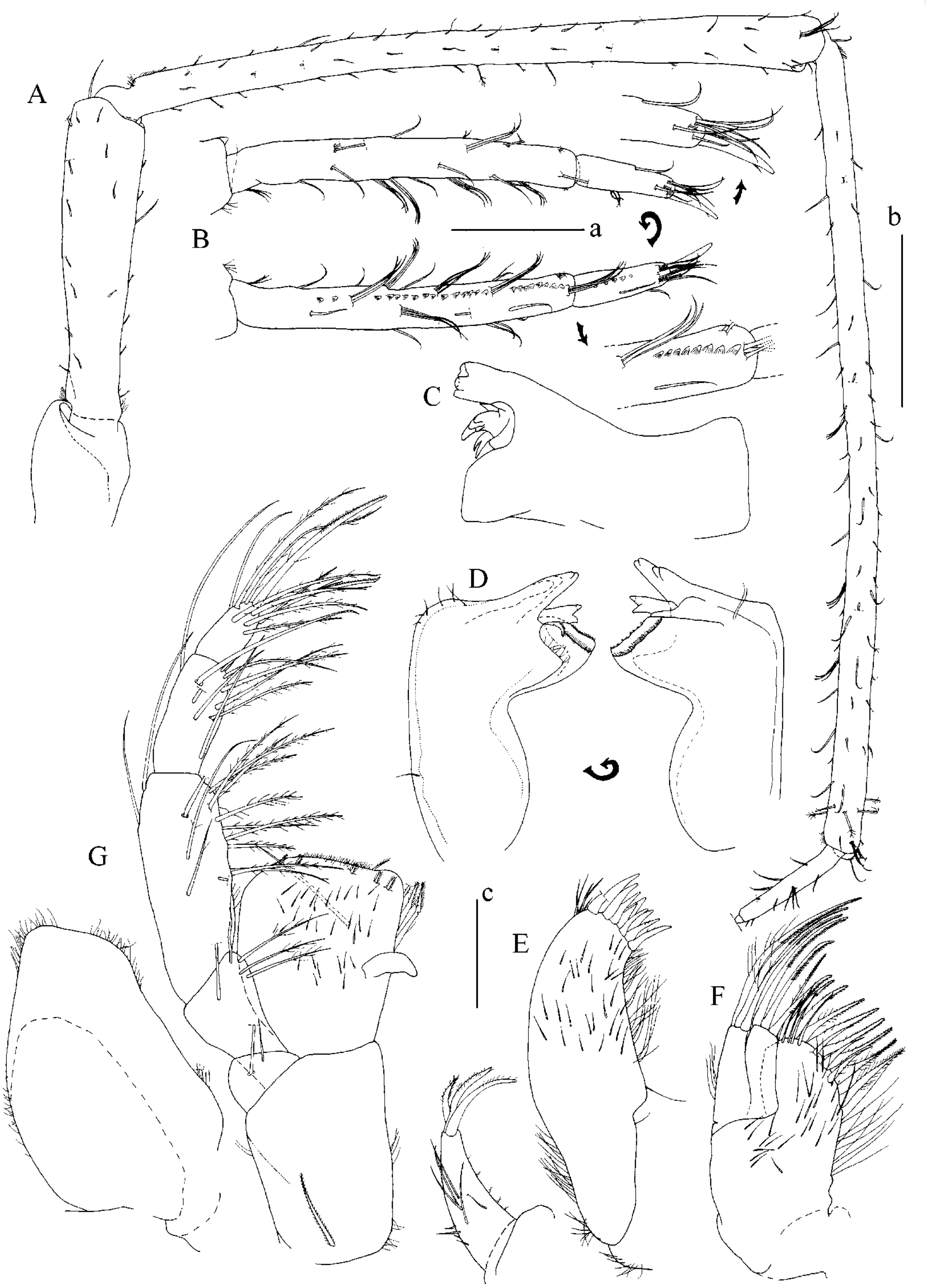

FIGURE 2. *Astacilla boreaphilis* **sp. nov.** A, C, paratype ♀, 7.4 mm (IMNH 2006.06.01.4). B, D–G, holotype ♀, 7.4 mm, (IMNH 2006.06.01.1). A, antenna 2. B, antenna 2, distal end, lateral and ventral view. C, left mandible. D, right mandible, different angles. E, maxilla 1. F, maxilla 2. G, maxilliped. Scales: a = 0.5 mm, b = 0.2 mm, c = 0.1 mm.

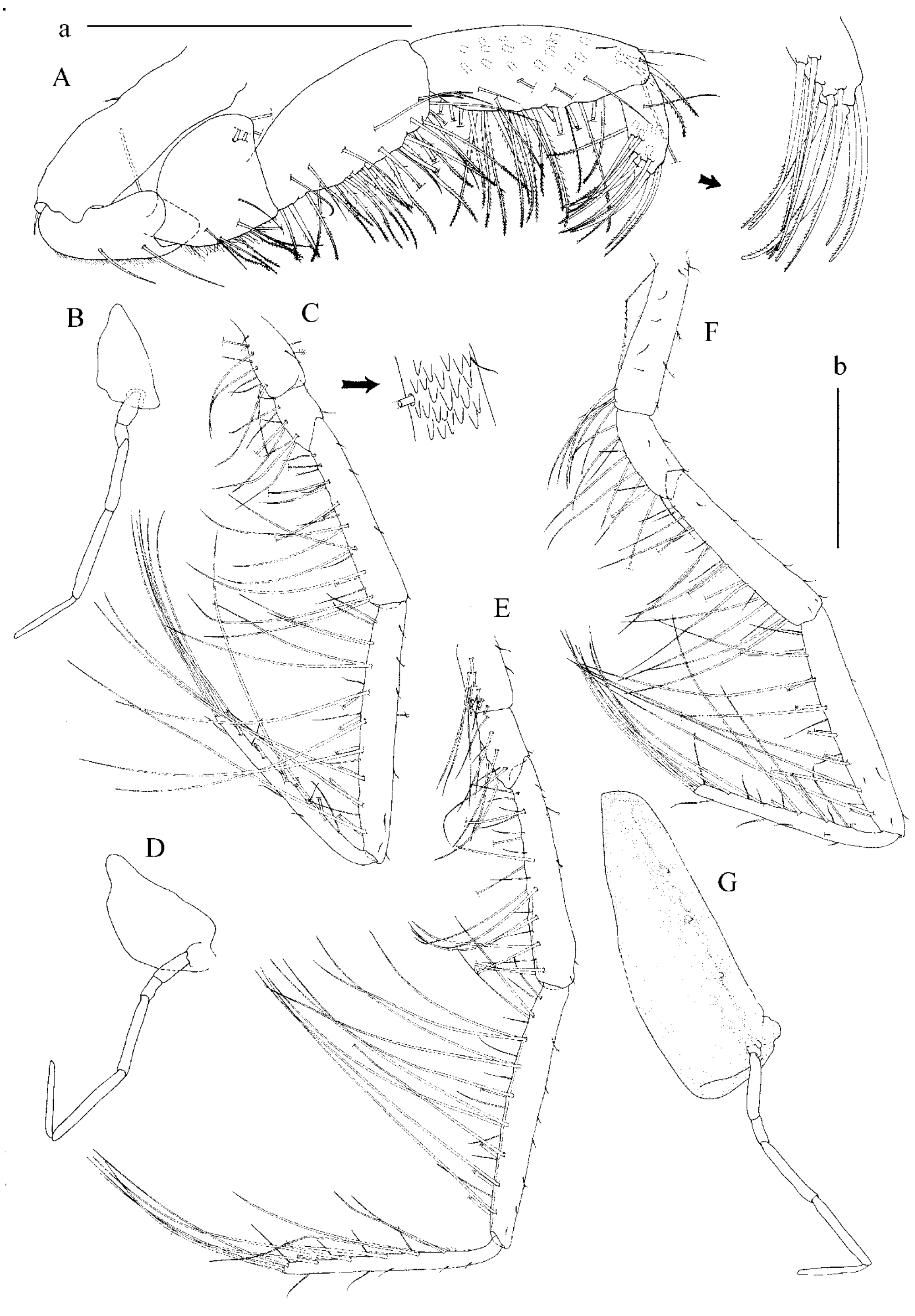

FIGURE 3. *Astacilla boreaphilis* **sp. nov.**, A, C, E, F, holotype ♀, 7.4 mm, (IMNH 2006.06.01.1), B, D, G, paratype ♀, 7.4 mm (IMNH 2006.06.01.4). A, pereopod 1. B, oostegite of pereopod 2. C, pereopod 2. D, oostegite of pereopod 3. E, pereopod 3. F, pereopod 4. G, oostegite of pereopod 4. Scales a, b = 0.5 mm.

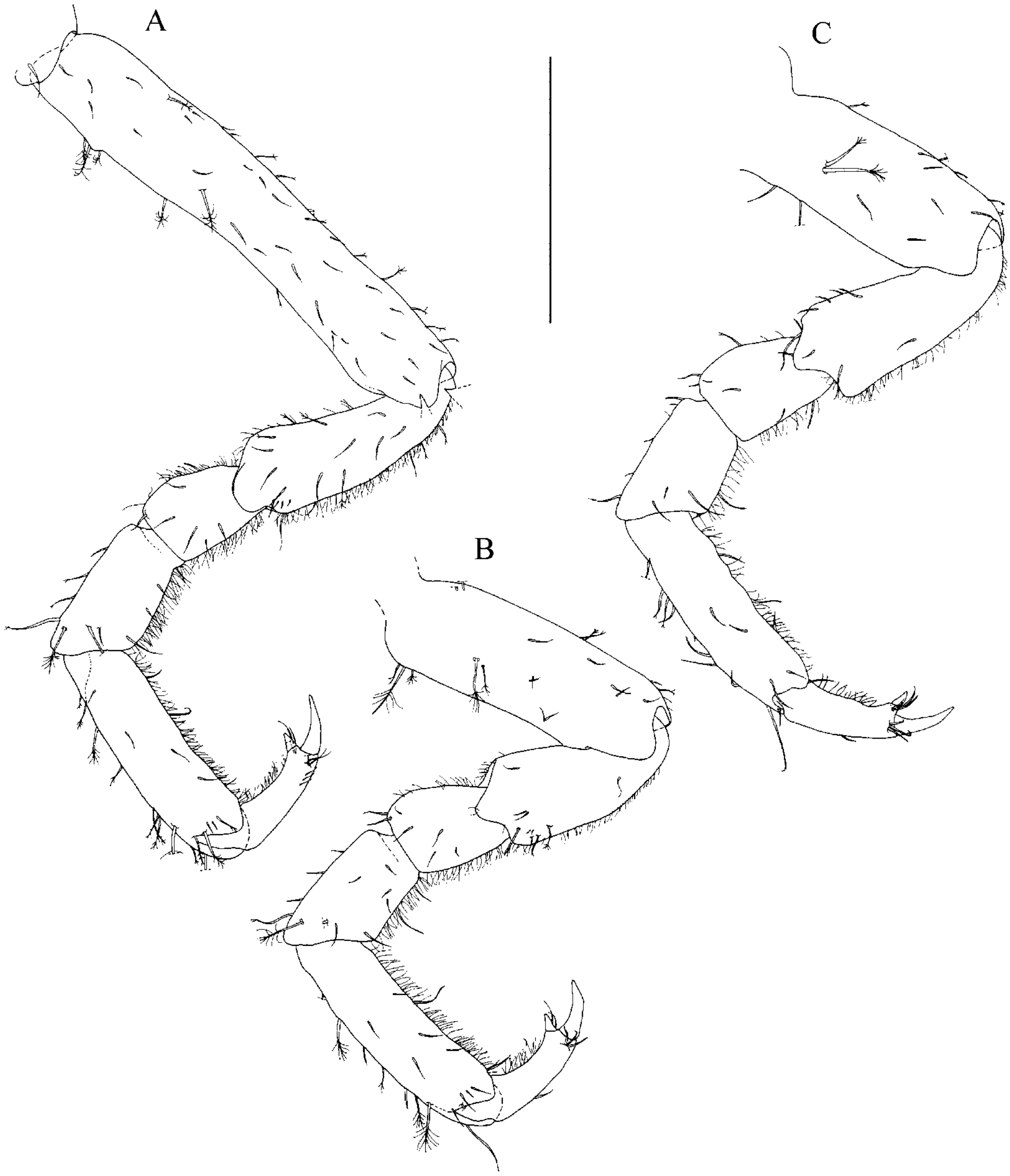

FIGURE 4. *Astacilla boreaphilis* **sp. nov.**, holotype ♀, 7.4 mm, (IMNH 2006.06.01.1). A, pereopod 5. B, pereopod 6. C, pereopod 7. Scale = 0.5 mm.

Maxilliped with basal articulation; with one coupling hook and three denticulate setae on inner margin (one broken off), distal margin with several very fine simple setae and five short denticulate setae; palp segments all free.

Pereopod 1 setose, ischium-dactylus dorsally with long simple setae; merus–dactylus ventrally with numerous mostly plumose setae with plumose shaft and short setules on tip; dactylus with several robust setae with pectinate tip; unguis pectinate, 1.1 times longer than propodus.

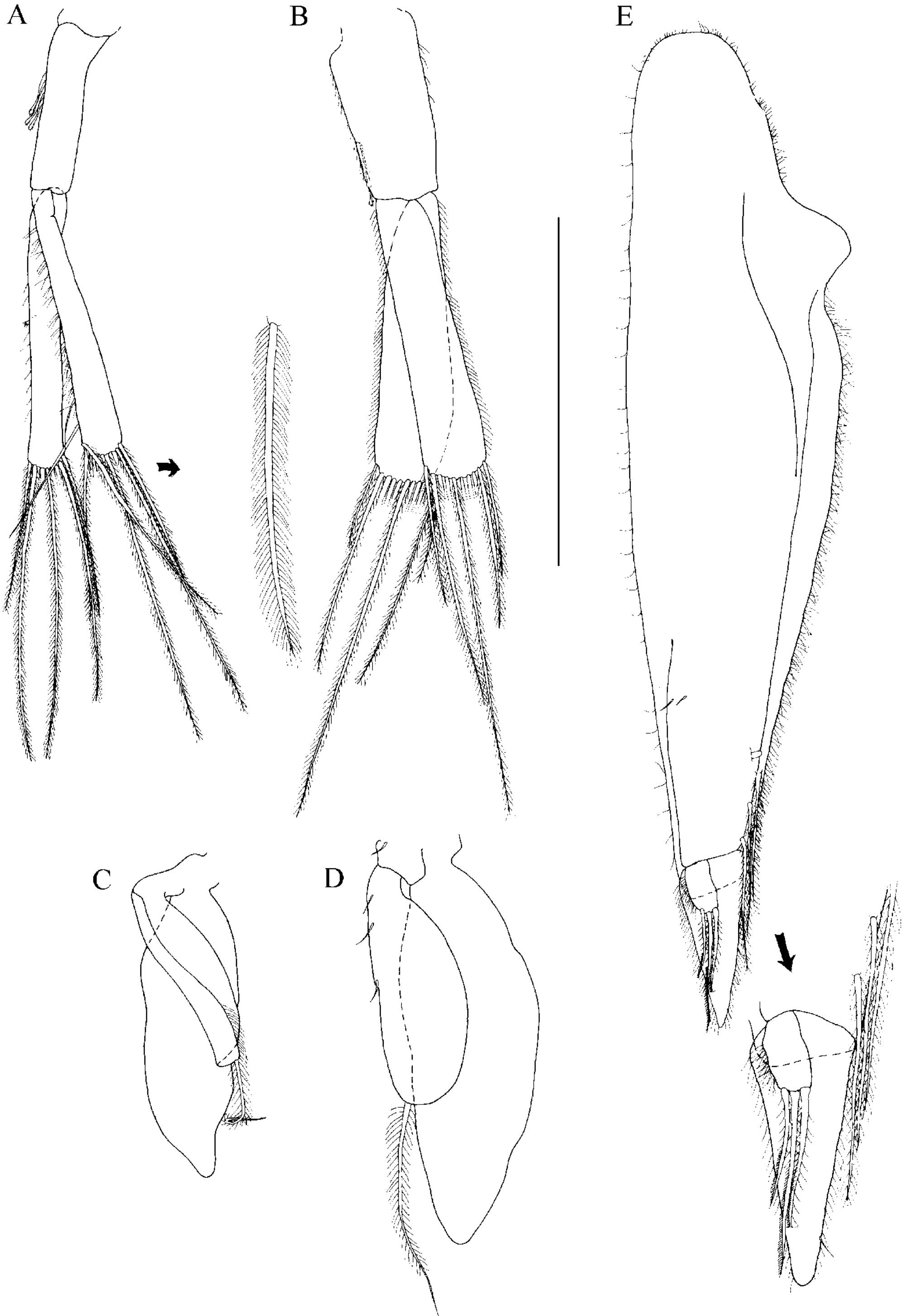

FIGURE 5. *Astacilla boreaphilis* **sp. nov.**, holotype ♀, 7.4 mm, (IMNH 2006.06.01.1). A, pleopod 1. B, pleopod 2. C, pleopod 4. D, pleopod 5. E, uropod. Scale = 0.5 mm.

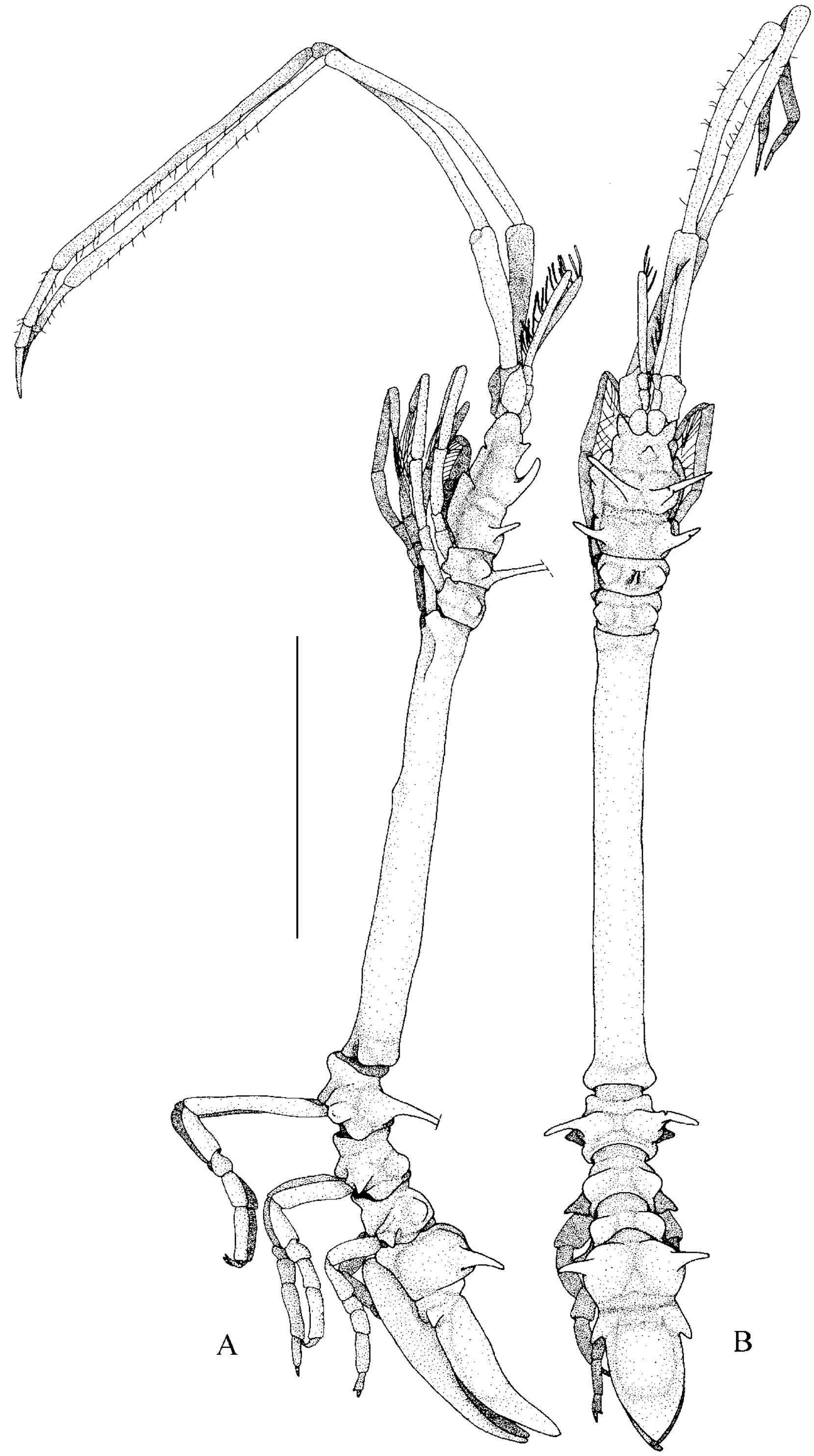

FIGURE 6. *Astacilla boreaphilis* **sp. nov.**, allotype ♂, 7.0 mm (IMNH 2006.06.01.2). A, habitus, lateral view. B, habitus, dorsal view. Scale = 2 mm.

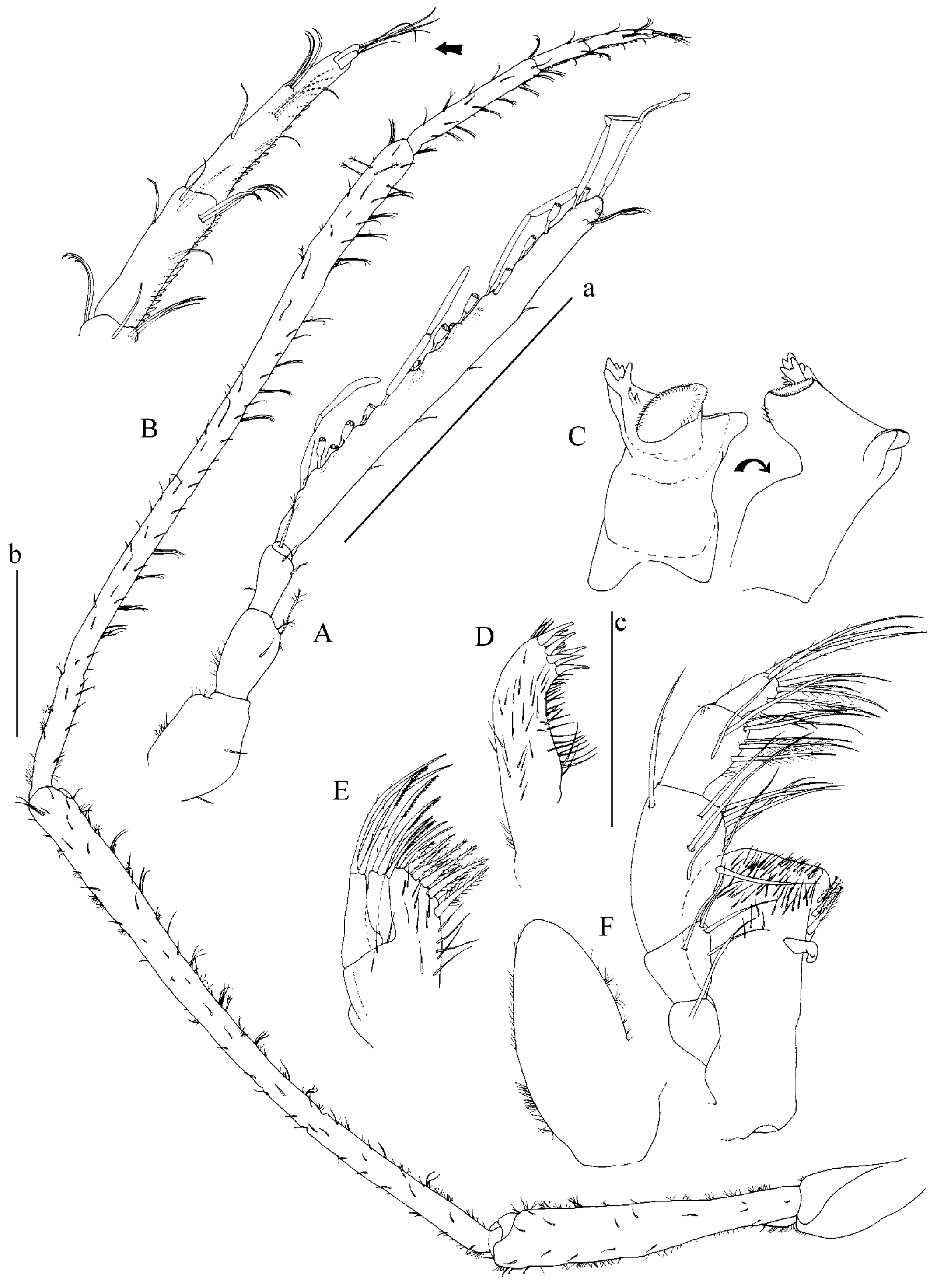

FIGURE 7. *Astacilla boreaphilis* **sp. nov.**, allotype ♂, 7.0 mm (IMNH 2006.06.01.2). A, antenna 1. B, antenna 2. C, right mandible, various angles. D, maxilla 1, outer lobe. E, maxilla 2. F, maxilliped. Scales: a, b = 0.5 mm, c = 0.2 mm.

FIGURE 8. *Astacilla boreaphilis* **sp. nov.**, allotype ♂, 7.0 mm (IMNH 2006.06.01.2). A, penial plate. B, pleopod 1. C, pleopod 2. D, pleopod 3. E, pleopod 4. F, pleopod 5. G, uropod. Scales: a = 0.2 mm, b = 0.5 mm.

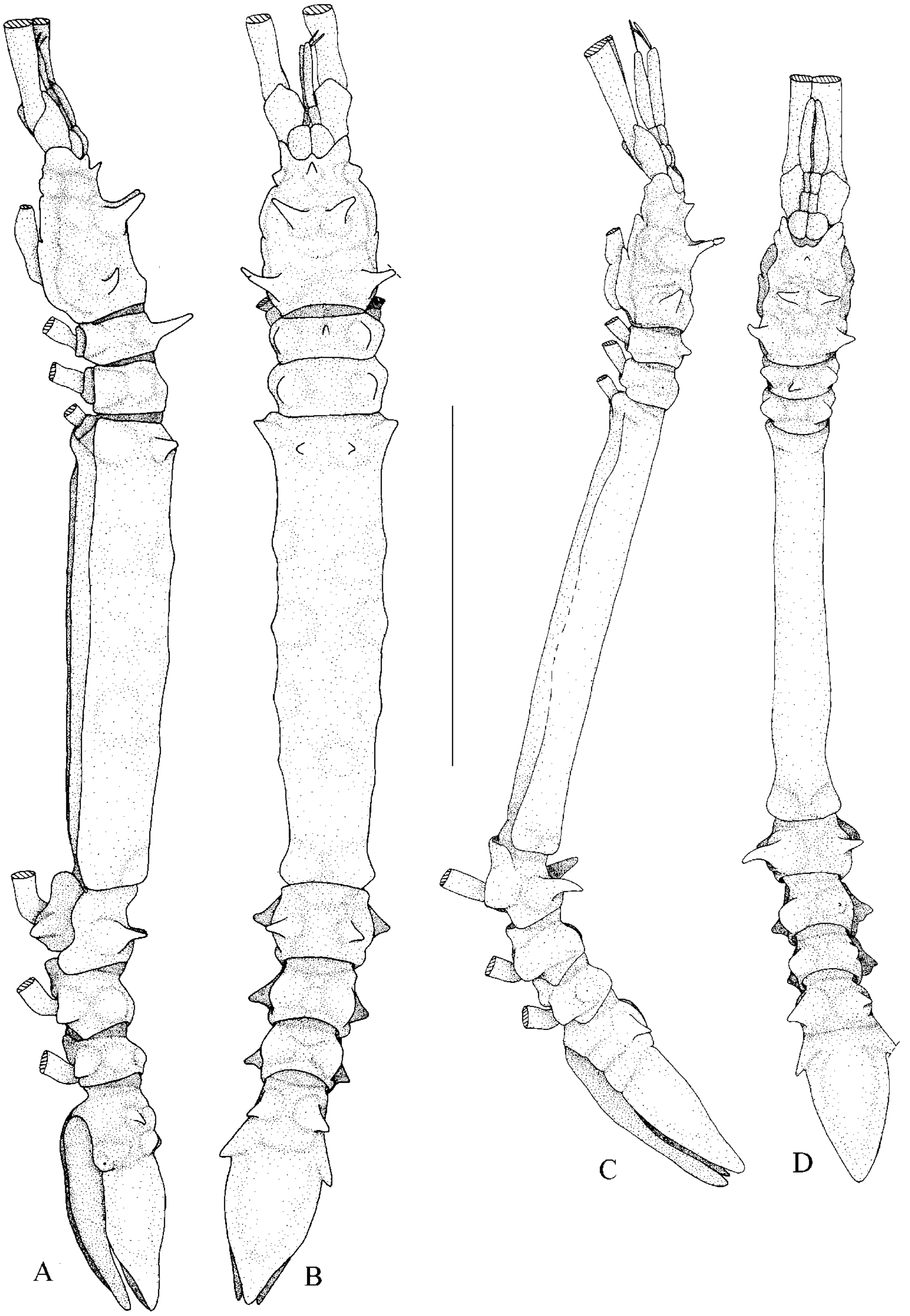

FIGURE 9. *Astacilla boreaphilis* **sp. nov.**, A–B, paratype preparatory ♀, 6.4 mm (IMNH 2006.06.01.5), C–D, paratype precopulatory ♂, 5.8 mm (IMNH 2006.06.01.7). A, habitus, lateral view. B, habitus, dorsal view. C, habitus, lateral view. D, habitus, dorsal view. Scale = 2 mm.

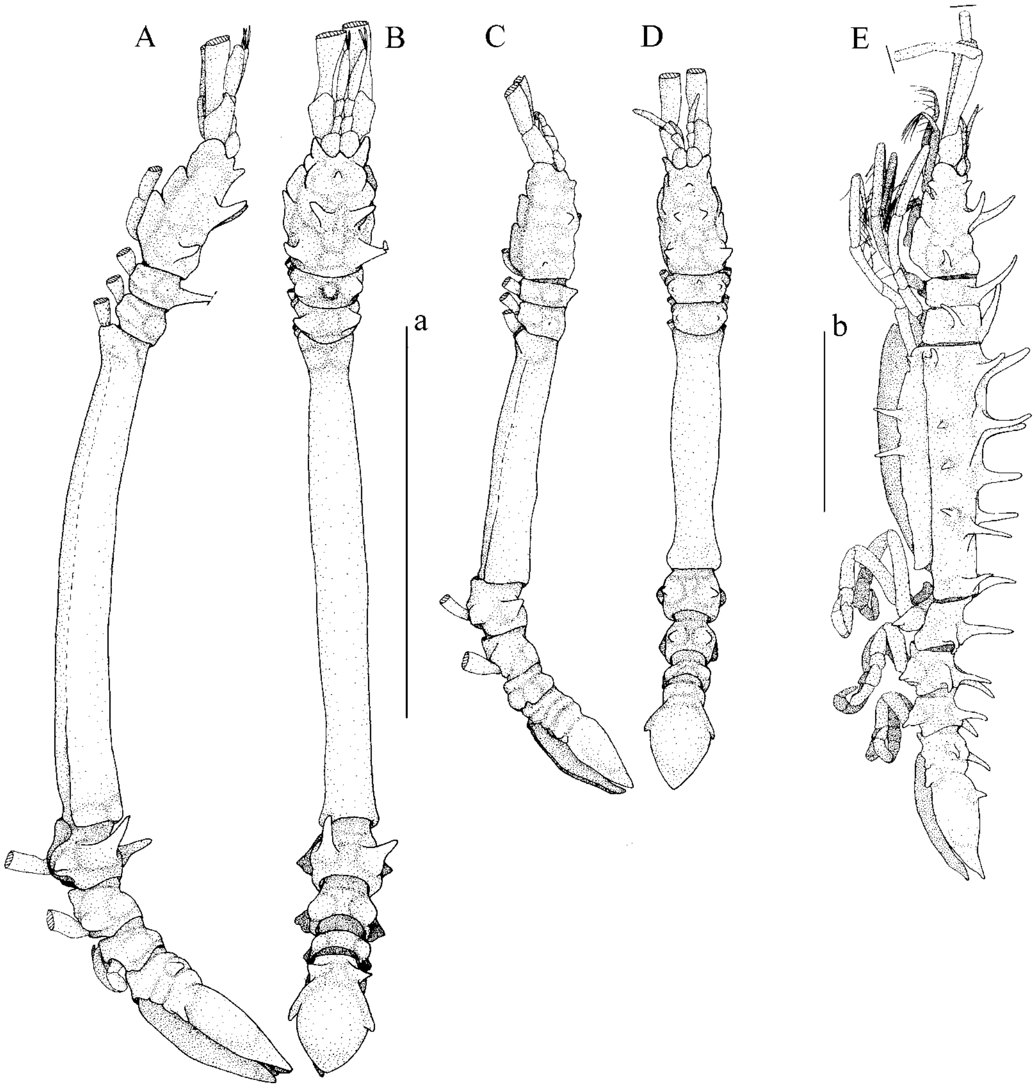

FIGURE 10. *Astacilla boreaphilis* **sp. nov.** A–B, paratype manca 3 stage, 4.9 mm (IMNH 2006.06.01.8), C–D, paratype manca 2 stage, 3.2 mm (IMNH 2006.06.01.9), E, paratype ♀ (IMNH 2006.06.01.3). A, lateral view. B, dorsal view. C, lateral view. D, dorsal view. E, lateral view. Scales: a, b = 2 mm.

Pereopods 2–4 setose, cylindrical, surface with scale-like structures; setae on merus to carpus in two ventral rows, mostly as long as segment or longer; dactylus absent.

Pereopods 5–7 progressively shorter; with two ungui, secondary unguis robust.

Pleopod 1 peduncle with three coupling hooks on inner margin; exopod without lateral notch or setae, with nine apical plumose setae of different length (middle longest); endopod with 11 apical plumose setae of different length (middle longest), with one small and one long slender seta on inner margin.

Pleopod 2 peduncle with three coupling hooks on inner margin (one broken off); exopod without lateral setae, with 12 apical plumose setae of different length (middle longest); endopod without lateral setae, with 10 apical plumose setae of different length (middle longest).

Pleopods 3–5 similar, exopod shorter than endopod; pleopod 3 exopod with two plumose distolateral setae; pleopods 4–5 exopods with one plumose distolateral seta.

Uropodal peduncle with four distal lateral plumose setae (one broken off); exopod present, shorter than half-length of endopod, with three setae of different length, setae plumose with plumose shaft and short setules on tip, outer seta more slender than other two.

Description of male allotype

Body 7.0 mm in length. Anterolateral margins of head rounded in lateral view, with medial indentation, small rostral point evident in fully developed specimens. Head and pereonite 1 with one small medial spine anteriorly, two dorsal spines medially and two dorsolateral spines distally; pereonites 2 and 3 of similar width and pereonites 3 and 4 of similar width. Pereonite 2 with one dorsal spine and two dorsolateral tubercles; pereonite 3 with two dorsolateral tubercles; pereonite 4 long and narrow, 2.25 times longer than head and pereonites 1–3 together, about 0.66 times the total body length, without spines, only insignificant tubercles anteriorly; pereonite 5 with two dorsolateral spines; pereonites 6–7 with two dorsolateral tubercles. Pleotelson with dorsolateral posterior wings, two dorsolateral spines, without dorsal tubercle/spine at mid-length.

Antenna 1 flagellum with two segmented aesthetascs along entire ventral margin.

Antenna 2 with row of medial spines along the entire flagellum.

Right mandible with two additional lobes; left mandible without lobes.

Maxilla 2 inner lobe with 10 robust denticulate setae in apical row, two simple setae and one pectinate seta proximal to middle lobe, inner surface with five simple setae and several small simple setae; outer lobe with three long setae, of which one is pectinate, margin without fine setae.

Maxilliped without basal articulation; dense setae distally on endite.

Pereopod 1 unguis pectinate; 1.6 times longer than propodus.

Penial plate straight and simple.

Pleopod 1 peduncle with four coupling hooks on inner margin; exopod with proximal lateral notch with four plumose setae, inserting not marginal but beneath; apically with 10 plumose setae of different length (middle longest), with one plumose seta on inner and outer margin respectively; endopod with 10 apical plumose setae of different length (middle longest), with two slender setae on outer margin and four plumose setae on inner margin.

Pleopod 2 exopod with 11 apical plumose setae of different length (middle longest); endopod with seven apical plumose setae of different length (middle longest), with one plumose setae on outer margin; appendix masculina straight, bifid.

Pleopods 3–5 similar, exopod shorter than endopod; pleopod 3 exopod with three plumose distolateral setae.

Uropodal peduncle with five plumose distolateral setae.

Remarks

Astacilla boreaphilis **sp. nov.** shows typical characters for this genus (King 2003), having pereopod 1 with unguis, absence of dactylus from pereopods 2–4, and having a claw on the tip of the flagellum of antenna 2. *A. boreaphilis* **sp. nov.** is easily distinguished from the other northern *Astacilla* species by the unique pattern of spination, with numerous and large dorsal and dorsolateral spines. In addition, the species differs from *A. arietina*, *A. granulata*, *A. intermedia*, *A. longicornis* and *A. pusilla* in the absence of eyes. *A. boreaphilis* sp. can be distinguished from *A. caeca* in the spination pattern (presence of small tubercles in *A. caeca* and in having three setae on uropodal exopod (two setae in *A. caeca*). A comparison with other *Astacilla* species, known from the southern North Atlantic (i.e. *A. bocagei*; *A. depressa* Castelló & Poore, 1998; *A. cinguicula* Castelló & Carballo, 2000) does not show any resemblance.

There is some variation in the spination pattern among brooding females. The pattern seen on the holotype reflects the form commonly observed among the brooding females. Some specimens (e.g. female paratype, IMNH 2006.06.01.3; Fig. 10E) showed even more pronounced spines at the posterior part of pereonite 4 and on the oostegites than seen on the holotype.

Furthermore, specimens at BIOICE stations 3280 and 3539 and to some extent specimens at BIOICE station 3527 had additionally a long spine middorsally on pereonite 1 and two pairs of short spines/tubercles posteriorly on the pleotelson. The spination pattern may partly be influenced by local conditions, such as high currents. Stations 3280 and 3539 are located near the Iceland–Færoe Ridge and station 3539 is the coldest one (2.41°C), indicating the presence of mixed water masses, partly originating from the Nordic Seas. These are known to overflow the ridge, often at high currents (Hansen & Østerhus 2000).

The mandibles vary further considerably in the presence of the two additional lobes, either being on the right or the left mandibles of the specimens.

There is further an indication of regional differences in body size. The brooding female from Greenland was considerably smaller (6.4 mm) than the brooding females collected off Iceland.

Size range

♀: 6.4–10 mm (brooding ♀: 7.4–10 mm) in body length; ♂: 5.8–8.7 mm (copulatory ♂: 7.0–8.7 mm) in body length.

Etymology

Greek, *boreas,* northern, referring to the distribution area; Greek, *phileas*, fondness, love, referring to the fact that it was found only within a limited boreal distribution of South Iceland and East Greenland.

Development of post-marsupial stages

The individual developmental stages were identified on basis of the development of the seventh pair of legs (see Hessler 1970), the development of spines along the body and the presence of the marsupium in ovigerous females. A noticeable character, which appeared very irregularly was a line on the lateral side of pereonite 4 (Figs 6, 9 and 10), sometimes just indicated (Fig. 6A), or sometimes a beginning of a continuous suture line (Figs 9C and 10A, C). It was confirmed that these specimens were indeed males (except in young manca stages when sexual characters were not sufficiently developed). This line was also recognizable in immature females where the marsupium was not well developed. This line may show the zone where the specimen opens the cuticula for a further moult. That would explain the varying development of this line. In well developed females, this line is probably hard to recognize due to the ventral plate and the oostegites.

At the manca 2 stage (Fig. 10C, D) pereonite 4 is elongated, being about 0.38 times the body length. This is further advanced in the manca 3 stage (Fig. 10A, B), where pereonite 4 is about 0.49 times the total body length. The spination pattern observed in the adults is already easily recognizable, both in Manca 2 and Manca 3 stages. In particular, the anterior head spine becomes well developed in these stages. At the subsequent female preparatory stage and assumed precopulatory male stage, larger changes in the habitus occur. While in the precopulatory male (Fig. 9C, D) the pereonite 4 remains slender and smooth and becomes even around 0.71 times the total body length, in the preparatory female, besides having two smaller spines already present, some tubercles along pereonite 4 were visible. Additionally to the spination, the female body gets broader at pereonite 4 and is easily distinguished from the male. At the brooding stage the spines are generally well developed, but their sizes on the posterior part of pereonite 4 in particular and on the oostegites may vary (compare oostegites in Figs 3G and 10E).

Distribution

In all, 1050 samples (each given a BIOICE station number) were taken of benthic invertebrates were taken during the BIOICE project on 579 locations in Icelandic waters at depths between 20 and 3000 m. *Astacilla boreaphilis* **sp. nov.** was found in 64 of these samples, all located west, south and southeast of Iceland (Fig. 11). *A. boreaphilis* **sp. nov.** was also found at one of the ten stations taken off South Greenland. The temperatures at the stations where the specimens were collected ranged between 2.41°C and 7.2°C (Icelandic waters) and the location in Greenland was well within this temperature range (4.4°C). The species is therefore restricted to Atlantic Water (AW), characterizing the area south of the Greenland–Iceland–Færoe Ridge, and to Atlantic Water mixed with overflow water masses originating from the Nordic Seas.

A. boreaphilis **sp. nov.** was found between 219 and 1809 m, with most of the findings between 800 and 1800 m. The depth range of the species differs somewhat between areas. South of Iceland (17° to 23°W) the species occurs at the depth range of 256–1809 m (36 samples), while west of Iceland the depth range is 304–1539 m (21 samples). Southeast of Iceland (13° to 16°W) the species occurs only at 1302–1692 m (7 samples only). Off Greenland the species was recorded at depths of 219 m. In light of numerous stations taken both deeper and shallower in the area, the observed depth range of the species in the area is presumably an accurate interpretation of the bathymetrical distribution of the species. It seems that the upper limit of the bathymetrical distribution is deeper at the ridge, where undiluted cold water masses cross the ridge, than off South Iceland and Southeast Greenland.

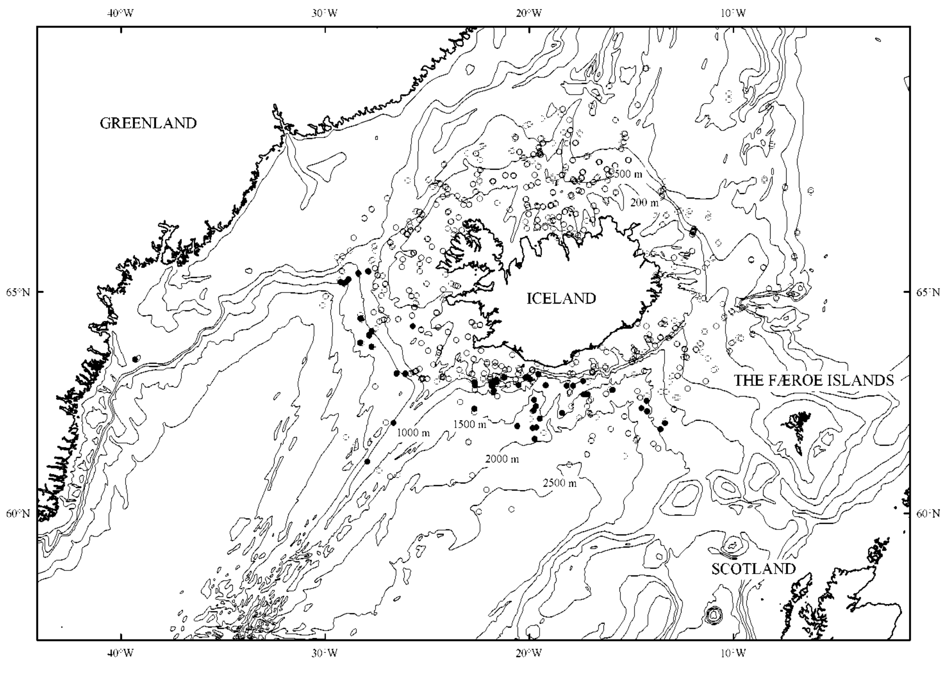

FIGURE 11. Map of the study area and all fully sorted BIOICE stations and *Walther Herwig* III stations in East Greenland (open dots). Filled dots represent the stations localities for *Astacilla boreaphilis* **sp. nov.**

The Greenland–Iceland–Færoe Ridge is probably not a barrier for dispersal of *A. boreaphilis* **sp. nov.** into the Nordic Seas, i.e. the Norwegian, Greenland and Iceland Seas. The Greenland–Iceland Ridge is mostly shallow (300–400 m; Malmberg 1985), but is cut by a channel with maximal depth of 650 m. Furthermore, the Iceland–Færoe Ridge has its saddle depth of 830–860 m, considerably deeper than the shallowest records of the species. Theoretically, *A. boreaphilis* **sp. nov.** could pass the ridge and inhabit the Nordic

Seas. But through these channels an overflow of cold water passes, with temperatures of <1°C. The temperature range of *A. boreaphilis* **sp. nov.** fits into the general regime of North Atlantic water masses with temperatures between 3–8°C (e.g. Weisshappel 2000, 2001), but it is probable that they are not adapted to temperatures of <1°C and thus the way to the Nordic Seas is impassable.

The cold water overflow currents across the ridge influences, however, the bathymetric distribution of *A. boreaphilis* **sp. nov.** in the area, resulting in absence of the species at the saddle depths of the ridges, where the temperature periodically reaches <0°C, before the overflow water mixes with deeper water masses south of the ridge. The occurrence of cold water masses in the channels of the Greenland—Iceland—Færoe Ridge may influence the genetic exchange between population off Iceland and Greenland and the cold water masses may be an obstacle for dispersal along the shallower part of the ridge. These cold water masses get, however, diluted with Atlantic water while entering the deep North Atlantic proper (Hansen & Østerhus 2000), allowing genetic exchange between populations in deeper waters.

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