

THE ACARTIA PLUMOSA T. SCOTT SPECIES GROUP (COPEPODA, CALANOIDA)

WITH DESCRIPTION OF A. TROPICA, N. SP.

BY

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Copepods identified as Acartia plumosa T. Scott have been reported from several widely separated brackish water localities of the world: Atlantic coast of Africa (T. Scott, 1894; Steuer, 1923; Marques, 1953; Vervoort, 1965; Neto & Paiva, 1966; Binet & Dessier, 1971), Indian Ocean waters (Sewell, 1932, 1934; Wellershaus, 1969; Abraham, 1970; Tranter & Abraham, 1971; Madhupratap, 1979) and West Pacific Ocean (Brodosky, 1948, 1950; Ueda et al., 1983). Because such a wide geographical distribution of a brackish species seemed unlikely, we reexamined specimens from both the Atlantic and Indo-West Pacific, including Scott's types. We conclude that specimens from the Indo-West Pacific are distinct from A. plumosa s. str. from the Atlantic, and that two closely related species, one of which is new to science, exist in the Indo-West Pacific. In this paper, we provide a detailed description of A. plumosa s. str. and the two related species with remarks on their synonyms and geographical distributions.

Specimens in 70 % lactic acid were examined and measured with a compound microscope with ocular micrometer. More detailed examination and illustrations were made with a differential interference microscope with drawing-tube attachment. We examined all appendages, but did not describe those from the second antenna to the fourth leg because these do not differ among the species. Abbreviations used are as follows: Ur1-Ur5, first-fifth urosomal segments; A1, first antenna; P5, fifth leg; RL and RW, length and width of right caudal ramus (see figs. 2b, c; 4a, b).

Acartia plumosa and the two related species described here are referable to the subgenus Acanthacartia and form a distinct species group, which is characterized by the following: in the female, the terminal

spine of P5 has a basal knob-like swelling, projecting noticeably backward (in other species of the subgenus, basal portion of the spine is only slightly swollen or has other distinctive features, e.g., acute lateral process in A. tsuensis Ito); in the male, left P5 has a backward thumb-like projection on the first segment, a long terminal segment which is as long as the first segment, and a long terminal spine (left P5 of the other species without a backward projection, and/or the terminal segment much shorter than the first segment and has a long terminal spine).

Acartia plumosa T. Scott, 1894

Figs. 1a, d; 2a-c; 3a, d, f; 4a, b; 5a

Acartia plumosa T. Scott, 1894: 66, pl. 7 figs. 22-32; Steuer, 1923: 112, figs. 110-114; Marques, 1953: 122, pl. 6 fig. a; Vervoort, 1965: 197; Neto & Paiva, 1966: 28; Binet & Dessier, 1971: 439.

Materials examined. -- Four syntype ♂♂, T. Scott's (1894) "Buccaneer collection"; 12 ♀♀ & 8 ♂♂, Pointe Noire (4°49.2'S 11°50.3'E), Congo, Apr.(?) 1975; 20 ♀♀, Vervoort's (1965) "Atlantide collection" (Stns. 129 & 130); 4 ♀♀ & 2 ♂♂, coast of South Yemen (13°45'N 46°35'E), 18 Dec. 1979.

The Scott's syntypes, which have been deposited in the British Museum (Natural History), consist of males only (G. A. Boxshall, pers. comm.). Because these few specimens are not in good condition, we examined them without dissection. Our detailed redescription is based on the specimens from Pointe Noire.

Measurements. -- Pointe Noire females 1.09-1.16 mm (av. 1.12 mm), males 1.01-1.05 mm (av. 1.03 mm).

Description. -- Female: Cephalosome slightly shorter than metasome (fig. 1a). Posterior corner of metasome (fig. 2a) rounded, on each side with 2 rows of conical spines and 1 fine hair laterally; medially with numerous minute spinules. Spines of outer row located at 5 loci; each locus with 0-4 (usually 1 or 2) spines. Spines of inner row smaller than those of outer and arranged in 2 groups, 7-13 smaller dorsal spines and 2-7 larger ventral spines. Ur1 (genital segment) (figs. 2b, c) longer than following two segments combined, with 7-10 spines on posterodorsal margin and 3 rows of very minute hair-like spinules on ventral surface; lateral surface without spinules. Ur2 with 6-13 posterodorsal spines, which are similar to or slightly smaller than those on Ur1. Ur3 (anal segment) with ventrolateral hairs. Caudal rami as long as Ur2, asymmetrical with dorsal seta of right ramus more distally located than that of left; RL/RW 1.5-1.7; lateral and distomedial margins fringed by hairs.

Rostral filaments (fig. 3a) straight or slightly curved in ventral view. A1 17-segmented, extending beyond last metasomal segment but not reaching posterior border of Ur1; 16th segment (fig. 3d) with 1 row of spinules on ventral surface. Basal segments of P5 (fig. 3f) fused medially; 2nd segment 23 μm long, 1.2 times as long as wide, with lateral plumose seta inserted at 0.7 distance along lateral margin. Terminal spine narrow (4 μm at mid-region), gently curved, 4 times longer than 2nd segment; basal portion swollen, produced posteriorly as a small knob, length of swollen portion 10 μm and ca. 1.5 times its width. Distal two-thirds of spine with dentate inner and outer margins. Lateral plumose seta as long as terminal spine.

Male: Cephalosome shorter than metasome (fig. 1d). Ur1 (figs.

4a, b) with numerous lateral hairs. Ur2 as long as following two segments combined; posterodorsal and posterolateral margins with 12-20 spines (lateral spines smaller than dorsal ones). Ventral surface with small spines at 2 or 3 loci on each side; each locus with 2-5 spines, most posterior locus located on posterior margin of segment. Ur3 and Ur4 respectively with 8-14 and 7-13 posterodorsal spines; these spines smaller than those on Ur2. Ur5 (anal segment) with ventrolateral hairs. Caudal rami nearly as long as Ur4 and Ur5 combined; RL/RW 0.9-1.0.

A1, when reflexed, extending beyond posterolateral border of 3rd metasomal segment but not beyond posterior end of metasome; all segments without row of spinules. Right A1 18-segmented, with geniculation between 14th and 15th segments; left A1 21-segmented.

First segment of right P5 (fig. 5a) ca. 35 μ m along outer margin, with plumose seta on distolateral corner; 2nd segment longer than 1st, with short seta on posterior surface; 3rd segment nearly as long as 1st, with large inner projection, slightly twisted, which terminates as two lobes of similar size; with 1 spine on distal margin of lobe. Terminal segment curved, 2 times longer than 3rd, with spine at 0.6 distance along inner margin; terminal spine of similar size; outer margin without spines or spinules, depressed at one-fifth and two-thirds distance from proximal border; these depressions sometimes with lamellate extensions. First segment of left P5 ca. 45 μ m along outer margin, with lateral plumose seta at 0.6 distance; posterior surface with backward thumb-like projection pointing posterodistally (see also fig. 4b); proximal half of inner margin depressed posteriorly but protruded anteriorly. Second segment without spines or setae. Terminal segment gently curved, as long as 1st segment, with short terminal spine as

long as that of right leg; inner margin with fine hairs where segment abruptly narrows and large spine at midpoint. This large spine almost straight, as long as half of segment, with small basal barb and acutely serrate margin on distal side.

Other characters similar to female.

Remarks. -- Specimens described as Acartia plumosa from Congo by Steuer (1923) and from Angola by Marques (1953) are identical with Scott's original A. plumosa, judging from female P5 and armature on posterolateral corner of metasome. All such Acartia so far identified from the Atlantic coast of Africa are regarded as A. plumosa.

The present record of Acartia plumosa s. str. from South Yemen is new to the Indian Ocean coast (fig. 6). South African planktologists (B. P. Boden, A. D. Connell, A. de Decker, J. R. Grindley and T. Wooldridge; pers. comm.) have not encountered A. plumosa in South African waters, indicating that the distribution of this species in the Atlantic does not extend south to the western South African coast. Atlantic and South Yemen populations are isolated from each other not only by the geographical distance but by temperature barrier around South Africa; natural dispersion from the Atlantic to the Indian Ocean or vice versa seems unlikely. These two populations may not been isolated for a long geological time, because our specimens exhibited no morphological differences, even in details of ornamentation between the two populations. Synanthropic introduction by ship ballast water is one explanation given for geographical disjunct populations of brackish plankton copepods (Jones, 1966; Grindley & Grice, 1969; Bowman, 1978; Orsi et al., 1983; Ferrari & Orsi, 1984). We consider it most likely for the disjunct distribution of A. plumosa. Although we have no adequate information

on the shipping along the coast of Africa, the introduction from the Atlantic to the Indian Ocean would be more reasonable because of the numerous, older records in the Atlantic.

Acartia sinjiensis Mori, 1940

Figs. 1b, e; 2d-f; 3b, g; 4c-e; 5b, c

Acartia sinjiensis Mori, 1940: 329, figs. 6-12.

Acartia plumosa, Brodsky, 1948: 74, pl. 25 figs. 1-6; Brodsky, 1950: 424, fig. 299; Ueda et al., 1983: 166.

Acartia iseana Ito, 1956: 468, fig. 1.

Acartia baylyi Greenwood, 1972: 313, figs. 1, 2; Greenwood, 1978: 11.

Acartia sp. Bayly, 1965: 327.

Materials examined. -- About 50 ♀♀ & 20 ♂♂, Lake Naka-umi (35°27'N 133°08'E), a brackish lake connected with the Japan Sea (although Mori did not designate the distinct single type locality of A. sinjiensis, Lake Naka-umi is one of the localities from which he collected this species), 7 Sept. 1982; 10 ♀♀ & 10 ♂♂, Ito's (1956) plankton collections from brackish fishponds in Mie Prefecture, Japan, 12-22 Oct. 1954; 12 ♀♀ & 8 ♂♂, Naha Harbor (26°12'N 127°41'E), Okinawa, 11 Oct. 1981; 5 ♂♂, Brisbane River mouth, Australia, 27 Sept. 1979. A lot of 15 ♀♀ and 15 ♂♂ from Lake Naka-umi is deposited in the National Science Museum, Tokyo (NSMT-Cr. 9117), and a similar sample in the U.S. National Museum (USNM 222992).

Measurements. -- Lake Naka-umi females 0.90-1.10 mm (av. 0.94 mm), males 0.85-0.90 mm (av. 0.87 mm). Males from Brisbane River mouth larger (0.99-1.00 mm) than those from the Japanese localities.

Description. -- Similar to Acartia plumosa but differing in the following respects:

Female: Cephalosome nearly as long as metasome (fig. 1b). Posterior

corner of metasome (figs. 2d-f) with 1 row of spines on each side; posteromedial region without spinules. The spines usually located at 5 loci; each locus with 0-2 (usually 1) spines; spines at most dorsal locus larger than those of the other loci (the latter spines may be absent). Ur1 with 1-14 posterodorsal spines, located at 6 loci; each locus with 0-4 (usually 1) spines; most lateral loci with smaller spines than medial ones or often lacking spines. Ventral surface of Ur1 without spinules. Ur2 with 2-8 (usually 4) posterodorsal spines at 4 loci; spines at medial loci larger than those at lateral ones, and as large as medial spines of Ur1. Ur3 without hairs. Caudal rami longer than Ur2 but shorter than Ur2 and Ur3 combined; RL/RW 1.6-1.9.

Rostral filaments (fig. 3b) curved in ventral view. A1 spinule rows absent on any segments. Second segment of P5 (fig. 3g) 1.4 times as long as wide. Terminal spine broad (7 μ m in mid-region) and blade-like, 3 times longer than 2nd segment; basal swelling nearly as long as wide. Lateral plumose seta shorter than terminal spine.

Male: Cephalosome as long as metasome (fig. 1e). Ur2 (figs. 4c, d) with 3-8 posterodorsal spines at 6 loci; ventral surface with hair-like spines at 3-4 (usually 3) loci on each side (each locus usually with 1 spine but rarely with 2 spines or without spines; if 4 loci represented, most posterior one is located on border of segment). Posterodorsal armature on Ur3 and Ur4 similar to that on female Ur2; spines on Ur3 smaller than those on Ur2 and Ur4, rarely absent. Two specimens from Brisbane River mouth with medial 2 spines on Ur4 directed diagonally outward (fig. 4e). Ur5 without hairs. RL/RW 1.0-1.1.

First segment of right P5 (fig. 5b) ca. 30 μ m along outer margin; inner margin with small depression at one-third distance. Inner

projection of 3rd segment not twisted, terminating in a smaller distal and a larger proximal lobe. Outer margins of all left P5 segments subequal, 35-38 μ m. First segment with small process at one-third distance along inner margin, some specimens with very fine hairs on this process (these hairs were easily observed on specimens from Brisbane River mouth); inner large spine of terminal segment (fig. 5c) curved terminally, ca. 0.8 times as long as segment.

Remarks. -- Tanaka (1965, p. 387) stated that Acartia sinjiensis is identical to A. plumosa, but we believe these two species are not conspecific. Brodsky's (1948, 1950) A. plumosa from Poseta Bay, USSR, whose male lacked spines on Ur3, falls within the range of variation exhibited by A. sinjiensis from other localities. Ito (1956) established two Acartia species, A. iseana and A. tsuensis, from fishponds of Mie, but designated no distinct type specimens. We reexamined his plankton samples collected from these ponds and found only two species of Acartia, as Ito reported. Specimens referable to A. iseana are very similar to A. sinjiensis; we regard A. iseana as a junior synonym of A. sinjiensis. A. baylyi, which was described from the Brisbane River mouth by Greenwood (1972), and A. sinjiensis are also conspecific; the variation of the Australian specimens overlaps that of the Japanese specimens, except for the difference in body size, which may result from local temperature differences.

Acartia sinjiensis is distributed in temperate-subtropical brackish waters of the West Pacific (fig. 6), but probably not in tropical waters inhabited by the closely related new species described below. Our report of A. sinjiensis from Naha Harbor, Okinawa is the southmost record in the Northern Hemisphere. As discussed for the distribution of A. plumosa,

the Australian population of A. sinjiensis is a disjunct distribution and synanthropic introduction also is responsible for this separation. One of us (H. U., unpublished data) found A. sinjiensis in Maizuru Bay from July to November, when the mean monthly water temperature ranged between 18-29°C. This species occurs in the Brisbane River estuary throughout the year, during which the temperature varies between 15-29°C (Bayly, 1965 -- as Acartia sp., see Greenwood, 1972). The mean monthly temperature in the two localities agrees most closely in October (about 22°C). We believe temperature would not inhibit settlement of these copepods after their introduction, even though the seasons of year are reversed between the Northern and the Southern Hemispheres. Greenwood (1977) reported the Oriental brackish copepod Pseudodiaptomus marinus from the same Australian locality, and suggested a synanthropic introduction of this species from Japan. T. Chad Walter (pers. comm.), however, is preparing to describe this Australian pseudodiaptomid population as a new species.

Acartia tropica n. sp.

Figs. 1c, f; 2g, h; 3c, e, h; 4f, g; 5d

Acartia plumosa, Sewell, 1932: 395; Sewell, 1934: 80; Wellershaus, 1969: 271, figs. 70-75 (not figs. 66, 67); Abraham, 1970: 115, figs. 1-3; Tranter & Abraham, 1971: 224, figs. 2Af, 2Bf.; Madhupratap, 1979: 5.

Materials examined. -- Thirty ♀♀ & 20 ♂♂, Chao Praya River mouth, Thailand, 18 Oct. 1976 and 9 Sept. 1984; 20 ♀♀ & 12 ♂♂, mouth of Cochin backwaters, India, May 1972.

Types. -- Holotype, 1 ♀ in National Science Museum, Tokyo

(NSMT-Cr.9118); paratype, lots of 15 ♀♀ & 15 ♂♂ in National Science Museum, Tokyo (NSMT-Cr.9119); Chulalongkorn University Museum of Zoology, Bangkok (CUMZ 2528.9.17.1-30) and U.S. National Museum (USNM 222991).

Type locality. -- Chao Praya River mouth, Thailand (13°29'N 100°28'E)

Measurements. -- Chao Praya River mouth, 9 Sept. 1984, females 0.93-1.04 mm (av. 0.97 mm), males 0.83-0.88 mm (av. 0.85 mm).

Description. -- Very similar to Acartia plumosa and A. sinjiensis but differing in the following respects:

Female: Cephalosome nearly as long as metasome (fig. 1c). Armature on posterior corner of metasome (figs. 2g, h) similar to that of Acartia sinjiensis, but spines at ventral-most locus nearly as large as those at dorsal-most locus; each locus with 0-3 (usually 1 or 2) spines. Ur1 with 9-18 spines on posterodorsal margin; these spines not grouped at loci but evenly distributed; ventral surface with several rows of very minute hair-like spinules. Ur2 with 6-10 posterodorsal spines; medial 2 spines larger than lateral ones and larger than spines on Ur1. Ur3 with ventrolateral hairs. Caudal rami as long as Ur2 and Ur3 combined; RL/RW 1.9-2.2.

Rostral filaments (fig. 3c) straight or slightly curved. A1 with 1 row of spinules on ventral surface of 9th to 12th segments (fig. 3e). Second segment of P5 (fig. 3h) 1.6 times as long as wide. Terminal spine almost straight, narrow (4 µm in mid-region), 3 times longer than 2nd segment; basal swelling ca. 2 times as long as wide. Lateral plumose seta shorter than terminal spine.

Male: Cephalosome as long as metasome (fig. 1f). Ur2 (figs. 4f, g) with 11-21 spines on posterodorsal and posterolateral margins; lateral

spines not smaller than dorsal ones. Ventral surface with spines at 2 loci on each side; each locus with 1-3 spines, most posterior locus located on border of segment. Ur3 and Ur4 with 4-8 and 4-6 posterodorsal spines, respectively, sometimes 4 loci can be distinguished on both segments; these spines usually larger than those on Ur2. Ur5 with ventrolateral hairs. RL/RW 1.1-1.3.

Segment sizes of P5 (fig. 5d) similar to those of Acartia sinjiensis. Inner projection of 3rd segment of right P5 not twisted and not bilobed (sometimes with slight medial indentation). Inner large spine of terminal segment of left P5 terminally curved, hook-like, nearly as long as segment.

Remarks. -- The specific name is derived from the geographical distribution of this species; tropical brackish waters in the Indo-West Pacific. This species is readily distinguished from Acartia plumosa by a single row of spines on posterior metasome, and from A. sinjiensis by the shape of the terminal spine of P5 in the female and by the size of spines on posterior metasome and on Ur2-Ur4 in the male (see table I).

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SUMMARY

Acartia (Acanthacartia) plumosa T. Scott and two closely related species, A. sinjiensis Mori and A. tropica n. sp. are (re)described. Specimens of the latter two species have been frequently incorrectly identified as A. plumosa. A. iseana Ito and A. baylyi Greenwood are junior synonyms of A. sinjiensis. Synanthropic introduction by ship ballast water is considered for disjunct geographical distributions of A. plumosa and A. sinjiensis.

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TABLE I

Comparative list of characters in the Acartia plumosa - sinjiensis - tropica n. sp. group

	<u>A. plumosa</u> T. Scott	<u>A. sinjiensis</u> Mori	<u>A. tropica</u> n. sp.
♀♂ rostral filaments in ventral view	straight or slightly curved	curved	straight or slightly curved
♀♂ spines on posterior corner of metasome	2 rows	1 row (dorsal-most spine largest)	1 row (ventral-most spine as large as dorsal-most one)
♀ caudal rami length	=Ur2	>Ur2, <(Ur2+Ur3)	=(Ur2+Ur3)
♀ A1, segment(s) with row of spinules	16th segment	no segment	9th-12th segments
♀ P5, terminal spine:			
proportional length to 2nd segment	4 times	3 times	3 times
breadth in mid-region	narrow (4 µm)	broad (7 µm)	narrow (4 µm)
basal swelling, length/width	ca. 1.5	ca. 1	ca. 2
♀ P5, lateral seta length	=terminal spine	< terminal spine	< terminal spine
♂ cephalosome length	< metasome	=metasome	=metasome
♂ Ur2-Ur4, medial spine size	Ur2>Ur3, Ur4	Ur2, Ur4>Ur3	Ur3, Ur4>Ur2
♂ left P5, terminal segment, ratio of inner spine length to segment length	ca. 0.5	ca. 0.8	ca. 1

Figure Legends

Fig. 1. Acartia females and males, dorsal view. a-c, female: a, A. plumosa; b, A. sinjiensis; c, A. tropica n. sp. d-f, male: d, A. plumosa; e, A. sinjiensis; f, A. tropica n. sp.

Fig. 2. Female posterior metasome, urosome and caudal rami. a-c, Acartia plumosa; d-f, A. sinjiensis (f, specimen with duplicate or triplicate spines on loci); g, h, A. tropica n. sp.

Fig. 3. Female rostral filaments, A1 and P5. a-c, rostral filaments, ventral view: a, Acartia plumosa; b, A. sinjiensis; c, A. tropica n. sp. d, e, right A1, ventral view: d, A. plumosa, 15th-17th segments; e, A. tropica n. sp., 8th-13th segments. f-h, P5, anterior view: f, A. plumosa; g, A. sinjiensis; h, A. tropica n. sp.

Fig. 4. Male urosome and caudal rami: a, b, Acartia plumosa (b, with P5, lateral view); c-e, A. sinjiensis (e, specimen from Brisbane River mouth); f, g, A. tropica n. sp.

Fig. 5. Male P5, anterior view: a, Acartia plumosa; b, c, A. sinjiensis (c, left terminal segment under cover glass); d, A. tropica n. sp.

Fig. 6. Distribution of Acartia plumosa, A. sinjiensis and A. tropica n. sp. based on the previous records and the present study (p.s.). Locality names and references are 1, Pointe Noire (Binet & Dessier, 1968; p.s.); 2, Congo River mouth (T. Scott, 1894), Cabinda (Marques, 1953), off Angola (Vervoort, 1965); 3, Luanda (T. Scott, 1894; Marques, 1953); 4, Benguela (Marques, 1953), Baia Farta (Neto & Paiva, 1966); 5, Moçâmedes (Marques, 1953); 6, South Yemen (p.s.); 7, Cochin backwaters (p.s.; as A. plumosa--Wellershaus, 1969; Abraham, 1970;

Tranter & Abraham, 1971; Madhupratap, 1979); 8, Salt Lakes (as A. plumosa--Sewell, 1932, 1934); 9, Chao Praya River mouth (p.s.); 10, Naha Harbor (p.s.); 11, Mie (as A. iseana--Ito, 1956); 12, Lake Naka-umi and Lake Shinji-ko (Mori, 1940; p.s.); 13, Maizuru Bay (as A. plumosa--Ueda et al., 1983); 14, Poseta Bay (as A. plumosa--Brodsky, 1948, 1950); 15, Brisbane River mouth (p.s.; as A. sp.--Bayly, 1965; as A. baylyi--Greenwood, 1972, 1978).

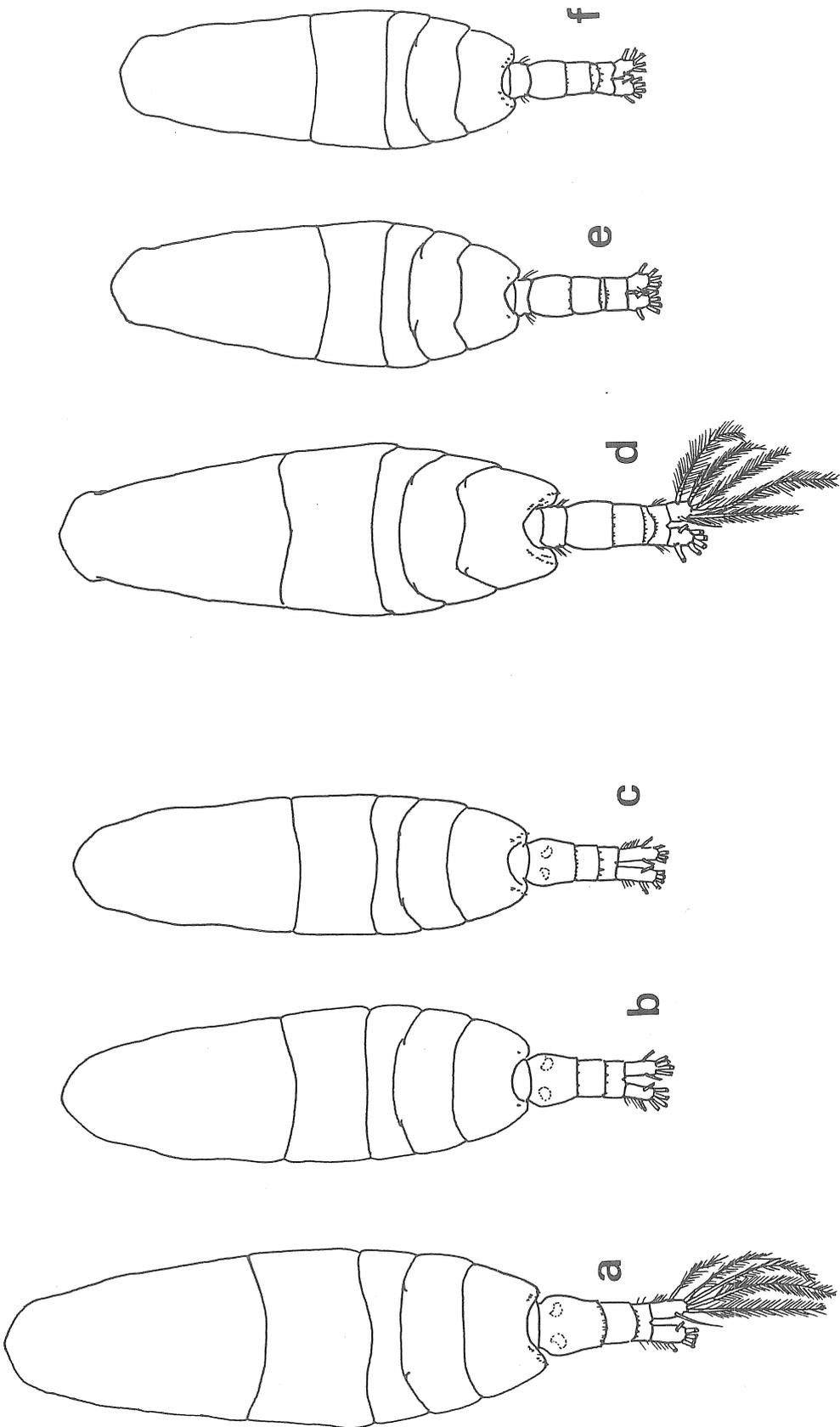


Fig. 1

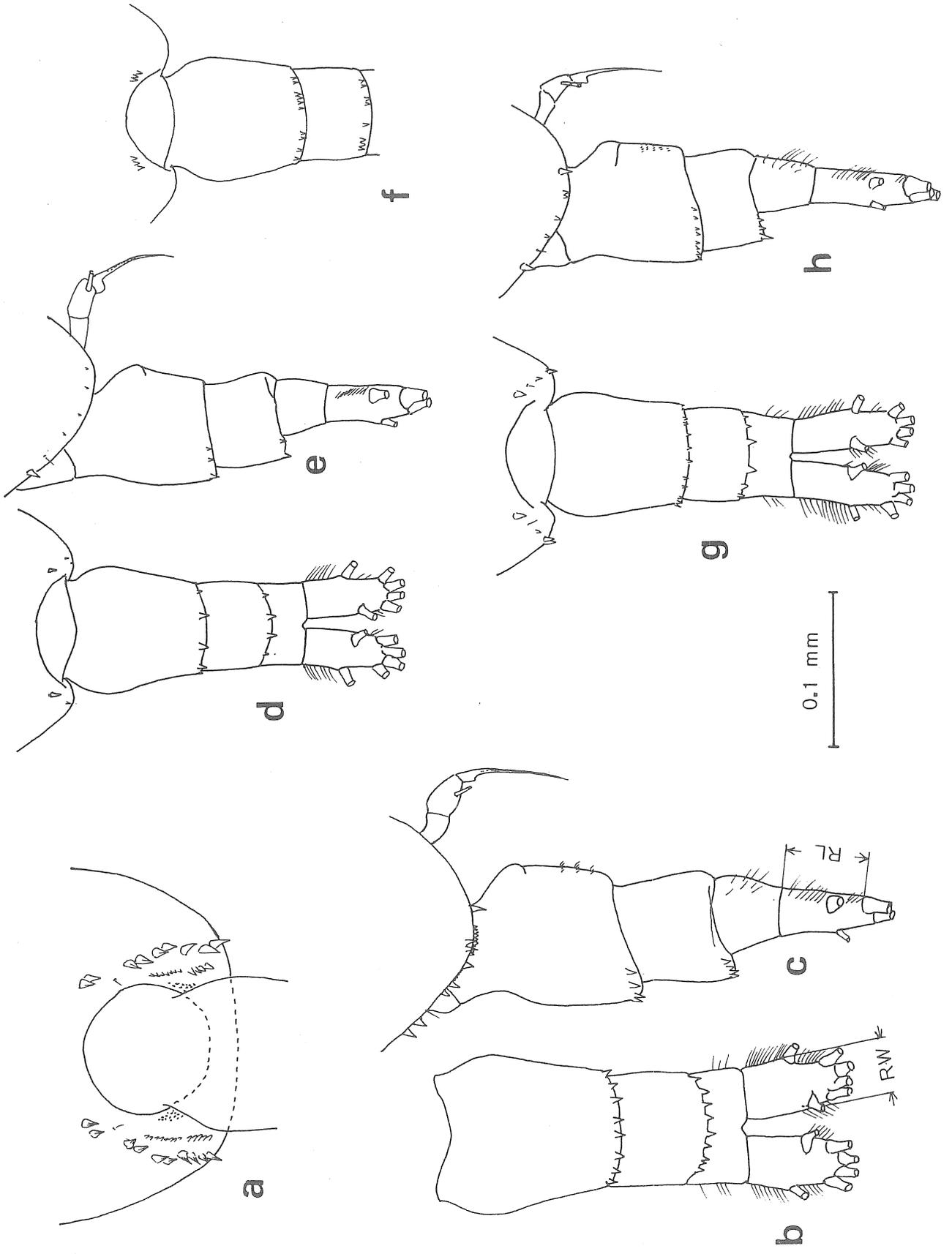
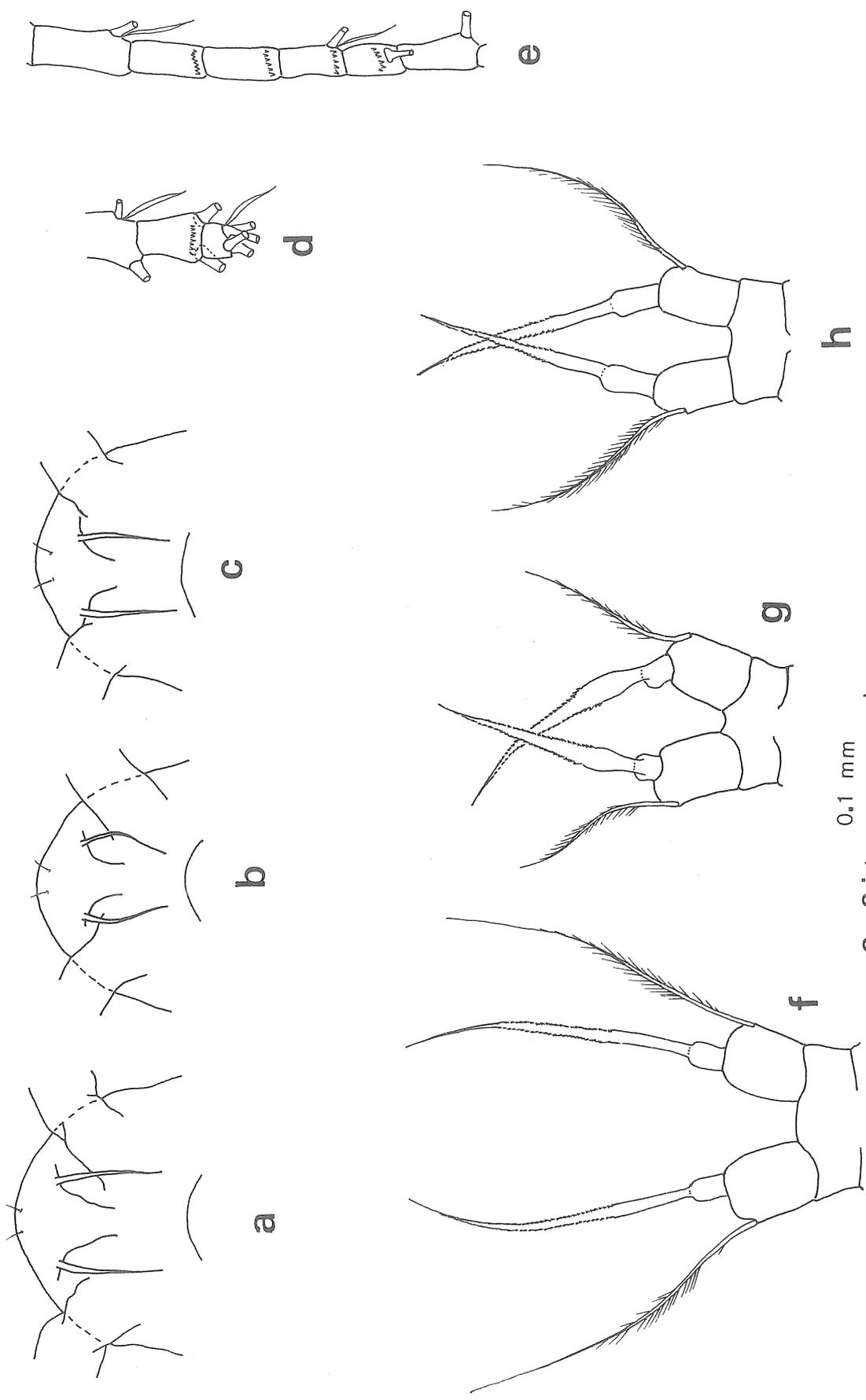


Fig. 2



a - e; 0.1 mm

f - g; 0.1 mm

Fig 3

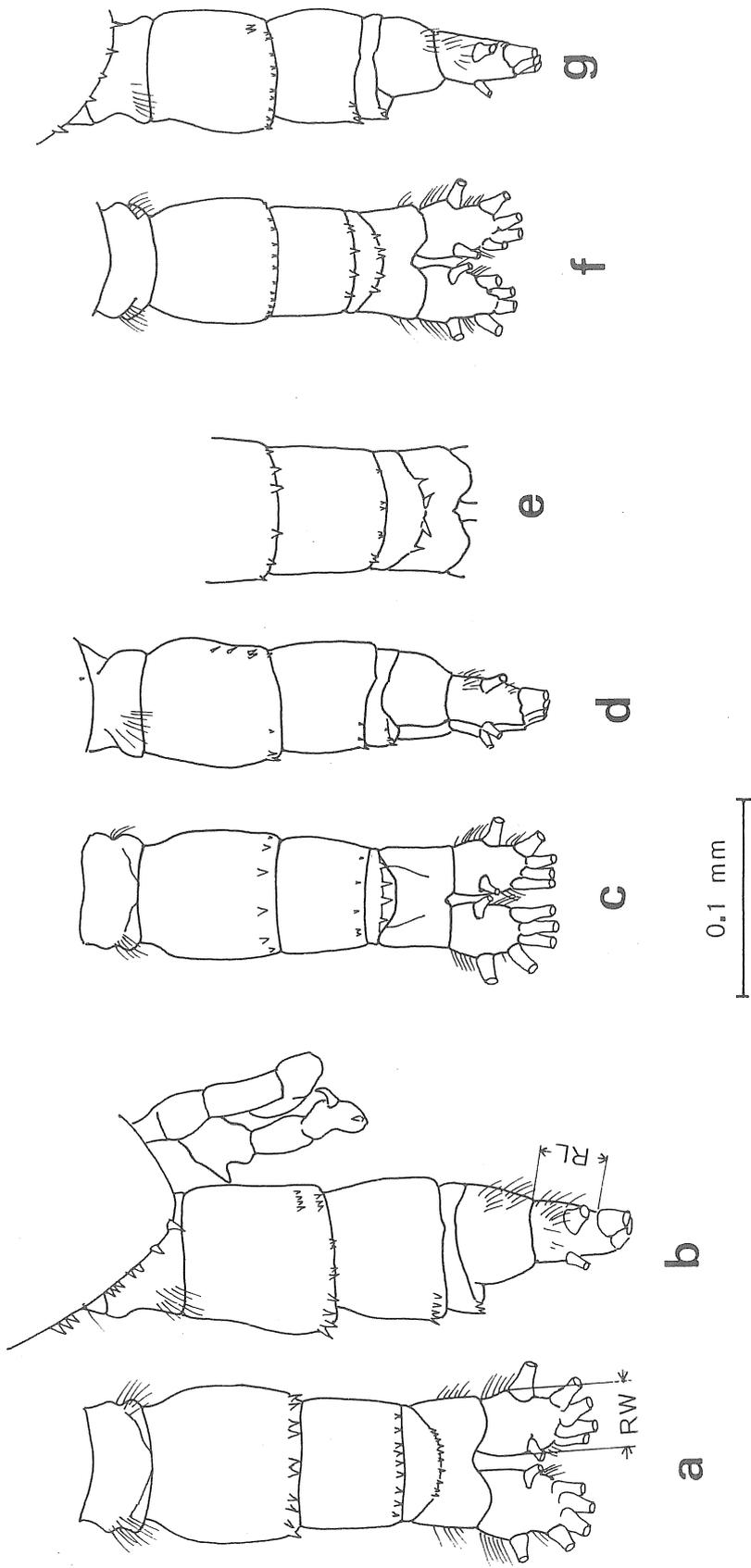


Fig. 4

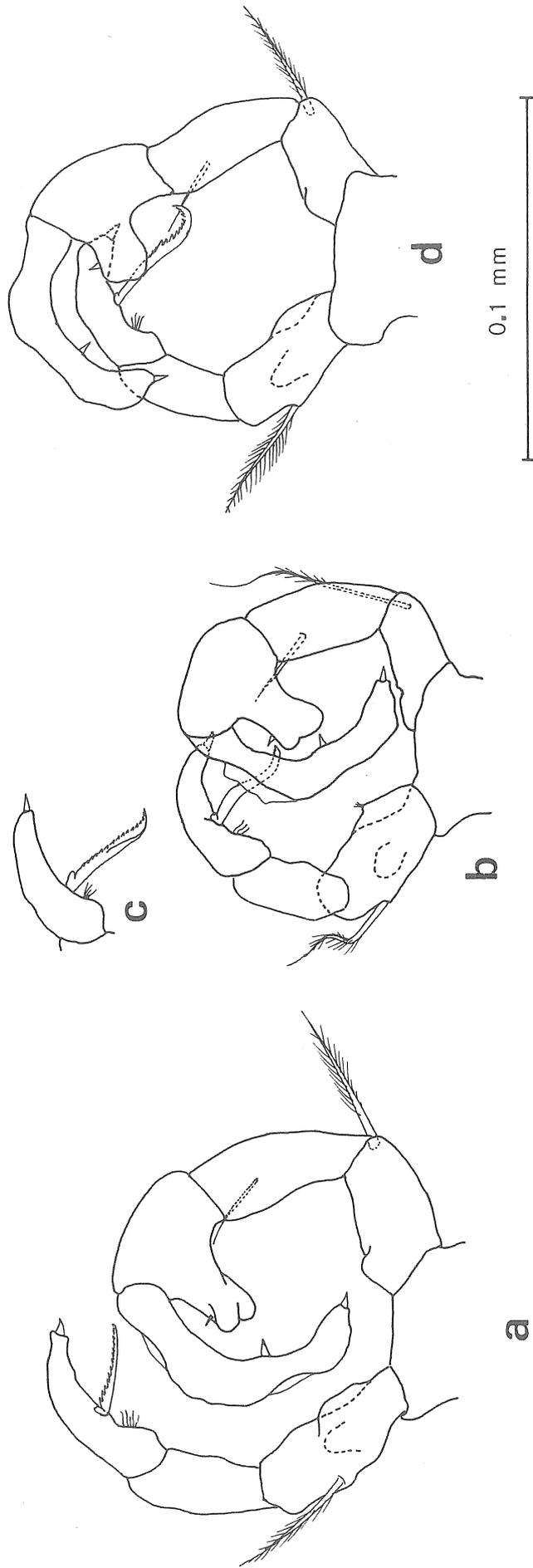


Fig. 5

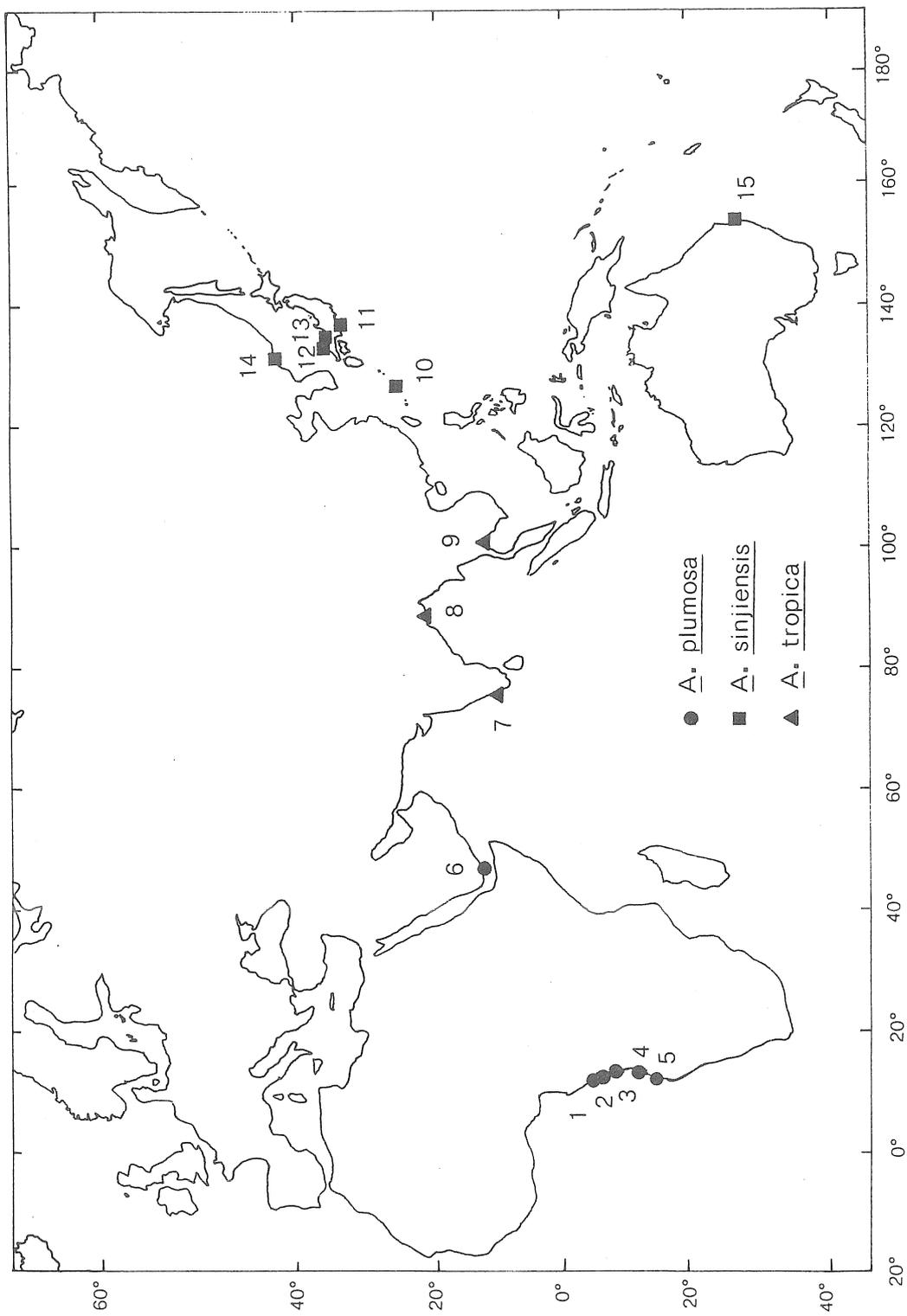


Fig. 6