

DISTRIBUTION OF WARM WATER ALPHEOID SHRIMP (CRUSTACEA, CARIDEA) ON THE CONTINENTAL SHELF OF EASTERN SOUTH AMERICA BETWEEN 23 AND 35° LAT. S.

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Synopsis

The southern boundaries of *Tozeuma serratum* A. Milne Edwards, *Salmoneus ortmanni* (Rankin) and *Processa profunda* Manning & Chace, previously known only from the northwestern Atlantic, have been extended to São Paulo, Paraná and Uruguay, respectively. *Latreutes parvulus* (Stimpson), previously not known beyond São Paulo, has been found to as far south as the Province of Buenos Aires. A systematic account of these four species is furnished, based mainly on material collected by the R/V "Prof. W. Besnard". The 16 species of Alpheoidea whose southern boundaries occur in warm-temperate shelf waters of eastern South America belong to two distinct faunal assemblages: (1) Tropical species — *Alpheus floridanus* Kingsley, *A. intrinsecus* Bate, *A. normanni* Kingsley, *Salmoneus ortmanni* (Rankin), *Synalpheus longicarpus* (Herrick), *Ogyrides alphaerostris* (Kingsley) (= *O. occidentalis* (Ortmann)), *Exhippolysmata oplophoroides* (Holthuis), *Latreutes parvulus* (Stimpson), *Processa bermudensis* (Rankin) and *P. hemphilli* Manning & Chace — which are largely restricted to coastal and inshore shelf waters less than 50 m deep; and (2) Sub-tropical species — *Alpheus pouang* Christoffersen, *A. puapeba* Christoffersen, *Merhippolyte americana* Holthuis, *Tozeuma serratum* A. Milne Edwards, *Processa guyanae* Holthuis and *P. profunda* Manning & Chace — which are largely restricted to the outer portion of the continental shelf within the studied area. Considering the temperature and distributional data available for each species, it is suggested that the poleward boundaries of *O. alphaerostris* are set by maximum summer temperatures of about 20°C required for the reproduction of the species, while the poleward boundaries of most of the tropical and subtropical species are set by minimum winter temperatures critical for their survival: about 15°C for *A. floridanus*, about 11°C for *E. oplophoroides*, about 9°C for *A. pouang*, *L. parvulus*, *P. guyanae*, *P. hemphilli* and *P. profunda*, and about 8°C for *A. puapeba* and *M. americana*. It is further suggested that the shoreward boundaries of some of the subtropical species are set by maximum summer temperatures critical for their survival: about 20-22°C for *A. puapeba* and about 17-18°C for *A. pouang* and *M. americana*.

Introduction

The shelf carideans of the superfamily Alpheoidea from southern Brazil and Uruguay have been sampled in 1961 by the French oceanographic ship "Calypso" and in the last 14 years mainly by the Brazilian oceanographic ship "Prof. W. Besnard". The most important material was obtained by the "Prof. W. Besnard" in the region between Torres, Brazil (29°S), and Maldonado, Uruguay (35°S), consisting of samples from 12 lines

perpendicular to the Brazilian coastline dredged in January, April, August and October of 1972, and from 3 lines perpendicular to the Uruguayan coastline, dredged in August and November of 1972 (Vazzoler, 1973).

Twelve species obtained from the continental shelf between 23 and 35°S have been reported upon in the "Calypso" results to South America (Christoffersen, 1979). This paper deals with the taxonomy of the four remaining species of Alpheoidea whose poleward boundaries have been established in the southwestern Atlantic by the "Prof. W. Besnard", and summarizes the patterns of distribution and faunal affinities of the known warm-water species from this section of the South American shelf.

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Material

Specimens from the following institutions have been included in this report: Institute of Marine Sciences, North Carolina (IMS); Instituto Oceanográfico da Universidade de São Paulo (IOUSP); Museu Nacional do Rio de Janeiro (MNRJ); Museu de Zoologia da Universidade de São Paulo (MZUSP); and United States National Museum, Washington, D.C. (USNM). Other specimens mentioned in the systematic section are under the author's care or in the collections of the Departamento de Biologia da Universidade Federal da Paraíba.

Systematic section

Salmoneus ortmanni (Rankin, 1898)
(Figs 1-3)

Athanas ortmanni Rankin, 1898: 251, pl. 30 fig. 7 [type locality: Near Nassau, New Providence Island, Bahamas]. - Verrill, 1900: 579 [Bermudas].

Jousseamea ortmanni - Coutière, 1900: 356 [discussion]. - Verrill, 1922: 122 [condensed original description].
- Schmitt, 1936: 367, pl. 12 fig. 2 h,i [discussion; Bermuda specimen figured in dorsal and lateral views].

Salmoneus ortmanni - Chace Jr., 1972: 79 [Yucatan Peninsula; key].
- Carvacho, 1979: 453 [Guadeloupe; synonymy].

Examined material

BRAZIL, SÃO PAULO: Cananéia: February 1, 1967, 1 ovig. spec. (MZUSP 29); Mar de Cananéia and Baía do Trapandé, 0.3 to 0.8-1.17 m, 18.72 to 34.41°C, 3.07 to 26.84 ‰. C. Jesus, M. Iwai & Lin coll. February 21, 1973 to March 13, 1975 (not collected in July and August), 35 samples (IOUSP).

- PARANÁ: 25°30'S - 48°29'W, 22 m, mud, December 11, 1971, "Prof. W. Besnard" Sta. 1587, 1 ovig. spec. (IOUSP).

Measurements

The largest ovigerous specimen measures 6 mm (carapace and rostrum) plus 11 mm (abdomen and telson) along the dorsal midline of the body, its major chela measures 5.5 mm (length of propodus) by 2 mm (width of propodus) by 1.5 mm

(height of propodus), while its minor first chela is absent. The largest non-ovigerous specimen measures 5 plus 9 mm, its major chela measures 5 by 2 by 1.5 mm, while its minor first chela is absent. The smallest ovigerous specimen measures 5 plus 9 mm, both chelae being absent.

Remarks

Of the 16 known species of *Salmoneus*, 13 inhabit the Indo-Pacific region and have a characteristic "trapeziform" notch in the posterior margin of the telson: *S. babai* Miyake & Miya, 1966, *S. brevirostris* (Edmondson, 1930), *S. bruni* Bamer & Banner, 1966, *S. cristatus* (Coutière, 1897), *S. gracilipes* Miya, 1972, *S. hilarula* (De Man, 1910), *S. latirostris* (Coutière, 1896), *S. mauiensis* (Edmondson, 1930), *S. rostratus* Barnard, 1962, *S. serratidigitus* (Coutière, 1896), *S. sibogae* (De Man, 1910), *S. tafaongae* Banner & Banner, 1966 and *S. tricristatus* Banner, 1959. *S. ortmanni* (Rankin, 1898) approaches Western Atlantic *S. arubae* (Schmitt, 1936) and Eastern Atlantic *S. jarli* (Holthuis, 1951) for having the posterior margin of the telson at most very slightly emarginate and somewhat depressed dorsoventrally among the two posterior pairs of spines, five to seven hairs being placed between these spines. *S. jarli* can be distinguished mainly by the general shape of the first pair of chelipeds (Holthuis, 1951: 95, fig. 20), while *S. arubae* can be distinguished mainly by the broadly triangular rostrum and by the relatively short dactylus of the third pereopod, which is contained in the propodus two and one-third times (Schmitt, 1936: 366).

The new material differs slightly from the original description in having the major chela 2.5 to 3 times longer than wide, instead of only twice as long as wide (Rankin, 1898: 251). In his key to the Western Atlantic species of *Salmoneus*, Chace Jr. (1972: 78) indicated... "third pereopod with dactyl nearly half as long as propodus, propodus shorter than carpus", but I have found this dactyl to measure five-sevenths of the length of the propodus, while the latter has about the same length as the carpus. Since the above differences appear to be only gradual, they may prove to fall within the range of vari-

ation of these characters in *S. ortmanni*. As only the very short original description based on a single specimen is available for this species, I have furnished complete illustrations for the new material (Figs 1-3). Other variations encountered are the following: rostrum reaching between end of first and end of second segment of antennular peduncle; antennal scale reaching between end of second and half of third segment of antennular peduncle. A remarkable morphological aspect is the presence of an appendix masculina on the second pleopod of all specimens examined, including those bearing eggs.

Biology

Ovigerous specimens have been collected at the Yucatan Peninsula in April (Chace Jr., 1972), at Cananéia, São Paulo, in February, and at Paraná in December. I have been unable to distinguish the sex of the Brazilian material due to the presence of an appendix masculina in all specimens examined.

The biological implications of this peculiar trait are not clear to me, especially as Chace Jr. (*op. cit.*) has apparently been able to distinguish between males and non-ovigerous females. The species appears to be abundant in shallow estuarine environments just below the low-water line, where measured water temperatures in which specimens were collected varied from 18.72 to 30.41°C, and measured salinities varied from 3.07 to 26.84 ‰.

Habitat

Within the bay waters at Yucatan Peninsula, specimens are most common on shallow turtle grass flats, but three specimens came from tide pools and rocks near low-tide level and one specimen was apparently taken from much eroded coral standing in 3 m of water (Chace Jr., 1972: 79). The species was found in estuaries in Guadeloupe (Carvacho, 1979: 453) and Cananéia, SP, where specimens are common on shallow mud flats. The "Prof. W. Besnard" specimen comes from muddy shelf sediments (22 m deep) facing the large estuarine complex of Cananéia-Paranaguá.

Distribution

Bermudas, Bahamas, Yucatan Peninsula, Guadeloupe, São Paulo and Paraná; intertidal region to a depth of 22 m.

Latreutes parvulus (Stimpson, 1866)

Rhynchocyclus parvulus Stimpson, 1866:48
[type locality: Saint Joseph Island, Texas].

Latreutes parvulus - Holthuis, 1951:131, figs 28-29 [description; synonymy; distribution]; 1952a:54 [Río de Oro, 16-20 m; Annobon, 15-31 m]. - Pearse & Williams, 1951:143 [South Carolina, 12-16.8 m]. - Wass, 1955:145 [Alligator Harbor region, Florida]. - Tabb & Manning, 1961:596 [East Cape Sable, Florida]; 1962:62 [Florida Bay]. - Hulings, 1961:217 [Panama City, Florida]. - Roussignol, 1962:131 [Congo]. - Williams, 1965:79, fig. 64 [Carolinas; Rio de Janeiro]. - Ejchel, 1965:326 [São Paulo]. - Rouse, 1970:139 [Everglades, Florida, 1.4-2.1 m]. - Fausto Filho, 1970:56 [Ceará]; 1978:66 [Piauí; Rio Grande do Norte]; 1980:113. - Uschakov, 1970:455 [Guinea]. - Crosnier, 1971:575 [Congo, 3 to 15 m]. - Chace Jr., 1972:124 [Yucatan Peninsula; key]. - Coelho & Ramos, 1972:153 [Paraíba; Pernambuco; Alagoas; 0 to 44 m]. - Wood, 1974:38, pl.5 figs 2-4 [key]. - Camp, Whiting & Martin, 1977:27 [Hutchinson Island, Florida, 7.1 to 11.2 m]. - Carvacho, 1979:465 [Guadeloupe, 0.5 m; synonymy]. - Bowen *et al.*, 1979:252 [between New Jersey and Virginia]. - Felder & Chaney, 1979:25 [Texas, 14 m; seasonal abundance]. - Ramos-Porto, 1980:303 [Pernambuco, 0.3 to 14-15 m].

Synonym - *Concordia gibberosus* Kingsley, 1880.

Examined material

USA, NORTH CAROLINA: Carteret County: Beaufort, 0-0.3 m, from *Zostera* flat, M. L. Christoffersen coll. June 15, 1978, 2 ovig. ♀; Morehead City, pier at "Institute of Fisheries Research", day and night plankton tows, A.B. Williams and E.E. Deubler, Jr. coll. from April 10 to October 9, 1957, and on March 13, 1959, 7 samples (9 spec.) (IMS 993 to 1204). - BRAZIL, BAHIA: Salvador, Praia de Manginhos, Y.M.R. Leite coll. September, 1975, 5 spec. - ESPÍRITO SANTO: Guarapa-

ri, Praia de Peracanga, 0-0.3 m, among algae and gorgonians, M.L. Christoffersen coll. January 10, 1978, at night, 1 spec. - RIO DE JANEIRO: Baía de Mangaratiba, Praia da Ribeira, mud, A. Lemos de Castro and Arnaldo coll. February 6, 1959, several spec. (MNRJ), 2 spec. (MNRJ 26-61), 3 ♂, 2 ovig. ♀, 1 young spec. (USNM 103769). 23°13'S - 44°15'W, 42 m, December 17, 1971, "Prof. W. Besnard" Sta 1631, 1 ovig. ♀ (IOUSP - C0397). - SÃO PAULO: Ubatuba: J. Loyola e Silva coll. January 16, 1963, 1 ♂, 5 ♀ (2 ovig.), 1 young spec. (USNM); Enseada do Flamengo, Praia da Andorinha, January 22, 1963, several spec.; *ibid.*, Praia do Lamberto, 1 to 6 m, sand, mud and shell fragments, L.F. Duarte coll. from July 20, 1961 to January 22, 1963, 6 samples (2 ♂, 1 ovig. ♀, 7 spec.) (MZUSP 15 to 20); *ibid.*, in *Sargassum*, July 13, 1967, 1 spec. (with spec. of *Bopyrina abbreviata* Rich. in branchial chamber) (MNRJ); *ibid.*, intertidal zone, in *Sargassum*, 1972, at night, 1 spec. (with spec. of *B. abbreviata* in branchial chamber) (MNRJ); *ibid.*, 0-1 m, in the red algae *Bryocladia* and *Acanthophora*, M.L. Christoffersen coll. July 8, 1976, 1 ♂, 1 ovig. ♀. 23°50'S-45°52'W, 22 m, December 15, 1971, "Prof. W. Besnard" Sta 1615, 1 ♂, 1 ovig. ♀ (IOUSP-C0391). 23°51'S-45°41'W, 25-26 m, mud, 21.12°C, August 11, 1970, "Prof. W. Besnard" Sta 1163, 2 samples (1 ovig. ♀, 1 spec.) (IOUSP-C0249). 24°21'S-46°38'W, 25 m, sand, 20.63°C, August 13, 1970, "Prof. W. Besnard" Sta 1170, 1 ovig. ♀ (IOUSP-C0254). 24°40'S-47°16'W, 19 m, December 13, 1971, "Prof. W. Besnard" Sta 1599, several spec. (IOUSP-C0384). 24°51'S-47°29'W, 21 m, sand, research vessel "Emília", 3 ovig. ♀ (IOUSP-C1082). 24°53'S-47°37'W, 19 m, sand, "Emília", 1 spec. (IOUSP-C1081). Cananéia: Mar de Cananéia, 0.6 m, 19.85°C, 26.30 ‰, August 9, 1974, 1 ovig. ♀ (IOUSP); Baía do Trapandê, 5 m, January 11, 1973, 7 spec. (6 ovig. ♀) (IOUSP); *ibid.*, 0.5 m, 22.59°C, October 30, 1973, 1 spec. (IOUSP). 25°00.5'S-47°44'W, 17 m, sand, "Emília", 2 samples (5 ovig. ♀, 1 spec.). 25°03.5'S-47°51'W, 12m, sand, "Emília", 1 ovig. ♀ (IOUSP-C1076). - PARANÁ: 25°30'S-48°29'W, 22 m, December 11, 1971, "Prof. W. Besnard" Sta 1587, 3 samples (6 ovig. ♀, 2 ♀) (IOUSP-C0379). 25°30'S-48°29'W, 23 m, shell fragments and sand, December 11, 1971, "Prof. W. Besnard" Sta 1587, 9 spec. (8 ovig. ♀) (IOUSP-C0379). 25°51'S-48°19'W, 21-22 m, sand with algae, 18.77°C, August 19, 1970, "Prof. W. Besnard" Sta 1180, 1 spec. (IOUSP-C0262). - SANTA CATARINA: 28°10'S-48°35'W, 32 m, clay, 20.26°C, December 9, 1970, "Prof. W. Besnard" Sta 1295, 1 ovig. ♀ (IOUSP-C0318). 28°18'S-48°34'W, 50 m, clay and empty shells, 24.75°C, March 1, 1971, "Prof. W. Besnard" Sta 1441, 1 spec. (IOUSP-C0338). 29°13'S-49°35'W, 21-22 m, fine sand, 24.01°C, 35.72 ‰, "Prof. W. Besnard" Sta 1699, 1 ♂ (part of MZUSP 45). - RIO GRANDE DO SUL: 29°24.0'S-49°10.0'W, 55 m, mud and shells, 18.81°C, 35.39 ‰, August 2, 1972, "Prof. W. Besnard" Sta 1843, 1 ovig. ♀ (IOUSP-C0524). 29°39'S-48°41'W, 122-124 m, mud and clay, 15.66°C, 35.67 ‰, January 30, 1972, "Prof. W. Besnard" Sta 1696, 2 samples (1 ovig. ♀, 6 spec.). 31°09'S-50°43'W, 21 m, dark mud, 22.28°C, 34.83 ‰, April 10, 1972, "Prof. W. Besnard" Sta 1725, 3 samples (3 ovig. ♀, 10 spec.) (IOUSP-C0485). 31°27'S-51°05'W, 16 m, sand, 22.17°C, 33.78 ‰, April 12, 1972, "Prof. W. Besnard" Sta 1732, 1 ovig. ♀ (IOUSP-C0494). 31°45'S-51°26'W, 16 m, fine sand and mud, 21.95°C, 33.43 ‰, April 12, 1972, "Prof. W. Besnard" Sta 1733, 5 ovig. ♀ (IOUSP-C0496). 32°20'S-51°22'W, 52 m, mud and sand, 19.45°C, 35.90 ‰, January 21, 1972, "Prof. W. Besnard" Sta 1662, 4 ovig. ♀ (IOUSP-C0420). 33°14.0'S-51°48.5'W, 45 m, calcareous sand, 11.94°C, 33.19 ‰, August 18, 1972, "Prof. W. Besnard" Sta 1893, 1 spec. (IOUSP-C0581). 33°45.5'S-53°16.5'W, 16 m, sand and shell fragments, 11.70°C, 29.91 ‰, August 16, 1972, "Prof. W. Besnard" Sta 1886, 2 samples (2 spec.) (IOUSP-C0573). - URUGUAY: 33°50.0'S-51°50.0'W, 75 m, fine sand, mud and shells, 12.17°C, 34.08 ‰, August 17, 1972, "Prof. W. Besnard" Sta 1889, 2 samples (3 spec.) (IOUSP-C0578). 34°01.5'S-52°44.0'W, 27 m, calcareous sand, 10.87°C, 33.08 ‰, August 16, 1972, "Prof. W. Besnard" Sta 1885, 1 spec. (IOUSP-C0570). 34°35.5'S-53°30.0'W, 20 m, mud and fine sand, 11.16°C, 30.55 ‰, August 14, 1972, "Prof. W. Besnard" Sta 1877, 1 spec. (IOUSP-C0560). - BUENOS AIRES: 35°00'S-54°50.2'W, 23 m, fine mud, 10.83°C, 32.84 ‰, August 11, 1972 "Prof. W.

Besnard" Sta 1866, 2 spec. (IOUSP-C0548). 35°18.0'S-54°13.0'W, 27 m, fine sand, 10.66°C, 33.62 ‰, August 12, 1972, "Prof. W. Besnard" Sta 1867, 2 spec. (IOUSP-C0550). 35°33.1'S-53°48.0'W, 57 m, fine sand, 10.02°C, 33.69 ‰, August 13, 1972, "Prof. W. Besnard" Sta 1868, 1 ♂ (part of MZUSP 50), 3 samples (22 spec.) (IOUSP-C0551).

Measurements

The largest male and the largest ovigerous female measure 4.5 mm (carapace and rostrum) plus 8 mm (abdomen and telson) along the dorsal midline of the body. The smallest ovigerous female measures 2.5 mm plus 4 mm.

Color

Wass (1955: 145) indicated that the specimens are "... usually associated with *Sargassum*, with which their mottled brown color blends". The two specimens I collected in the red algae *Bryocladia* and *Acanthophora* had a body which was transparent spotted by numerous blue chromatophores, and less distinctly mottled by yellow markings.

Remarks

Latreutes parvulus is closely related to the Chilean species *L. antiborealis* Holthuis. The latter differs "... in the more elongate rostrum and in having less spines on the third maxilliped" (Holthuis, 1952b: 65).

Biology

The species appears to be most common in estuarine and marine waters less than 30 m deep, but occurs to a depth of 122-124 m. The northern range limit of the species, between New Jersey and Virginia, is based on samples of pelagic larvae and pelagic adults (Bowen *et al.*, 1979: 252). In North Carolina both day and night plankton tows have provided specimens. In southeastern Brazil I have collected this species in shallow algal beds during low-tide both during the day and during the night. Eggs

measure from 0.4 to 0.5 mm in diameter (Holthuis, 1951: 131), and a female measuring 9.4 mm in carapace length was found to have 70 eggs (Crosnier, 1971: 575). Although ovigerous females have been taken throughout the year in various parts of the range north of the Equator (Williams, 1965: 79), towards the southern boundary ovigerous females have only been taken in water temperatures above 15.66°C: at 29°39'S (122-124 m deep, 15.66°C) and 32°20'S (52 m deep, 19.45°C) in summer (January), at 31°45'S (16 m deep, 21.95°C) in autumn (April) and at 29°24'S (55 m deep, 18.81°C) in winter (August). To the south of São Paulo, measured water temperatures in which specimens were collected varied from 10.02 to 24.01°C, and salinities from 26.30 to 35.90 ‰. In eastern Florida, these values varied from 21.6 to 29.5°C and from 34.8 to 38 ‰. (Camp, Whiting & Martin, 1977: 27), while in southwestern Florida these values varied from 16 to 34°C and from 15 to 50 ‰ (Rouse, 1970: 139).

Habitat

The species has been found over a wide variety of substrates: fine mud; clay; fine sand; calcareous sand; shell fragments; shells and foraminiferans, shells and hydroids (Holthuis, 1951: 131); on a shell of *Pinna* (Crosnier, 1971: 575); from *Halodule* grass flats (Ramos-Porto, 1980:303); from *Zostera* grass flats; among algae, including *Sargassum*, *Bryocladia* and *Acanthophora*; from sponges (Williams, 1965: 79); among algae and gorgonians; from *Phragmatopoma* sand reefs (Jacques van Montfrans, personal communication); from calcareous algae (Coelho & Ramos, 1972: 153); from eroded dead coral (Chace Jr., 1972: 124); in a piece of rock (Crosnier, 1971: 575).

Distribution

Western Atlantic from between New Jersey and Virginia (Bowen *et al.*, 1979: 252) to the Province of Buenos Aires, Argentina. Eastern Atlantic from Spanish Sahara to Congo and Annobon Island; larvae possibly belonging to this species are referred from as far south as Angola (Lebour, 1959: 124). Intertidal region to 122-124 m deep.

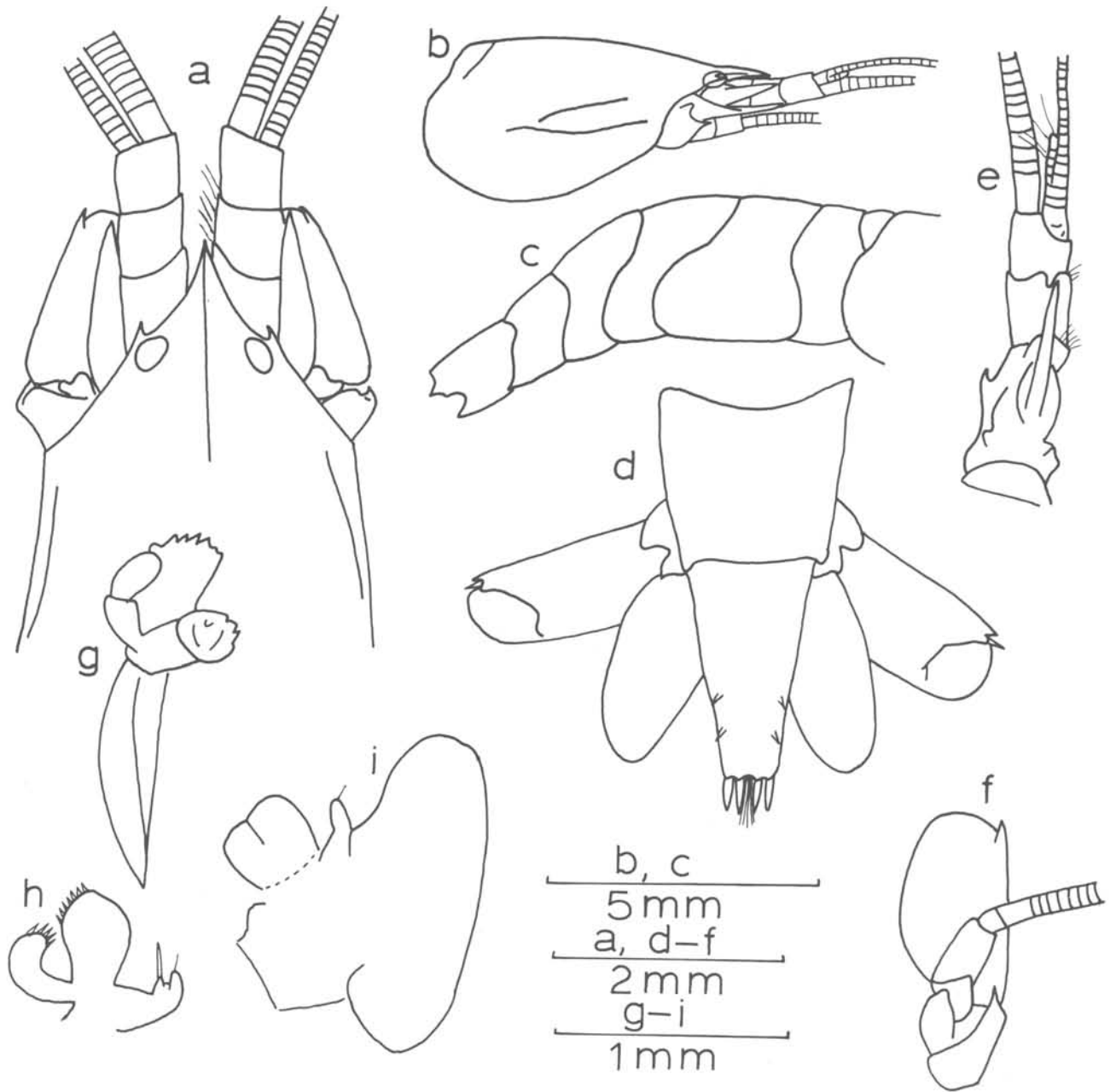


Fig. 1. *Salmoneus ortmanni* (Rankin), ovigerous specimen from Cananéia (MZUSP 29): a, anterior region, dorsal view; b, same, lateral view; c, abdomen, lateral view; d, telson and uropods, dorsal view; e, antennule, lateral view; f, antenna, ventral view; g, mandible; h, first maxilla; i, second maxilla.

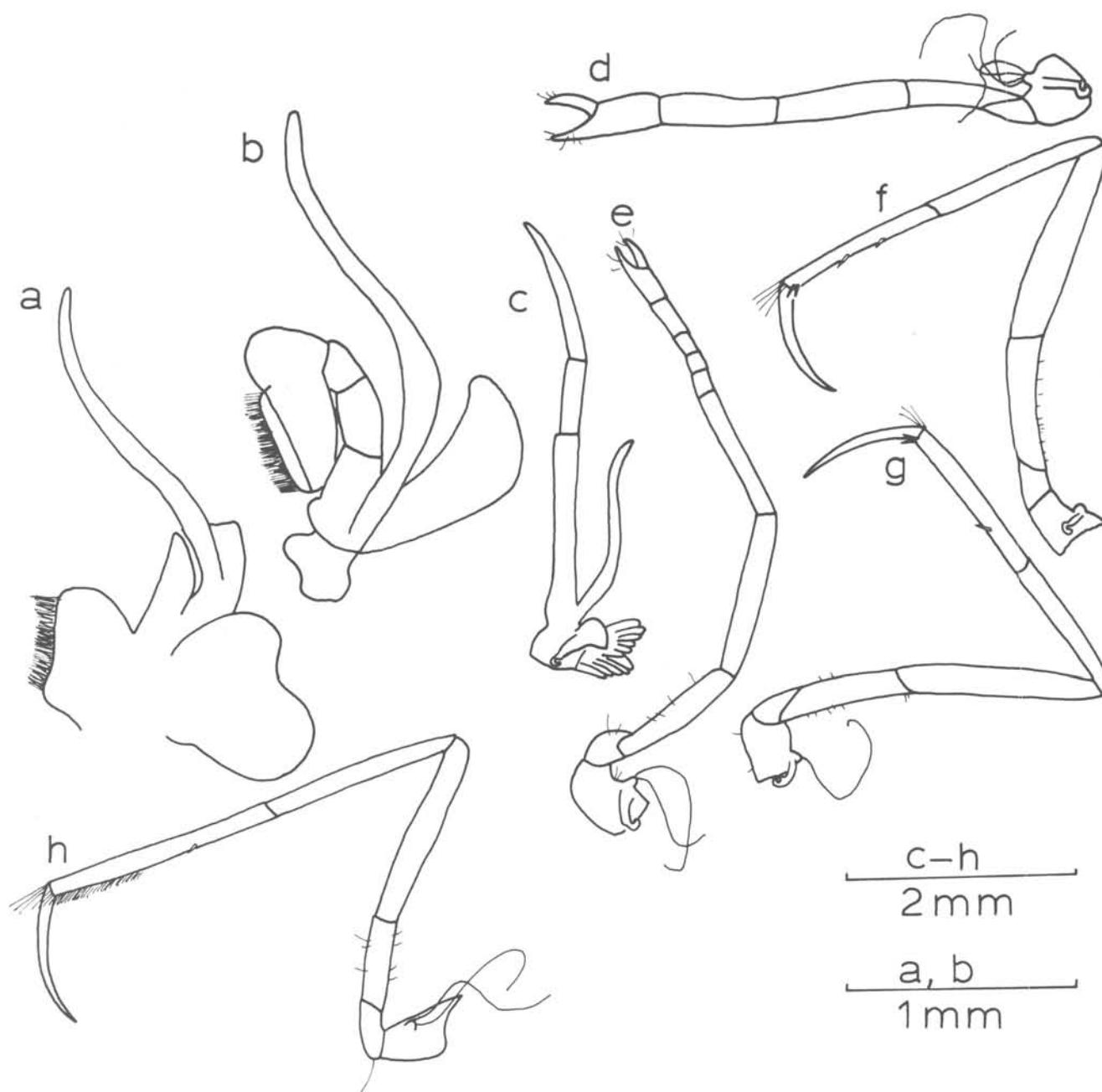


Fig. 2. *Salmoneus ortmanni* (Rankin), ovigerous specimen from Cananéia (MZUSP 29): a, first maxilliped; b, second maxilliped; c, third maxilliped; d, first right pereiopod; e, second pereiopod; f, third pereiopod; g, fourth pereiopod; h, fifth pereiopod.

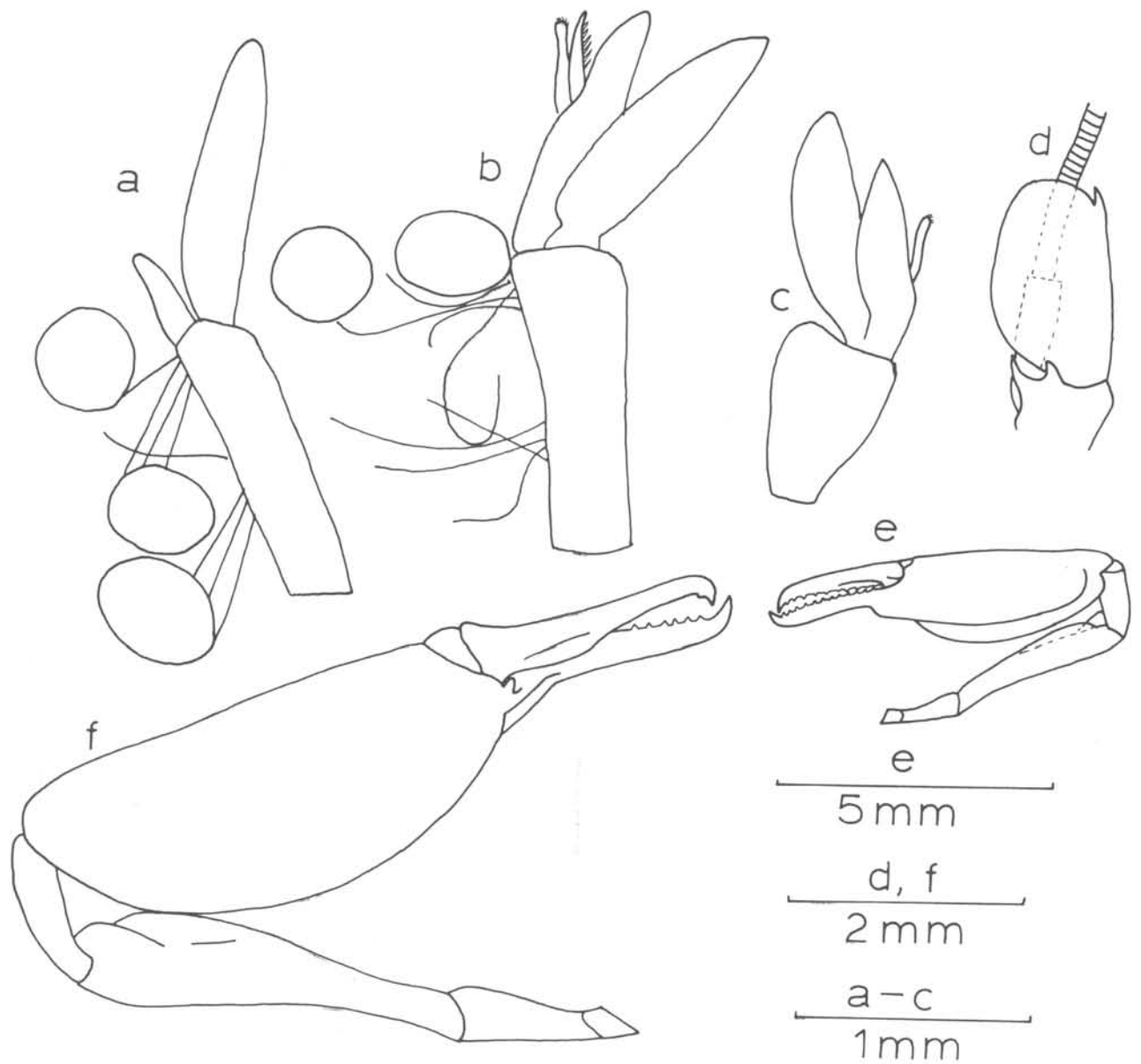


Fig. 3. *Salmoneus ortmanni* (Rankin), ovigerous specimen from Cananãia (MZUSP 29): a, first pleopod; b, second pleopod; c, fifth pleopod. Ovigerous specimen from R/V "Prof. W. Besnard" Sta 1587: d, antenna, dorsal view; e, major cheliped, dorsomesial surface; f, same, lateral surface.

Tozeuma serratum A. Milne Edwards, 1881
(Figs 4-5).

Tozeuma serratum A. Milne Edwards, 1881:
16 [type locality: off Barbados,
102.4 m]; 1883: pl. 29. - Schmitt,
1924: 83 [Barbados]. - Holthuis, 1947:
23 [listed as *species incertae*]. -
Ewald, 1969: 511 [deep water east
of Florida keys]. - Chace Jr., 1972:
141 [northwestern and south Florida,
44 to 46 m; key]. - Herbst, Williams &
Boothe Jr., 1978: 991 [North Carolina,
32 m; Massachusetts].

Examined material

BRAZIL, RIO DE JANEIRO: 22°59'S-42°27'W,
41 m, January 17, 1975, "Prof. W.
Besnard" Sta 2152, 1 ♀ (part of MZUSP
34). - SÃO PAULO: 24°09'S-44°59'W,
79-82 m, sand, 15.9°C, May 28, 1970,
"Prof. W. Besnard" Sta 1029, 1 ♂
(IOUSP).

Measurements

The male measures 11 mm (rostrum) plus
6 mm (carapace) plus 15 mm (abdomen and
telson). The female measures 9 plus 4.5
plus 13 mm.

Remarks

Although Holthuis (1947:23) had included
T. serratum in his list of *species
incertae*, commenting that "...this species
perhaps belongs to a new genus as the
carpus of the second pereopod contains
7 segments", it can hardly be doubted
that the present specimens with 3 carpal
articles on the second pereopod (Figs
4-5) refer to the same distinct species
as the previous references for this name.

As well as the presence of a series
of sharp teeth on the dorsal margin of
the rostrum, *T. serratum* differs from
T. carolinense Kingsley by the antennal
scale being longer than the scaphocerite,
by the long and narrow propodus of the
first and second pereopods, and by the
telson being longer than the sixth
abdominal segment and deeply notched in
the posterior margin.

Biology

The species may be absent from shallow
tropical waters. A single ovigerous
female has been reported from the northern
range of the species, from a depth of
32 m and in water measuring 17.3°C in
summer (Herbst, Williams & Boothe Jr.,
1978: 991).

Distribution

The species is known from waters
32 to 102.4 m deep, off Massachusetts,
North Carolina, Florida, Barbados,
Rio de Janeiro and São Paulo.

Processa profunda Manning & Chace Jr., 1971

Processa canaliculata - Rathbun, 1902
(not Leach, 1815): 104 [northwest
Florida, 202 m; part].

Processa profunda Manning & Chace Jr.,
1971: 25, figs 13-15 [type lo-
cality: 28°36'N-85°33'30'W, off
west coast of Florida, 202 m;
other locality: 24°20'N-83°20'W,
Gulf of Mexico, 346 m]. - Chace
Jr., 1972: 143 [key]. - Bowen *et
al.*, 1979: 259 [between New
Jersey and Virginia].

Examined material

BRAZIL, SÃO PAULO: 24°05'S-43°25'W,
205-210 m, sand, mud and calcareous
rock, 13.70°C, December 3, 1970, "Prof.
W. Besnard" Sta 1263, 2 spec. (IOUSP-
C0289). - RIO GRANDE DO SUL: 29°51'S-
48°11'W, 200 m, April 7, 1972, "Prof. W.
Besnard" Sta 1709 extra, 2 spec. (IOUSP-
C0466). 29°51'S-48°11'W, 315 m,
calcareous rock, 11.74°C, 35.09 ‰,
April 7, 1972, "Prof. W. Besnard" Sta
1709, 2 samples (1 ♂, 1 spec.) (IOUSP-
C0465). 29°52'S-48°20'W, 200 m,
calcareous rock, 15.88°C, 35.71 ‰,

April 7, 1972 "Prof. W. Besnard" Sta 1708, 19 spec. (1 ovig. ♀) (IOUSP-C0464). 29°53.0'S-48°19.8'W, 186 m, mud and sand, 14.29°C, 35.82 ‰, August 3, 1972, "Prof. W. Besnard" Sta 1846, 2 spec. (IOUSP-C0526). 30°20'S-48°37'W, 184-190 m, 16.40°C, 35.74 ‰, January 29, 1972, "Prof. W. Besnard" Sta 1692, 9 spec. (IOUSP-C0449). 30°28'S-48°42'W, 150 m, sand, April 7, 1972, "Prof. W. Besnard" Sta 1711 extra, 2 samples (7 spec.) (IOUSP-C0468). 30°31'S-49°52'W, 200 m, calcareous rock, 17.28°C, 35.87 ‰, April 11, 1972, "Prof. W. Besnard" Sta 1728, 6 spec. (IOUSP-C0490). 30°42.7'S-49°03.4'W, 186 m, mud, sand and shells, 15.80°C, 35.65 ‰, August 5, 1972, "Prof. W. Besnard" Sta 1856, 19 spec. (IOUSP-C0535). 30°46'S-49°07'W, 170-172 m, coarse sand and gravel, 16.37°C, 35.76 ‰, January 27, 1972, "Prof. W. Besnard" Sta 1684, 5 spec. (IOUSP-C0441). 31°13'S-49°36'W, 232-241 m, calcareous rock and sand, 17.31°C, 36.02 ‰, January 27, 1972, "Prof. W. Besnard" Sta 1681, 1 ovig. ♀ (IOUSP-C0440). 31°14'S-49°35'W, 180 m, calcareous rock, 16.58°C, 35.76 ‰, April 10, 1972, "Prof. W. Besnard" Sta 1721, 2 samples (6 spec.) (IOUSP-C0479). 32°24'S-50°14'W, 188-202 m, mud and sand, 17.00°C, 35.82 ‰, January 22, 1972, "Prof. W. Besnard" Sta 1666, 1 spec. (IOUSP-C0423). 33°17'S-50°34'W, 166 m, fine sand and mud, 15.83°C, 33.80 ‰, January 19, 1972, "Prof. W. Besnard" Sta 1656, 1 spec. (IOUSP-C0414). - URUGUAY: 34°06'S-51°33'W, 139-145 m, gravel, 14.47°C, 35.58 ‰, January 17, 1972, "Prof. W. Besnard" Sta 1648, 2 samples (1 ovig ♀, 6 spec.) (IOUSP-C0407). 34°27.2'S-51°50.0'W, 175 m, calcareous rock, 13.45°C, 35.33 ‰, August 15, 1972, "Prof. W. Besnard" Sta 1883, 14 spec. (IOUSP-C0568). 34°28'S-51°50'W, 170 m, coarse sand, 16.82°C, 35.81 ‰, April 18, 1972, "Prof. W. Besnard" Sta 1740, 13 spec. (2 ovig. ♀) (IOUSP-C0503).

Measurements

The largest male measures 10.5 mm (carapace and rostrum) plus 20 mm (abdomen and telson) along the dorsal midline of the body. The largest ovigerous female measures 13.5 plus

25 mm.

Remarks

In the new material the right second pereopod has 17-22 meral and 34-43 carpal articles, instead of 21-22 and 45-46, respectively (Manning & Chace Jr., 1971: 26), while the left second pereopod has 15-17 carpal articles, rather than 18-21 (*loc. cit.*). Otherwise, only the following slight differences in proportions of appendages were observed: the third pair of maxillipeds overreaches the antennal scale by no more than the distal segment, while the first pair of pereopods is slightly shorter than the antennal scale. The differences mentioned above complement the ranges of variation of these morphological characters, and I may add that the fifth pereopod - incomplete in the type material - has the propodus four times longer than the dactyl.

Biology

This species appears to be restricted to the outer portion of the continental shelf and the upper slope throughout its range. Measured water temperatures and salinities in which specimens were collected vary from 11.74 to 17.31°C and from 35.09 to 36.02 ‰, respectively. Ovigerous females have been collected in March and April in the Gulf of Mexico (Manning & Chace Jr., 1971: 25), and in January and April in South America. In the latter region, the water temperatures in which ovigerous females were collected varied from 14.47 to 17.31°C.

Habitat

The sediment types in which specimens were collected were as follows: mud; mud and fine sand; coarse sand; mud, sand and shells; gravel; calcareous rock.

Distribution

The species is recorded from between New Jersey and Virginia, from the eastern Gulf of Mexico, and from São Paulo to Uruguay, from 139-145 to 346 m deep.

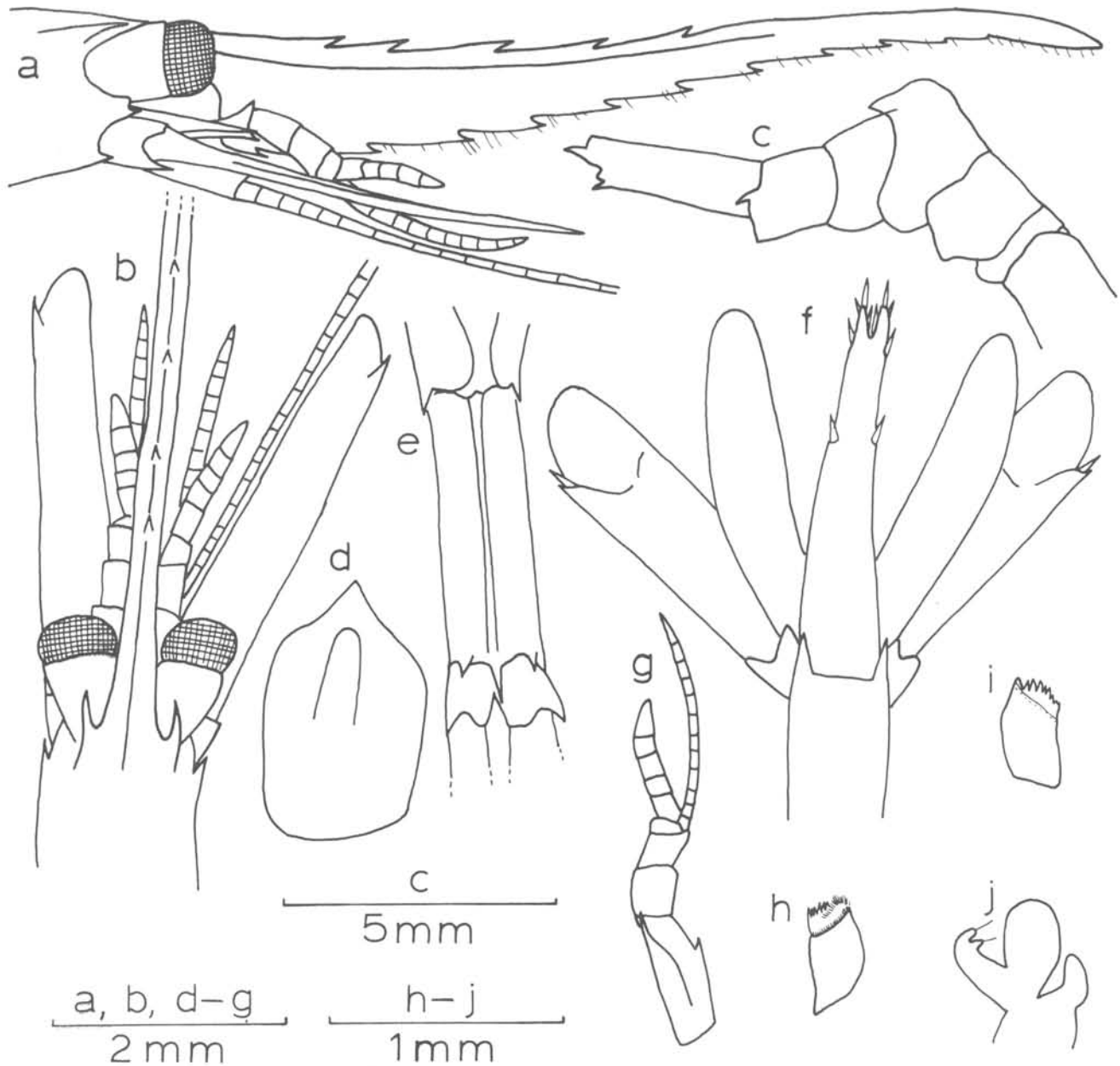


Fig. 4. *Tozeuma serratum* A. Milne Edwards, female from R/V "Prof. W. Besnard" Sta 2152: a, anterior region, lateral view; b, same, dorsal view; c, abdomen, lateral view; d, third abdominal somite, dorsal view; e, sixth abdominal somite, ventral view; f, telson and uropods, dorsal view; g, antennule, lateral view; h, mandible, ventral surface; i, same, dorsal surface; j, first maxilla.

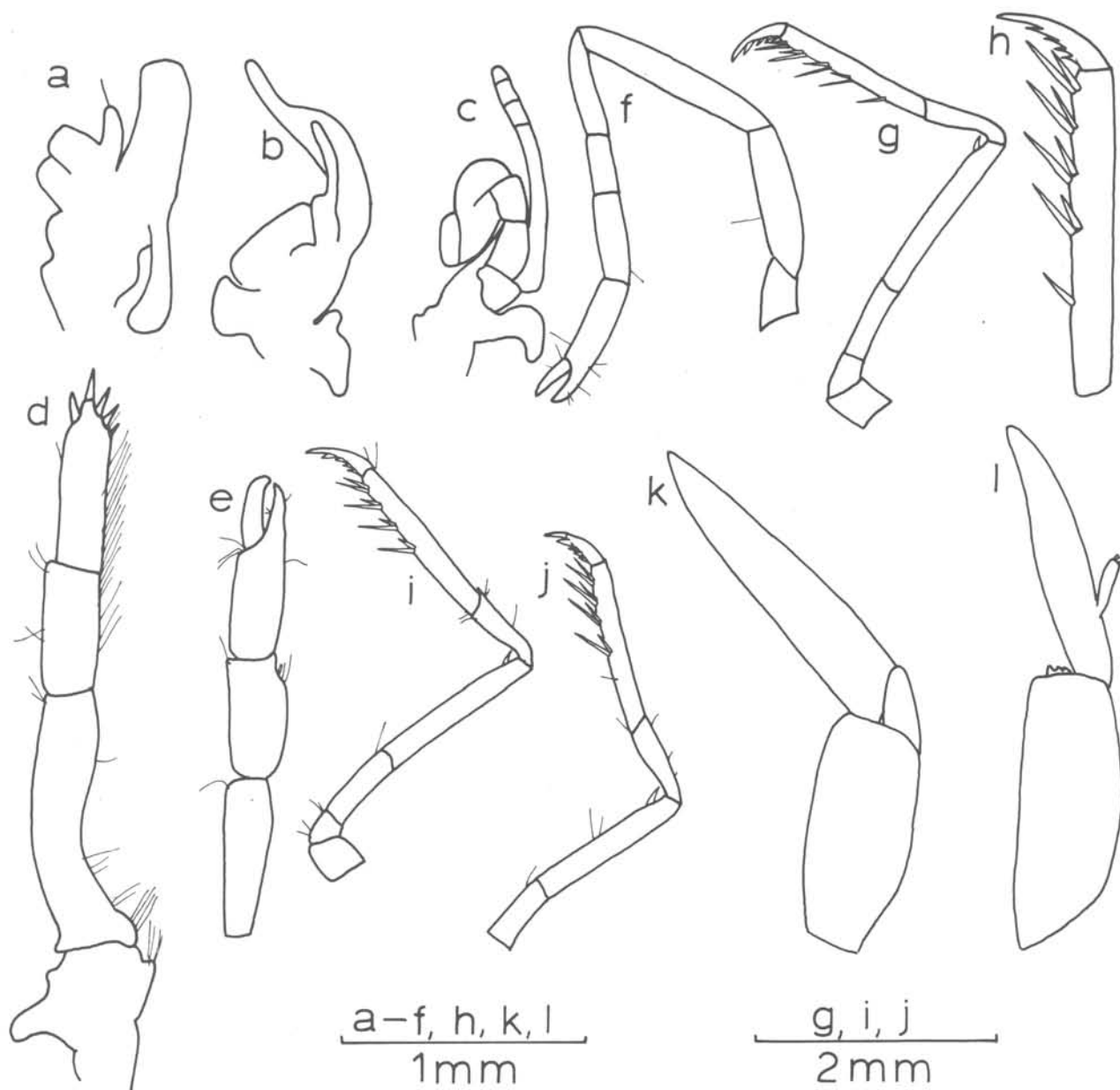


Fig. 5. *Tozeuma serratum* A. Milne Edwards, female from R/V "Prof. W. Besnard" Sta 2152: a, second maxilla; b, first maxilliped; c, second maxilliped; d, third maxilliped; e, anterior portion of first pereopod; f, second pereopod; g, third pereopod; h, propodus and dactyl of third pereopod; i, fourth pereopod; j, fifth pereopod; k, first pleopod; l, second pleopod (exopod missing).

Discussion

Two distinct faunal assemblages may be recognized on the continental shelf of eastern South America, between 23 and 35°S (Fig. 6):

Tropical species

This is the largest group: *Synalpheus longicarpus* (Herrick, 1891), *Processa bermudensis* (Rankin, 1900), *Alpheus normanni* Kingsley, 1878, *Salmoneus ortmanni* (Rankin, 1898) and *Alpheus intrinsecus* Bate, 1888, are apparently restricted to some of the most protected areas within the large bay formed between Cabo Frio, State of Rio de Janeiro (23°S) and Cabo de Santa Marta, State of Santa Catarina (28°S). *Alpheus floridanus* Kingsley, 1878, *Ogyrides alphaerostris* (Kingsley) (= *O. occidentalis* (Ortmann)), *Exhippolysmata oplophoroides* (Holthuis), *Processa hemphilli* Manning & Chace and *Latreutes parvulus* (Stimpson) are more widely distributed within this large bay, and also occur on the continental shelf facing the State of Rio Grande do Sul and Uruguay.

All the tropical species are present in shallow coastal waters (intertidal region to 5 m deep), being largely restricted to the eulittoral zone (less than about 50 m deep). The most notable exceptions are a sample of *P. hemphilli* from 154 m deep and a sample of *L. parvulus* from 122-124 m deep.

The species of this group have all been collected in measured water temperatures above 20.26°C (Christoffersen, 1979: 317), being present in the shallow tropical waters between southern Florida and eastern Brazil in which water temperatures are always warmer than 24°C (Hutchins & Scharff, 1974: pl. 1,2). Salinity ranges of individual species may vary considerably - e.g., from 3.07 to 37‰ for *O. alphaerostris* (Christoffersen, 1979: 299) and from 15 to 50‰ for *L. parvulus* - according to the extent of their invasion of estuarine environments and hypersaline coastal waters.

Subtropical species

Alpheus pouang Christoffersen, 1979, *A. puapeba* Christoffersen, 1979, *Merhippolyte americana* Holthuis, 1961, *Processa guyanae* Holthuis, 1959, *P.*

profunda Manning & Chace, 1971 and *Tozeuma serratum* A. Milne Edwards, 1881 are absent from shallow coastal waters (less than 30 m deep), being largely restricted to the outer portion of the continental shelf within the studied area. *A. pouang* and *A. puapeba* may so far be considered endemic to this area. *T. serratum* and *P. guyanae* are possibly restricted to cooler subsurface waters within the tropics and range to North Carolina (Herbst, Williams & Boothe Jr., 1978: 991; Christoffersen, 1979: 368). *M. americana* and *P. profunda* are only known from deeper waters in the Gulf of Mexico and the eastern United States, ranging, respectively, to North Carolina (Holthuis, 1961: 1) and to between Virginia and New Jersey (Bowen *et al.*, 1979: 252). The species of this group have all been collected in measured water temperatures below 21.22°C, while measured salinities varied from 32.15 to 36.04‰ (Christoffersen, 1979: 300).

We can obtain suggestions about the factors that set the poleward boundaries of the tropical and subtropical species known beyond 29°S from the temperature and distributional data available for each species (Tab. I). This is possible mainly because there are marked differences in the fluctuations of the maximum and minimum monthly mean sea temperatures in the northwestern Atlantic (up to about 22°C in surface waters around Cape Hatteras) and in the southwestern Atlantic (up to about 11°C in surface waters around the Río de la Plata) (based on Hutchins & Scharff, 1947: pl. 1,2).

The poleward boundaries of *A. floridanus* (Tab. I) may be set by their inability to survive temperatures below about 15°C, because if these boundaries were set by the requirement of temperatures above about 21°C for the completion of some phase of the process of repopulation of the species, their northern limit of distribution in shallow waters would be expected to reach Long Island, New York. A critical winter temperature of 15°C would also explain the absence of this species from shallow coastal waters in the Carolinian Province, because south of Cape Hatteras the bottom winter temperatures in the inshore shelf waters are expected to be slightly lower than the average surface temperatures of 11-14°C at this season

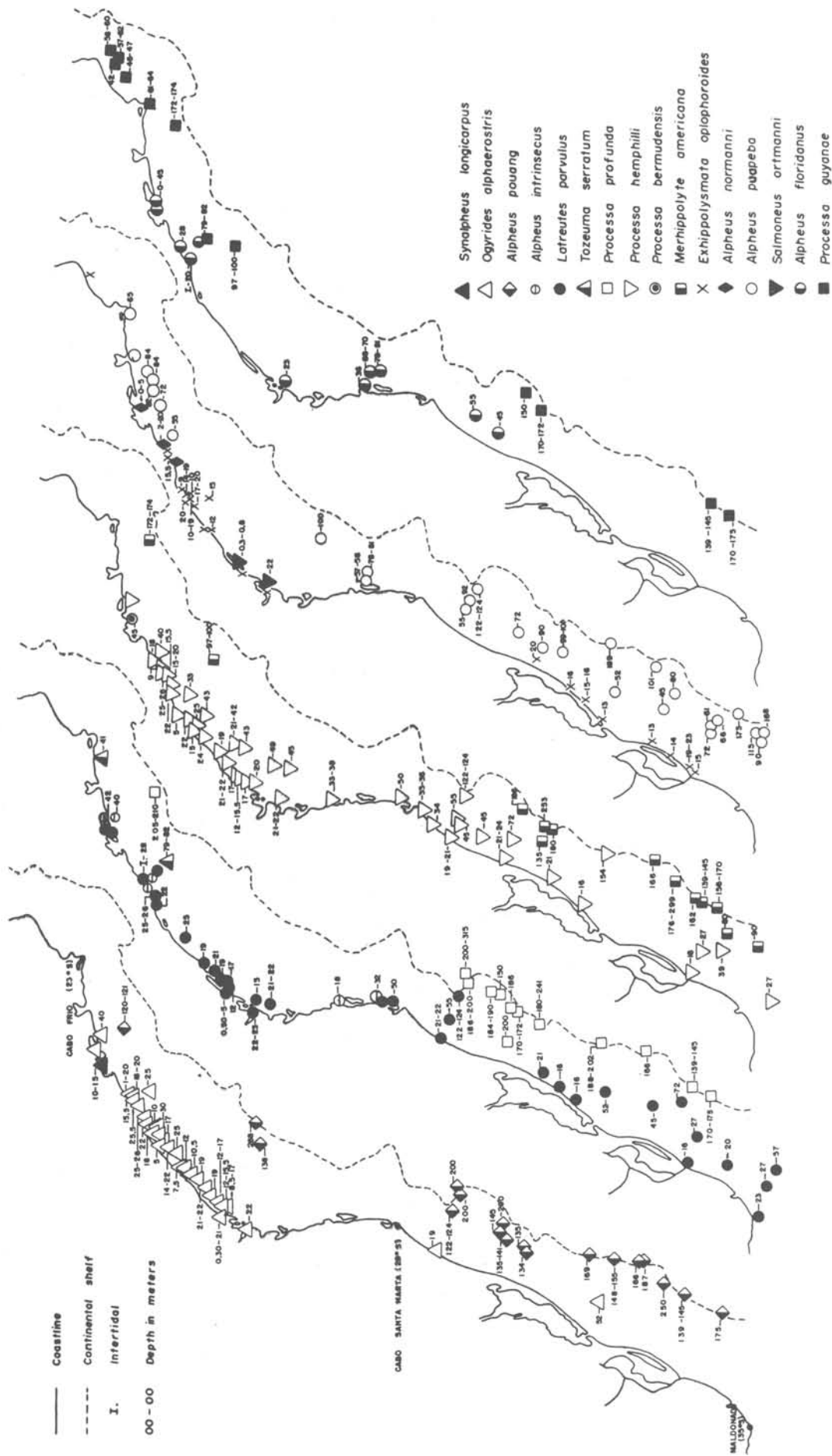


Fig. 6. Distribution of tropical and subtropical species of Alpheoidea in the warm-temperate shelf waters of eastern South America.

Table 1 - Expected winter and summer northern boundaries of western Atlantic warm-water Alpheoidea known to the south of 29°S, based on the maximum and minimum temperature conditions at their southern boundaries and compared to their known distributions and the measured temperature ranges in which specimens were collected

Faunal assemblages	Warm-water species collected to the south of 29°S by the R/V "Prof. W. Besnard"	Known distribution	Measured water temperatures in which specimens were collected	Minimum winter temperature at southern boundary (based on Miranda, Luedemann & Miyao, 1973)	Expected northern boundary in shallow water if minimum winter temperature is critical for survival (based on Hutchins & Scharff, 1947)	Measured water temperatures in which ovigerous females were collected	Maximum summer temperature at southern boundary (based on Miranda, Luedemann & Miyao, 1973)	Expected northern boundary in shallow water if maximum summer temperature is critical for repopulation (based on Hutchins & Scharff, 1947)
	<i>Alpheus konzidanus</i> Kingsley	North Carolina to Rio Grande do Sul; Intertidal to 78-81 m	15.2-27°C	15°C	North Carolina	25.3°C	21°C	Long Island, New York
	<i>Ogyrides alphaeocentris</i> (Kingsley)	Virginia to Rio Grande do Sul; 0-0.30 to 52 m deep	11.0-31°C	15°C	—	20.41-23.21°C	20°C	Long Island, New York
	<i>Exhippothamata ophiotoxides</i> (Holthuis)	North Carolina to Rio Grande do Sul - Uruguay border; 5 to 45 m deep	16.7-27°C	11°C	North Carolina	16.7-24.72°C	22°C	—
	<i>Proceana kempkillei</i> Manning & Chace	North Carolina to Buenos Aires; 1.8-5 to 154 m deep	10.66-32.0°C	9°C	North Carolina	15.10-25.36°C	—	—
	<i>Latentia parvulus</i> (Stimpson)	Virginia to Buenos Aires; Intertidal to 122-124 m deep	10.02-34°C	9°C	North Carolina	15.66-22.28°C	—	—
	<i>Proceana guyanae</i> Holthuis	North Carolina to Uruguay; 30 to 331 m deep	13.45-19.48°C	9°C	—	14.47-19.48°C	17°C	—
	<i>Proceana proclunda</i> Manning & Chace	Virginia to Uruguay; 150 to 346 m deep	11.74-17.31°C	9°C	—	14.47-17.31°C	17°C	—
	<i>Alpheus pouang</i> Christoffersen	São Paulo to Uruguay; 120-121 to 268 m deep	10.49*-16.99°C	9°C	—	16.80°C	—	—
	<i>Alpheus puapua</i> Christoffersen	Espírito Santo to Buenos Aires; 45 to 175 m deep	8.14-21.22°C	8°C	—	11.94-20.12°C	—	—
	<i>Meshippodyte americana</i> Holthuis	North Carolina to Buenos Aires; 80 to 274.2 m deep	8.14-17.94°C	8°C	—	14.49-16.82°C	—	—

* The lower temperature limit indicated in Christoffersen (1979) was a mistake, for the bottom temperature at the R/V "Prof. W. Besnard" Sta 1856 is 15.80°C, instead of 03.89°C

(Cerame-Vivas & Gray, 1966: 265). Thus the male and ovigerous female collected to the southeast of Cape Hatteras, in water 38 m deep and measuring 25.3°C in summer (Herbst, Williams & Boothe Jr., 1978:991), could represent either a permanent or a temporal range boundary for this species. In the first case, the collection site would be permanently under the influence of the warm Florida Current, which flows over the outer shelf and has a relatively mild climate even in winter: a minimum temperature of 19.5°C was registered in this region, at a depth of 146 m (Cerame-Vivas & Gray, 1966: 265). In the second case, this point may represent a seasonal range extension beyond the survival boundary of the species, that is, towards shallower waters in summer.

Bottom samples of *O. alphaerostris* have been taken in waters as cold as 13-13.5°C in Mississippi (Christoffersen, 1979: 356), and larvae in waters as cold as 11.0°C in the Chesapeake Bay, even though less than 1% of these larvae were taken in water temperatures below 19°C (Sandifer, 1973: 241). If the poleward boundaries of *O. alphaerostris* were set by winter temperatures of about 11°C critical for the survival of the most resistant stage (Tab. I), the species would not be expected to occur along the inner shelf waters beyond Cape Hatteras, because north of this point bottom temperatures as low as 4.5°C have been measured at a depth of 18.3 m in North Carolina (Cerame-Vivas & Gray, 1966: 265), and as low as 3°C in waters less than 20 m deep between Virginia and New Jersey (Bowen *et al.*, 1979: 218). Furthermore, towards the south the species would be expected to reach the northern shelf of Uruguay, in waters shallower than 40 m (based on Miranda, Luedemann & Miyao, 1973: 46, figs 30a, 44a; Furtado, 1973: 113, fig. 9). The occurrence of *O. alphaerostris* in shallow waters of the Virginian Province, on the other hand, fits the expected distribution for this species if temperatures above about 20°C are required for some fase of the repopulation of the species. This is because between New Jersey and Virginia maximum bottom temperatures of 20°C are expected in waters shallower than 20 m (Bowen *et al.*, 1979: 218), while a little to the North of Cape Hatteras a maximum

temperature of 23.9°C was recorded at 18.3 m deep (Cerame-Vivas & Gray, 1966: 265). It seems probable that maximum summer temperatures of about 20°C are required for the reproduction of the species, as ovigerous females have apparently only been collected in the warmer months of the year towards both their poleward boundaries (Christoffersen, 1979: 356).

Specimens of *E. oplophoroides* may not survive temperatures below 11°C, while temperatures below 9°C may be critical to the survival of specimens of specimens of *P. hemphilli* and *L. parvulus* (Tab. I). If maximum summer temperatures between 15.10 and 16.7°C were required for the reproduction of these species, their poleward boundaries in shallow waters would be expected to reach Nova Scotia in the north and the Patagonian coast of Argentina in the south (Hutchins & Scharff, 1947: pl.1). Even with critical winter temperatures as low as 9°C, these tropical species are not expected to occur in shelf waters beyond North Carolina, because between New Jersey and Virginia bottom temperatures as low as 3-4°C are expected over the continental shelf (Bowen *et al.*, 1979: 218). Thus the recent range extension of *P. hemphilli* from Florida to North Carolina (Herbst, Williams & Boothe Jr., 1978: 992) confirms the expected boundary for this species, assuming the minimum winter temperature of 9°C limits the poleward distribution of this species. The pelagic larvae and pelagic adults of *L. parvulus* collected between New Jersey and Virginia (Bowen *et al.*, 1979:252), on the other hand, may belong to a temporary population which has spread beyond the survival boundary of 9°C. That this is a highly mobile or migratory species appears to be indicated by the fact that *L. parvulus* is not restricted to specific substrate types and has been frequently collected in plankton tows in North Carolina.

Although less information is available on the extreme bottom temperatures in the deeper sublittoral waters in which the group of subtropical species are encountered, it seems improbable that their poleward boundaries are set by maximum summer temperatures required for the reproduction or completion of the life cycles of these

species (Tab. I). At least for *P. guyanae* and *P. profunda*, ovigerous females were encountered in water temperatures somewhat lower (14.47°C) than the maximum summer conditions at the southern range limit of these species (17°C). Furthermore, if *P. guyanae*, *P. profunda* and *M. americana* required temperatures above 14.47-14.49°C for their reproduction or completion of life cycles, the poleward distributions of these species would be expected to range much further north along the eastern United States, because in waters less than 20 m deep between New Jersey and Virginia, bottom water temperatures are still expected to reach 20°C (Bowen *et al.*, 1979: 218). Thus the poleward boundaries of *P. guyanae*, *P. profunda* and *A. pouang* may be set by their inability to survive winter temperatures below 9°C, while these boundaries for *A. puapeba* and *M. americana* may be set by critical winter temperatures of about 8°C. With these critical temperatures the three species known from the northwestern Atlantic would only be expected to occur beyond Cape Hatteras at the shelf break (80-100 m) and at the uppermost continental slope, where the warmer and more constant temperatures of 10-12°C are expected to occur between New Jersey and Virginia (Bowen *et al.*, 1979: 218).

It has further been noticed that the limit of distribution of *A. pouang* and *M. americana* towards the shallower coastal waters perpendicular to the State of Rio Grande do Sul coincides very nearly with the maximum summer temperatures of about 17-18°C, while the shoreward boundary of *A. puapeba* in this region appears to coincide with the maximum summer temperatures of about 20-22°C (based on Miranda, Luedemann & Miyao, 1973: 10, figs 4a, 18a). Thus the shoreward boundaries of these subtropical species appear to be set by critical summer temperatures in the shallower coastal waters, which are too high for the survival of the species. The absence of *M. americana* from the continental shelf of the eastern United States — the species has been recorded from off Cape Lookout, at a depth of 195.6 m (Holthuis, 1961: 1), and the continental slope of North Carolina begins at about 128-183 m (Cerame-Vivas & Gray, 1966: 265) — may also be due to this upper survival

boundary of 17-18°C, for the shelf waters south of Cape Hatteras are expected to reach much higher values in summer: 26-29°C in surface waters and only a few degrees lower in offshore bottom waters (Cerame-Vivas & Gray, 1966: 265).

Acknowledgements

I would like to thank Drs Plínio Soares Moreira, Motonaga Iwai (IOUSP), Paulo E. Vanzolini, Gustavo A. S. de Mello (MZUSP), Alceu Lemos de Castro (MNRJ), Raymond B. Manning, Fenner A. Chace Jr., Austin B. Williams (USNM) and Charles Petersen (IMS) for making crustacean collections available and providing working space during my visits to their institutions.

The financial support in North America was obtained from Rockefeller Foundation and UNESCO, and in Brazil from "Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)" and "Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)".

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- (Manuscript received on 02/Feb./1982;
accepted on 05/May/1982)