Zootaxa 1653: 21–39 (2007)
www.mapress.com/zootaxa/

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

New species and records of alpheid shrimps, genera *Salmoneus* Holthuis and *Parabetaeus* Coutière, from the tropical western Atlantic (Decapoda, Caridea)

ARTHUR ANKER

Instituto Smithsonian de Investigaciones Tropicales, Apartado 0843–03092, Balboa, Ancón, Panamá, República de Panamá / Smithsonian Tropical Research Institute, Naos Unit 0948, APO AA 34002, USA. E-mail: ankera@si.edu

Abstract

Six species of the alpheid shrimp genus *Salmoneus* Holthuis, 1955, including two new species, are reported from the tropical western Atlantic. *Salmoneus ortmanni* (Rankin, 1898) is reported for the first time from Atol das Rocas, Brazil and Aruba, Netherlands Antilles. *Salmoneus carvachoi* **n. sp.** is described on the basis of specimens previously misidentified as *S. ortmanni* from Guadeloupe, French Antilles, and is also known to occur in Brazil. The main difference between *S. carvachoi* **n. sp.** and *S. ortmanni* is the much more slender dactylus of the third to fifth pereiopods in the first species. The two species also appear to be ecologically separated: *S. carvachoi* **n. sp.** prefers silt-mud bottoms of estuaries and mangroves, while *S. ortmanni* occurs mostly in the rocky-coralline algae intertidal and on seagrass beds with reef patches, under rocks and coral rubble. *Salmoneus rocas* **n. sp.** is described on the basis of a single specimen collected at Atol das Rocas; this species belongs to the mostly Indo-Pacific *S. serratidigitus* (Coutière, 1896) species complex. *Salmoneus teres* Manning & Chace, 1990 and *S. setosus* Manning & Chace, 1990 previously known only from the isolated Ascension Island in the central Atlantic, are reported for the first time from the tropical western Atlantic: Guadeloupe and northeastern Brazil, respectively. Finally, *Parabetaeus hummelincki* (Schmitt, 1936) is recorded for the first time in Brazil.

Key words: *Salmoneus*, *Parabetaeus*, Alpheidae, Caridea, new species, new records, western Atlantic, Brazil

Introduction

The alpheid shrimp genera *Salmoneus* Holthuis, 1955 and *Parabetaeus* Coutière, 1897 are among the biologically and taxonomically poorest known carideans. This is mainly due to their small size – usually less than 10 mm in total length; inconspicuous colour patterns – often colourless and semitransparent; and cryptic life style – most species dwell deep in crevices, under rocks, among rubble or in burrows of other crustaceans, which also explains their apparent rarity.

Salmoneus is currently represented by three species in the western Atlantic: *S. ortmanni* (Rankin, 1898), *S. arubae* (Schmitt, 1936) and *S. cavicolus* Felder & Manning, 1986 (Rankin, 1898; Schmitt, 1936; Chace, 1972; Felder & Manning, 1986). However, this number does not reflect the actual diversity of this genus in the western Atlantic region, which is probably closer to 14 (Anker & Marin, 2006; A. Anker, pers. obs.).

Salmoneus is characterized mainly by the asymmetrcial and usually unequal chelipeds, with the major chela (or both chelae) being carried folded against the merus; the absence of a distinct articulated plate on the sixth abdominal somite; the well developed rostrum; the well-marked acute orbital spines; the typical alpheid gill formula, which includes an arthrobranch above the third maxilliped and five strap-like epipods on the coxae of the third maxilliped and the first to fourth pereiopod (e.g., Banner & Banner, 1973; Chace, 1988); and finally, by the presence of an appendix masculina invariably in both sexes (Carvacho, 1989). This latter

Accepted by J. Goy: 1 Oct. 2007; published: 3 Dec. 2007

feature is extremely rare among caridean shrimps, and is found in only one other alpheid, *Yagerocaris cozumel* Kensley, 1988 (Kensley, 1988).

Salmoneus ortmanni was previously known from the western Atlantic, ranging from the Bahamas to southern Brazil (Christoffersen, 1982, 1998), and the eastern Pacific, from the Gulf of California to Galapagos (Wicksten & Hendrickx, 2003). However, the morphological variation in *S. ortmanni* reported by Christoffersen (1982) and Ríos (1989, 1992) appears to be beyond intraspecific level, suggesting that *S. ortmanni* is a species complex with two or more species. The present author recently collected specimens of *S. ortmanni* in Aruba, Netherlands Antilles, and also examined several specimens of this species collected at Atol das Rocas (AR), off northwestern Brazil, deposited at the Museu Nacional, Rio de Janeiro, Brazil (MNRJ), as well as Carvacho's (1979) material from Guadeloupe, French Antilles, identified and reported as *S. ortmanni*, and deposited at the Muséum national d'Histoire naturelle, Paris, France (MNHN).

A comparison between the recently collected specimens and Rankin's (1898) original description and figures enabled to determine the taxonomic identity of *S. ortmanni sensu stricto* (*sensu* Rankin, 1898) and to separate a distinct, unnamed western Atlantic species previously confused with *S. ortmanni* (Carvacho, 1979; Christoffersen, 1982). This species is herewith described as new on the basis of Carvacho's material from Guadeloupe, French Antilles.

A second new species of *Salmoneus* is described from a single specimen collected at Atol das Rocas and deposited at the MNRJ. Two other *Salmoneus* species that were previously known only from type specimens collected around the isolated Ascension Island in the central Atlantic (Manning & Chace, 1990) are reported for the first time from the western Atlantic (Caribbean and Brazil).

Parabetaeus Coutière, 1896 (junior synonym: *Neoalpheopsis* Banner, 1953; see Nomura & Anker, 2000) is characterized by the symmetrical and equal chelipeds, carried extended, but capable of ventral flexion; the frontal margin of the carapace bearing blunt orbital spines, with or without rostrum; the typical alpheid gill formula (with an arthrobranch and five strap-like epipods); and the acutely produced posterior margin of the telson (Nomura & Anker, 2000). This genus is represented by only one species in the western Atlantic: *P. hummelincki* (Schmitt, 1936), previously reported from a few Caribbean localities (as *Neoalpheopsis hummelincki*, Chace, 1972) and Ascension Island [as *Neoalpheopsis euryone* (de Man, 1910)] by Manning & Chace (1990). This species is reported for the first time from Brazil; the synonymy of *P. hummelincki* with *P. euryone*, first suggested by Banner & Banner (1985) is discussed.

Material and methods

All drawings were made under the dissection microscope with the aid of a camera lucida. Carapace length (CL) and total length (TL) were measured along the mid-dorsal line from the rostrum tip to the posterior margin of the carapace and telson, respectively. The material is deposited in the collections of the Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (MNRJ), Muséum national d'Histoire naturelle, Paris, France (MNHN) and National Museum of Natural History, Smithsonian Institution, Washington DC, USA (USNM). Other abbreviations: AR—Atol das Rocas; BAMZ—Bermuda Aquarium, Museum and Zoo, Bermuda; DR—Dominican Republic; Mxp—maxilliped; P—pereiopod.

I follow Watling's (1989) terminology of cuticular structures in the Crustacea: "spiniform seta" is used for robust articulated cuticular extension (often called "spine" or "movable spine"); "spine" is reserved for sharp non-articulated cuticular extension (sometimes called "tooth"); and "tooth" is used to describe bluntly ending, fixed extension (for instance, teeth on the finger cutting edges of the major cheliped). A more exhaustive and updated account of the alpheid terminology will be provided elsewhere (Anker, in prep.).

Taxonomy

Family Alpheidae Rafinesque, 1815

Genus *Salmoneus* Holthuis, 1955

Synonym: *Jousseaumea* Coutière, 1896

Salmoneus ortmanni (Rankin, 1898)

Fig. 1, 2

Athanas ortmanni Rankin, 1898: 251; Verrill, 1900: 579.
Jousseaumea ortmanni – Coutière, 1900: 356; Verrill, 1922: 122; Schmitt, 1936: 367.
Salmoneus ortmanni – Chace, 1972: 79 (part.?); Banner & Banner, 1981: 56; Martínez-Iglesias *et al.*, 1996: 35; Christoffersen, 1998: 362 (part.).
Not *Salmoneus ortmanni* – Carvacho, 1979: 453; Christoffersen, 1980: 137; Christoffersen, 1982: 94; Christoffersen, 1998: 362 (part.); Coelho dos Santos & Coelho, 2001: 78 (= *S. carvachoi* **n. sp.**, see below).
(?) Not *Salmoneus ortmanni* – Carvacho & Ríos, 1983: 283; Ríos & Carvacho, 1983: 462; Christoffersen & Ramos, 1988: 63; Villalobos Hiriart *et al.*, 1989: 16; Ríos, 1989: 154; Ríos, 1992: 7; Wicksten & Hendrickx, 1992: 6; Wicksten, 1993: 151; Villalobos, 2000: 74; Wicksten & Hendrickx, 2003: 66 (= *Salmoneus* sp. aff *ortmanni*; see below).
Salmoneus evermanni (*lap. cal.*) – Holthuis, 1990: 111.
Salmoneus sp. – Rodríguez, 1986: 180.

Material examined: 2 ovig. females, MNRJ 20213, Brazil, Atol das Rocas (AR), LT 800, Ilha do Cemitério, intertidal, coll. C. Serejo and M.C. Rayol, 20 Oct 2001 [1 specimen dissected]; 1 ovig. female, MNRJ 20214, LT 795, Brazil, Atol das Rocas, between Ilha do Farol and Ilha do Cemitério, low tide, coll. C. Serejo and M.C. Rayol, 31 Oct 2001; 2 ovig. females, MNRJ 20215, Brazil, Atol das Rocas, between Ilha do Farol and Ilha do Cemitério, low tide, coll. C. Serejo and M.C. Rayol, 25 Oct 2001; 1 non-ovigerous specimen (male?), MNHN-Na 15686, Aruba, Pos Chiquito, from coral rocks, depth 0.5–1 m, coll. A. Anker, 7–8 Dec 2003; 1 ovig. female, MNHN-Na 15685, Aruba, Baby Beach, from coral rubble and porous rocks, depth 1–1.5 m, coll. A. Anker, 6 Dec 2003.

Description: Carapace slightly setose (Fig. 1a, c). Rostrum as long as broad, reaching half length of second segment of antennular peduncle, with acute tip (Fig. 1b); lateral margins slightly convex proximally; ventral margin unarmed (Fig. 1c); rostral carina distinct, reaching beyond eyes posteriorly (Fig. 1b). Orbital spines acute, slightly mesially directed (Fig. 1b). Pterygostomial margin protruding anteriorly, rounded (Fig. 1a, c). Eyes covered in dorsal and lateral view (Fig. 1a, b). Antennule with stylocerite reaching or slightly overreaching distal margin of second segment of antennular peduncle, with acute tip; second segment as long as wide (Fig. 1b). Antenna with basicerite bearing acute distoventral spine (Fig. 1c); scaphocerite broadly ovate, distolateral spine small, acute (Fig. 1b). Third maxilliped with rounded lateral plate; tip of ultimate segment with short apical and subapical spiniform setae (Fig. 1d, e). Chelipeds strongly asymmetrical in shape, unequal in size (Fig. 2). Major cheliped (Fig. 2a–e) with unarmed ischium; merus inflated distally, ventrally flattened; carpus elongated, ventrally flattened to slightly depressed, distally lobed (Fig. 2c); chela excavated ventrally, flattened mesially (Fig. 2a, c); fingers about half as long as palm, cutting edges serrated, with about 10–12 rounded teeth (Fig. 2e). Minor cheliped (Fig. 2f, g) with ischium subequal to merus, both unarmed; carpus slightly shorter than merus; chela small, simple, with fingers subequal to palm. Second pereiopod (Fig. 1f) with unarmed ischium; carpus bearing five segments, first segment longer than sum of four other segments. Third pereiopod (Fig. 1g) with ischium bearing one ventrolateral spiniform seta; merus about four times as long as wide; carpus unarmed except for one slender distoventral spiniform seta; propodus with four slender ventral spiniform setae, including distal spiniform seta; dactylus simple, conical, moderately slender, less than half length of propodus. Fifth abdominal somite with subacute posteroventral angle. Sixth abdominal somite

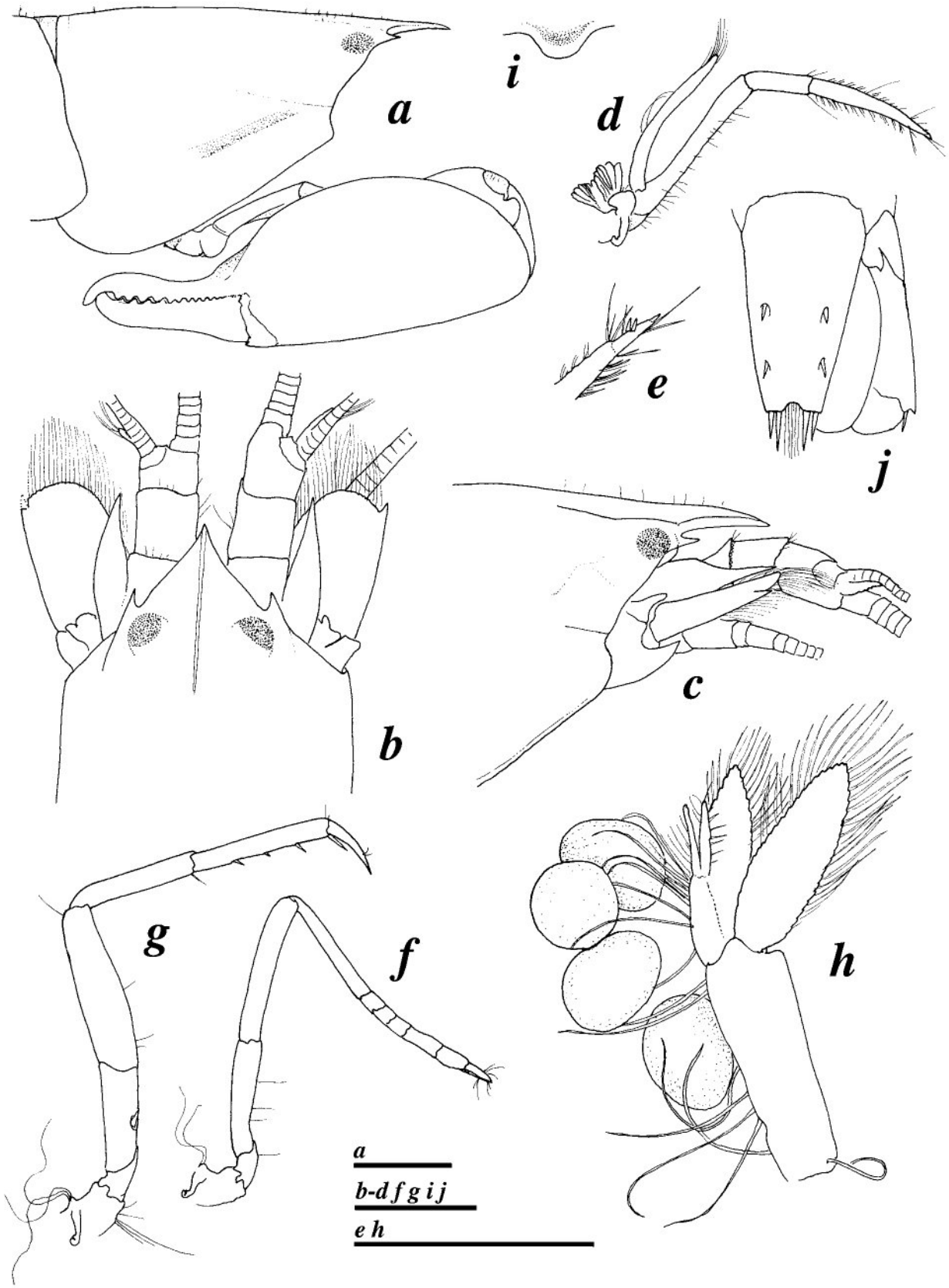

FIGURE 1. *Salmoneus ortmanni* Rankin, 1898, ovigerous specimen from Atol das Rocas, Brazil (MNRJ 20213): a—cephalothorax and major cheliped, lateral view; b—frontal region, dorsal view; c—same, lateral view; d—third maxilliped, lateral view; e—same, tip of ultimate segment; f—second pereiopod, lateral view; g—third pereiopod, lateral view; h—second pleopod with eggs, mesial view; i—preanal plate of sixth abdominal somite, ventral view; j—telson and right uropod, dorsal view. Scale bars = 1 mm.

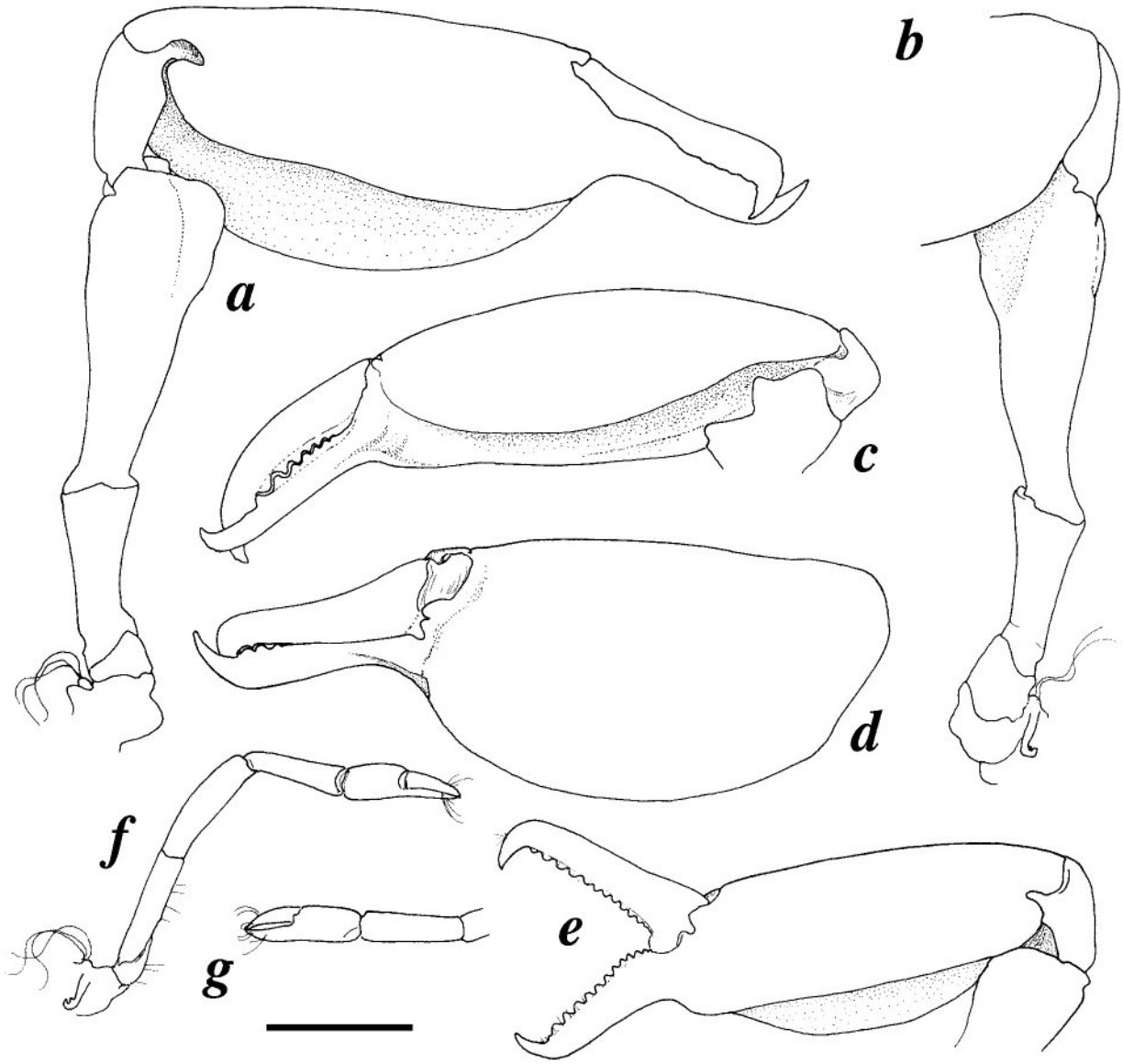

FIGURE 2. *Salmoneus ortmanni* Rankin, 1898: ovigerous specimen from Atol das Rocas, Brazil (MNRJ 20213): a—major cheliped, mesial view; b—same, coxa to carpus, lateral view; c—same, chela, ventrolateral view; d—same, dorsolateral view; e—same, chela with opened fingers, lateral view; f—minor cheliped, lateral view; g—same, carpus and chela, mesial view. Scale bar = 1 mm.

without articulated plate, with subacute posteroventral projection; preanal plate rounded (Fig. 1i). Second pleopod with appendix masculina subequal to appendix interna, furnished with slender setae on apex and along outer margin (Fig. 1h). Uropod with sinuous diaeresis and slender distolateral spinform seta (Fig. 1j). Telson about twice as long as wide proximally, tapering posteriorly, with two pairs of dorsal spiniform setae, inserted at about mid-length and 3/4 telson length, respectively (Fig. 1j); posterior margin with rounded median notch and two pairs of spiniform setae at posterolateral angles, mesial setae distinctly longer than lateral setae (Fig. 1j). Gill/exopod formula typical for genus: 5 pleurobranchs (above P1-5); 1 arthrobranch (above Mxp3); 0 podobranch; 2 lobe-shaped epipods (Mxp1-2); 5 mastigobranchs or strap-like epipods (Mxp3, P1-4); 5 sets of setobranchs (P1-5); 3 exopods (Mxp1-3).

Colour: The specimens from Aruba were uniformly yellow-orange.

Size: The largest AR specimen has CL 4.5 mm, TL 13.5 mm.

Ecology: The Aruba specimens were found in crevices of coral rubble and rocks in a depth of 1–1.5 m; the AR specimens were collected intertidally, probably under rocks. In the Caribbean, *S. ortmanni* occurs under rocks from the tide pool level down to about 3–4 m, and on turtle grass flats, under rocks and rubble (Chace, 1972; pers. obs.), occasionally also in tide pools near low tide level (Chace, 1972) and inside empty *Strombus* shells and among mangrove roots (Rodríguez, 1986).

Type locality: Nassau, New Providence, Bahamas.

Distribution: Western Atlantic: Caribbean Sea: Bahamas, Cuba, W Mexico (?), Lesser Antilles, Aruba, Venezuela; Bermuda (Rankin, 1898; Verrill, 1922; Chace, 1972; Christoffersen, 1982, 1998; Rodríguez, 1986; Martínez-Iglesias *et al.*, 1996; present study), Brazil: Atol das Rocas (present study). Christoffersen's (1982) record of *S. ortmanni* from southern Brazil most likely refers to *S. carvachoi*, **n. sp.** (see below). The records of *S. ortmanni* from the eastern Pacific (Ríos & Carvacho, 1983; Villalobos Hiriart *et al.*, 1989; Ríos, 1989, 1992; Wicksten, 1993; Villalobos, 2000) most probably refer to closely related, undescribed species (see below).

Remarks: *Salmoneus ortmanni* belongs to the *S. ortmanni* species group (see Anker & Marin, 2006 for definition of species groups). Members of this group are unique in having a major cheliped with inflated and ventrally excavated merus and carpus. Until now, all western Atlantic and eastern Pacific specimens with this features were assigned to *S. ortmanni* (e.g., Carvacho, 1979; Christoffersen, 1998; Wicksten & Hendrickx, 2003). However, variation in the proportions of the major chela and especially in the shape of the dactylus of the third to fifth pereiopods suggests that *S. ortmanni* is a species complex, with two distinct forms in the western Atlantic (and perhaps one or two distinct forms in the eastern Pacific, see below).

In Christoffersen's specimens from southern Brazil (São Paulo and Paraná), the major chela is 2.5–3 times longer than wide, compared to only twice as long as wide in the type (Rankin, 1898: 251). In the AR specimens, the major chela appears to be stouter compared to that of the specimen from São Paulo illustrated by Christoffersen (1982), and approaching the ratio of the chela in the original figure by Rankin (1898). Furthermore, the dactylus of the third pereiopod of the AR specimens is moderately slender, only about half as long as the propodus, and so very similar to the proportions of the dactylus in Rankin's figure, as well as in the Caribbean material reported by Chace (1972). In contrast to this, Christoffersen's (1982) specimens had a very slender dactylus, with a ratio dactylus/propodus equal to 5/7. A similar ratio is also found in specimens from Guadeloupe reported by Carvacho (1979) (see below). Also, the merus and propodus of the third pereiopod are significantly broader in the AR specimens compared to the specimen from São Paulo (cf. Fig. 1g and Christoffersen, 1982: 99, fig. 2f).

Christoffersen (1982) also reported variation in the shape of the rostrum and length of the scaphocerite. In the AR specimens, the rostrum is indeed slightly broader than in Christoffersen's specimen from São Paulo (cf. Fig. 1b and Christoffersen, 1982: 98, fig. 1a). Furthermore, in the AR specimens, the telson is broader and has a more pronounced median notch on the posterior margin (cf. Fig. 1j and Christoffersen, 1982: 98, fig. 1d). Notably, both Christoffersen's and Carvacho's specimens with the elongate P3-5 dactyli were found on mud bottoms in mangrove-estuarine conditions, while the AR and Aruba specimens with a stouter P3-5 dactyli were collected on mixed sand-rubble bottoms. This ecological difference seem to corroborate the differences in morphology, suggesting that two species are currently confused under *S. ortmanni*: a coral rubble-seagrass species, with stouter P3-5 dactyli – *S. ortmanni sensu stricto* (*sensu* Rankin, 1898), and a mangrove-estuarine species with longer and more slender P3-5 dactyli – *S. ortmanni sensu* Carvacho (1979) and Christoffersen (1982). The latter species is described below as new.

The specimens from Los Roques, Venezuela, reported as "*Salmoneus* sp." by Rodríguez (1986) agree almost perfectly with the AR specimens, including the shape of the rostrum and the broad telson bearing a shallow rounded median notch.

The records of *S. ortmanni* from the Gulf of California and Galapagos (e.g., Ríos & Carvacho, 1983; Ríos, 1989, 1992; Wicksten, 1993; Villalobos, 2000) should be regarded as questionable. Ríos (1989, 1992) exam-

ined and compared specimens from the Gulf of California (Bahía Concepición and Rio Mulegé), Laguna Percebú (Baja California), and Guadeloupe, French Antilles (Carvacho's specimens), and noted that the posterior margin of the telson sometimes has a "vestigial" median notch. However, this notch – an important taxonomic character of the *Salmoneus* species - is quite deep in the AR specimens (Fig. 1j) and Los Roques specimens (Rodríguez, 1986). Ríos (1992) noted that the ischium of the third and fourth pereiopods may bear either one or two spiniform setae. Ríos also found that the specimens from the Gulf of California differ from the specimens from Guadeloupe (described below as *S. carvachoi* **n. sp.**) by the absence of the ischial spiniform seta on the second pereiopod; this seta also lacks in the AR specimens (Fig. 1f). The present author examined several specimens of *S.* cf. *ortmanni* collected by Rafael Robles (University of Louisiana, Lafayette, LA, USA) from the mudflats of the Rio Mulegé estuary, northern Gulf of California, and specimens identified as *S. ortmanni* from Bahía Málaga, Pacific coast of Colombia (USNM 244251). All these specimens appear not to represent *S. ortmanni sensu* Rankin, 1898. The above-listed differences, if shown to be consistent, could prove to be important characters in the separation of the eastern Pacific form (or forms) from both *S. ortmanni* and *S. carvachoi* **n. sp.** However, the status of the eastern Pacific specimens of *S. ortmanni s. lat.* will be subject of a separate study.

Salmoneus carvachoi n. sp.

Fig. 3

Salmoneus ortmanni (not Rankin, 1898) – Carvacho, 1979: 453; Christoffersen, 1980: 137; Christoffersen, 1982: 94; Christoffersen, 1998: 362 (part.); Coelho dos Santos & Coelho, 2001: 78.
[?] *Salmoneus* aff. *ortmanni* – Hernández Aguilera et al., 1996: 35.
[?] *Salmoneus* sp. – Coelho & Ramos, 1972: 151.

Material examined: Holotype: 1 non-ovig. specimen (male?), MNHN-Na 13680, Guadeloupe, estuary of Rivière Lézarde, dredge ("chalutage") between estuary and canal, time: 15.40, coll. Rojas-Hostache, 13 Jun 1977. Paratypes: 1 ovig. female, MNHN-Na 2699, Guadeloupe, M 42.1, coll. and det. (as *Salmoneus ortmanni*) A. Carvacho, 27 Jan 1977; 1 non-ovigerous specimen (male?), MNHN-Na 2669, Guadeloupe, M 32.5, coll. and det. (as *Salmoneus ortmanni*) A. Carvacho, 27 Jan 1977 [dissected].

Description: Carapace glabrous (Fig. 3b, c). Rostrum longer than broad, reaching half length of second segment of antennular peduncle, with acute tip (Fig. 3a); lateral margins slightly concave proximally; ventral margin unarmed (Fig. 3b); rostral carina slight, not reaching beyond eyes posteriorly (Fig. 3a). Orbital spines acute, slightly mesially directed (Fig. 3a). Pterygostomial margin feebly protruding anteriorly, rounded (Fig. 1a, c). Eyes covered in dorsal view, visible in lateral view (Fig. 3a, b). Antennule with stylocerite falling short of distal margin of second segment of antennular peduncle, with acute tip; second segment as long as wide (Fig. 3a). Antenna with basicerite bearing subacute distoventral spine (Fig. 3b); scaphocerite broadly ovate, distolateral spine small, acute (Fig. 3a, b). Third maxilliped with rounded lateral plate; tip of ultimate segment with short apical and subapical spiniform setae. Chelipeds strongly asymmetrical in shape, unequal in size (Fig. 3d–h). Major cheliped (Fig. 3d–g) with unarmed ischium; merus somewhat inflated distally, ventrally flattened (Fig. 3e); carpus elongated, ventrally flattened to slightly depressed, distally with blunt lobes (Fig. 3d); chela excavated ventrally, flattened mesially (Fig. 3d, c); fingers about half as long as palm, cutting edges serrated, with about 13–14 small rounded teeth (Fig. 3f, g). Minor cheliped (Fig. 3h) with ischium shorter than merus, both unarmed; carpus subequal to merus; chela small, simple, with fingers subequal to palm. Second pereiopod (Fig. 3i) with ischium bearing small spiniform seta; carpus with five segments, first segment longer than sum of four other segments (Fig. 3j). Third pereiopod (Fig. 3k) with ischium bearing two small ventrolateral spiniform seta; merus about six times as long as wide; carpus unarmed; propodus with three slender ventral spiniform setae, including distal seta; dactylus simple, conical, very slender, about 3/4 length of propodus

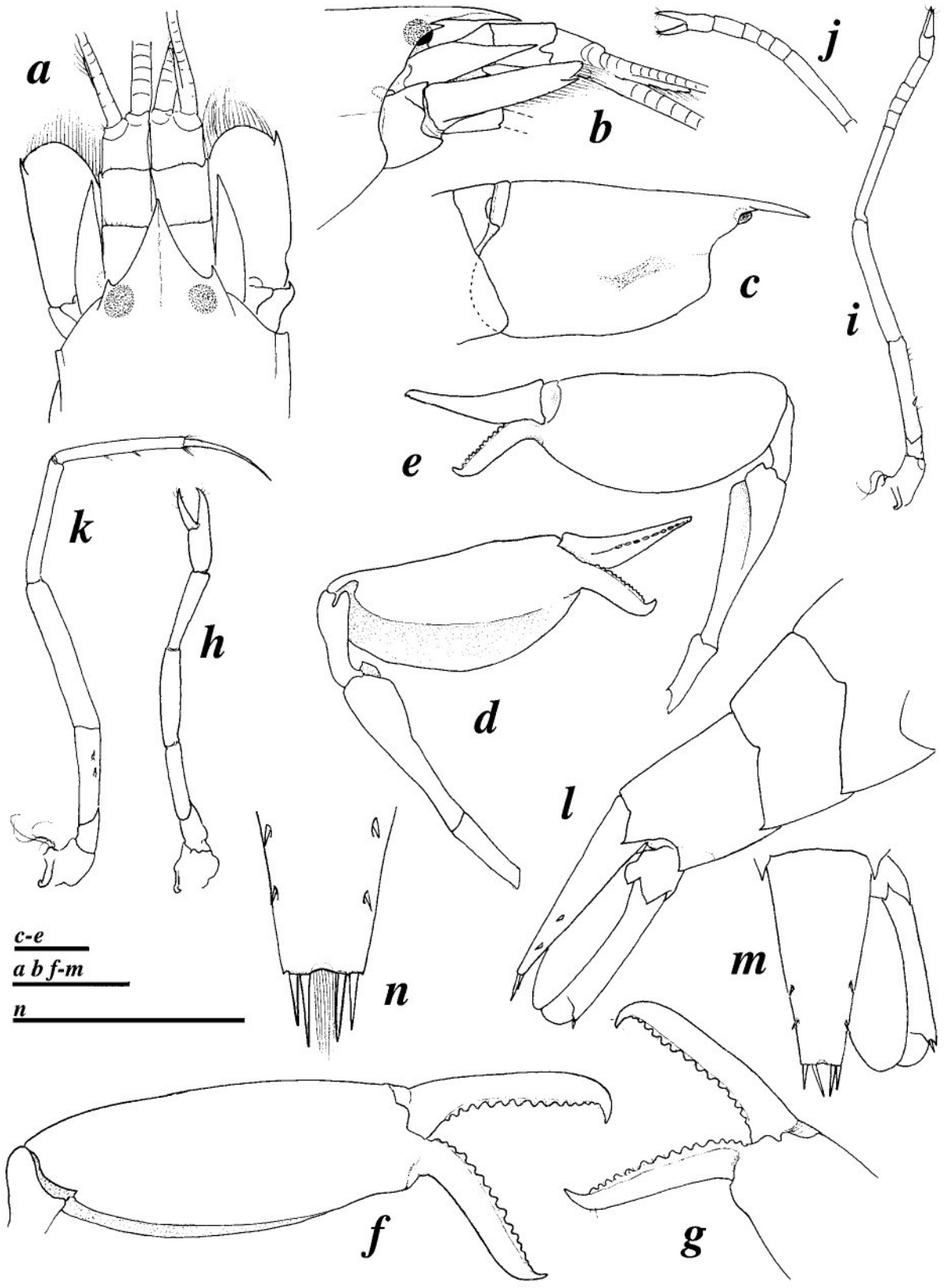

FIGURE 3. *Salmoneus carvachoi* **n. sp.**: paratype, non-ovigerous specimen (male?) from Guadeloupe, French Antilles (MNHN-Na 2669): a—frontal region, dorsal view; b—same, lateral view; c—carapace, lateral view; d—major cheliped, ventromesial view; e—same, lateral view; f—same, chela with opened fingers, mesial view; g—same, chela fingers (opened), lateral view; h—minor cheliped, lateral view; i—second pereiopod, lateral view; j—same, carpus and chela; k—third pereiopod, lateral view; l—posterior abdominal somites and tail fan, lateral view; m—telson and right uropod, dorsal view; n—telson, posterior half, dorsal view. Scale bars = 1 mm.

Fifth abdominal somite with acute posteroventral angle (Fig. 3l). Sixth abdominal somite without articulated plate, with acute posteroventral projection (Fig. 3l); preanal plate rounded. Second pleopod with appendix masculina subequal to appendix interna, furnished with slender spines on apex and along outer margin. Uropod with sinuous diaeresis and slender distolateral spiniform seta (Fig. 3m). Telson more than twice as long as wide proximally (Fig. 3m), tapering posteriorly, with two pairs of dorsal spiniform setae, inserted at about mid-length and 3/4 telson length, respectively (Fig. 3m); posterior margin with very shallow median notch and two pairs of spiniform setae at posterolateral angles, mesial setae distinctly longer than lateral setae (Fig. 3n). Gill/exopod formula typical for genus (see under *S. ortmanni*).

Colour: Unknown.

Size: Holotype: CL 4.1 mm, TL 13.1 mm; ovigerous female paratype: CL 4.9 mm, TL 14.6 mm, non-ovigerous paratype: CL 4.3 mm, TL 13.4 mm.

Etymology: The new species is named after Professor Alberto Carvacho (associated with the Museo Nacional de Historia Natural, Santiago de Chile), who collected most of the type specimens and published several studies dealing with alpheid and other caridean shrimps, including an important taxonomic note on *Salmoneus* (Carvacho, 1989).

Ecology: This species is probably confined to estuaries of brackish mangrove rivers and is able to tolerate low salinities (Carvacho, 1979; Christoffersen, 1982). In Mar de Cananéia and Baía do Trapandé (São Paulo), it was collected at depths of 0.3–1.2 m. The ovigerous specimen from Paraná was dredged from the mud bottom at 22 m (Christoffersen, 1982).

Type locality: Guadeloupe, French Antilles.

Distribution: Western Atlantic: French Antilles: Guadeloupe (Carvacho, 1979, as *S. ortmanni*; present study); Brazil: São Paulo, Paraná, possibly also Pernambuco and Sergipe (Coelho & Ramos, 1972, as *Salmoneus* sp.; Christoffersen, 1982, 1998, as *S. ortmanni*). The species reported as "*S.* aff. *ortmanni*" from southwestern Gulf of Mexico, from Veracruz to Yucatan (Hernández Aguilera et al., 1996) may also refer to *S. carvachoi* **n. sp.**, as well as part of Chace's (1972) material from the Caribbean.

Remarks: *Salmoneus carvachoi* **n. sp.** differs from *S. ortmanni* by the slightly concave lateral margins of the rostrum (vs. slightly convex in *S. ortmanni*, cf. Fig. 1b, 3a); the more slender walking legs (P3-5), with the P3 merus being six times as long as wide (vs. four in *S. ortmanni*), and with a much more elongate dactylus (cf. Fig. 1g, 3k); the P3 ischium armed with two spiniform setae (vs. one seta in S. *ortmanni*, cf. Fig. 1g, 3k); the presence of a small spiniform seta on the P2 ischium (absent in *S. ortmanni*, cf. Fig. 1f, 3i); the longer telson, bearing a less pronounced median notch on the posterior margin (cf. Fig. 1j, 3n); the more slender merus and chela of the major cheliped (cf. Fig. 2a–d, 3d–f); and the slightly higher number of teeth on the fingers of the major chela (13–14 in *S. carvachoi*, **n. sp.** vs. 10–12 in *S. ortmanni*, cf. Fig. 2e, 3f). The Brazilian specimens of *S. carvachoi* **n. sp.** (Christoffersen, 1982, as *S. ortmanni*) are morphologically similar to those from the Caribbean.

Salmoneus rocas n. sp.

Fig. 4

Material examined: Holotype: ovig. female, MNRJ 20216, Brazil, Atol das Rocas, east of Laguna Interna, in calcareous alga, depth 1 m, coll. F.B. Pitombo and R. Barroso, 18 Oct 2000 [dissected].

Description: Carapace not setose, with numerous minute pits (Fig. 4a–d). Rostrum much longer than broad; slightly overreaching distal margin of second segment of antennular peduncle (Fig. 4a, b); lateral margins slightly convace proximally; ventral margin unarmed (Fig. 4b, c); rostral carina distinct, reaching beyond eyes posteriorly (Fig. 4a). Orbital spines large, acute, slightly mesially directed (Fig. 4a). Pterygostomial margin slightly protruding anteriorly, broadly rounded (Fig. 4b–d). Eyes covered in dorsal view, visible in lateral

view (Fig. 4a–d). Antennule with stylocerite distinctly overreaching distal margin of second segment of antennular peduncle, with acute tip; second segment about 0.7 times as long as wide (Fig. 4a). Antenna with basicerite bearing subacute distoventral spine (Fig. 4b); scaphocerite ovate, distolateral spine small, subacute (Fig. 4a). Third maxilliped with rounded lateral plate; ultimate segment with tapering tip, without distinct spiniform setae (Fig. 4j). Chelipeds strongly asymmetrical in shape, unequal in size (Fig. 4k–m). Major cheliped (Fig. 4k, l) with unarmed ischium; merus not inflated distally, ventral surface somewhat depressed; carpus cup-shaped, ventrally not depressed, distally with rounded lobes (Fig. 4k); chela mostly smooth, subcylindrical, not depressed ventrally, not flattened mesially, with deep groove proximoventrally (Fig. 4k); fingers subequal to palm, cutting edges serrated, with 11 subtriangular-rounded teeth, distal teeth larger (Fig. 4l). Minor cheliped (Fig. 4m) with ischium subequal to merus, both unarmed; carpus slightly shorter than merus; chela small, simple, with fingers subequal to palm. Second pereiopod Fig. 4n) with unarmed ischium; carpus bearing five segments, first segment subequal to sum of other four segments. Third pereiopod (Fig. 4o, p) with ischium bearing one ventrolateral spiniform seta; merus about four times as long as wide; carpus distally with small ventral spiniform seta; propodus with four small ventral spiniform setae, including distal seta; dactylus simple, conical, moderately slender, less than half length of propodus. Fifth abdominal somite with subacute posteroventral angle (Fig. 4e). Sixth abdominal somite without distinct articulated plate, with acute posteroventral projection (Fig. 4e); preanal plate acutely produced towards telson (Fig. 4f). Second pleopod with appendix masculina shorter than appendix interna, furnished with slender spiniform setae on apex and along outer margin (Fig. 4h). Uropod with with sinuous diaersis and relatively stout distolateral spiniform seta (Fig. 4e). Telson about 1.7 times as long as wide proximally, tapering posteriorly, with two pairs of dorsal spines, inserted at about mid-length and 2/3 telson length, respectively (Fig. 4g); posterior margin with subtriangular median notch and two pairs of spiniform setae at posterolateral angles, mesial setae distinctly longer than lateral setae (Fig. 4g). Gill/exopod formula typical for genus (see under *S. ortmanni*).

Colour: Unknown.

Size: Holotype: CL 3.8 mm, TL 11.6 mm.

Etymology: The new species is named after the type locality, Atol das Rocas off the northeastern coast of Brazil.

Ecology: The holotype was found in a crust of calcareous algae, in 1 m deep water.

Type locality: Atol das Rocas, Brazil.

Distribution: Western Atlantic: presently known only from the type locality, Atol das Rocas.

Remarks: The new species appears to be related to *S. arubae* (Schmitt, 1936) from the western Atlantic; *S. teres* Manning & Chace, 1990, *S. setosus* Manning & Chace, 1990, both from the western and central Atlantic (see below); and *S. serratidigitus* (Coutière, 1896) from the Indo-Pacific. It can be separated from *S. arubae* and *S. teres* by the very different shape of the frontal margin of the carapace (cf. Schmitt, 1936: fig 2a; Manning & Chace, 1990: fig. 10b); from *S. arubae* by the presence of a posteromedian notch on the telson (absent in *S. arubae*; cf. Schmitt, 1936: fig. 2g); from *S. setosus* by the absence of conspicuous thickened setae on the carapace, abdomen and telson (a diagnostic feature of *S. setosus*; cf. Manning & Chace, 1990: fig. 9a, b; see also Fig. 6a, b); from *S. serratidigitus* by the ischium of the third pereiopod bearing one spiniform seta (vs. two or three setae in *S. serratidigitus*), and the subtriangular median notch on the posterior margin of the telson (vs. U-shaped in *S. serratidigitus*; cf. Banner & Banner, 1981: fig. 8). The present evidence suggests that *S. rocas* **n. sp.** is most closely related to *S. serratidigitus* from the Indo-Pacific and may represent the *S. serratidigitus* species complex in the western Atlantic.

The minute pits on the carapace are present in *S. rocas* **n. sp.**, but also in *S.* cf. *arubae* (cf. Holthuis, 1990) and *S. teres* (R. Lemaitre, pers. comm.; see also below), and may be an important taxonomic and phylogenetic character within the *S. serratidigutus* species group (Anker & Marin, 2006).

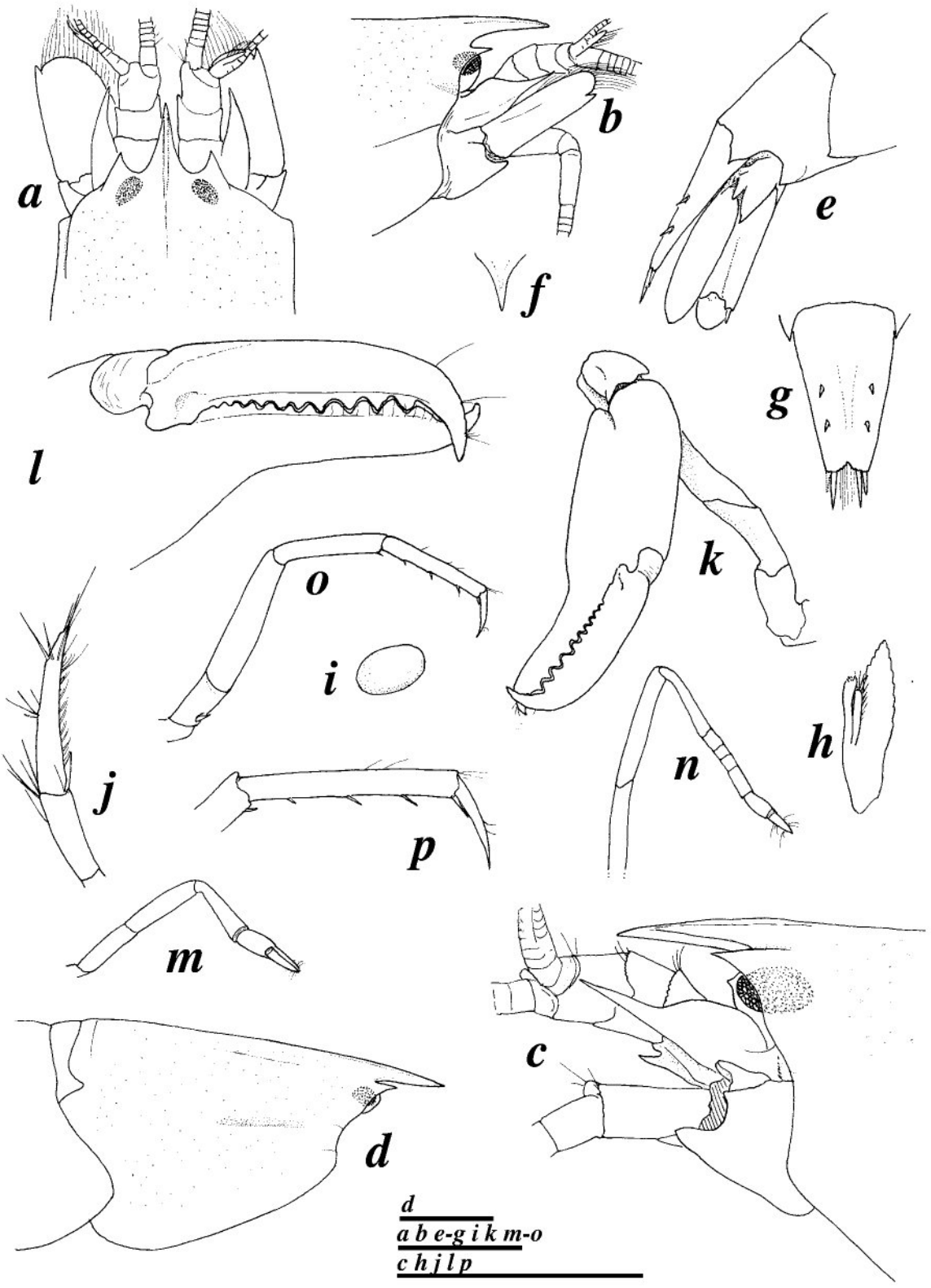

FIGURE 4. *Salmoneus rocas* **n. sp.**, holotype, ovigerous female from Atol das Rocas, Brazil (MNRJ 201216): a—frontal region, dorsal view; b—same, lateral view (right side); c—same, more detailed (left side); d—carapace, lateral view; e—posterior abdominal somites and tail fan, lateral view; f—preanal plate of sixth abdominal somite, ventral view; g—telson, dorsal view; h – endopod of second pleopod, mesial view; i —egg; j—penultimate and ultimate segments of third maxilliped, lateral view; k—major cheliped, "lateral" view; l—same, chela fingers; m—minor cheliped, lateral view; n—second pereiopod, lateral view; o—third pereiopod, lateral view. Scale bars = 1 mm.

Salmoneus teres Manning & Chace, 1990
Fig. 5, 8a

Salmoneus teres Manning & Chace, 1990: 20.

Material examined: 1 non-ovig. specimen (male?), MNHN-Na 13712, Guadeloupe, Grand Cul de Sac, under rock on sand-silt bottom, depth about 2 m, hand net, coll. F. Fasquel, Nov 1999.

Description: See Manning & Chace (1990).

Colour: Whitish, semitransparent, brownish inner organs partly visible through carapace (Fig. 8a).

Size: The Guadeloupe specimen has CL 4.4 mm, TL 13.1 mm, CL of the Ascension holotype was 2.8 mm (Manning & Chace, 1990).

Ecology: The single specimen was found under a rock on the silt-sand bottom, at a depth of about 2 m.

Type locality: Ascension Island.

Distribution: Central Atlantic: Ascension Island (Manning & Chace, 1990). Western Atlantic: Caribbean Sea: French Antilles: Guadeloupe (present study).

Remarks: The present specimen agrees in most features with the holotype of *S. teres* from Ascension Island (Manning & Chace, 1990), except for a few minor differences. According to Manning & Chace (1990), the rostrum is "without indication of median rostral carina", while in the present specimen there is a very slight carina extending to the level of corneas (Fig. 5a). The lateral margins of the rostrum are somewhat more convex in the holotype (cf. Manning & Chace, 1990: fig. 10b) compared to those of the Guadeloupe specimen (Fig. 5a). The carapace of the Guadeloupe specimen is distinctly pitted (Fig. 5a), however, these pits are also present in the type (R. Lemaitre, pers. comm.), although they were not illustrated and their presence was not mentioned by Manning & Chace (1990).

The finding of *S. teres* in Guadeloupe eliminates this species from the list of endemic decapods of Ascension Island (Manning & Chace, 1990), and represents a considerable range extension of *S. teres* from the central Atlantic (Ascension) to the western Atlantic (eastern Caribbean). Manning & Chace (1990) analyzed the faunal composition of the Ascension decapods and found that of 74 species known from this isolated central Atlantic island, 41 species (55 %) also occur in the western Atlantic. Therefore, more taxa that are currently believed to be endemic to Ascension may eventually be found in the western Atlantic (see also under *S. setosus*).

Salmoneus setosus Manning & Chace, 1990
Fig. 6

Salmoneus setosus Manning & Chace, 1990: 17.

Material examined: 2 ovig. females, MNRJ 17890, Brazil, Atol das Rocas, northeast part of atoll, between Barretão and Barretinha, Pedra de Tartaruga, in calcareous algae, depth 10 m, coll. F.B. Pitombo and R. Barroso, 24 Dec 2000 [1 specimen dissected]; 1 ovig. female, MNHN-Na 13626, Brazil, Fernando do Noronha, coll. Rallier du Baly, 1913.

Description: See Manning & Chace (1990).

Colour: Unknown.

Size: The larger of the two AR specimens has CL 3.1 mm, TL 8.7 mm; the specimen from Fernando do Noronha has CL 3.7 mm, TL 10.2 mm. CL of the Ascension specimens ranged from 1.2 to 2.0 mm (Manning & Chace, 1990).

Ecology: The specimens from Atol das Rocas were extracted from crevices in calcareous algae that were collected at a depth of 10 m. The type series from Ascension Island was collected in tide pools (probably under rocks or among calcareous algae).

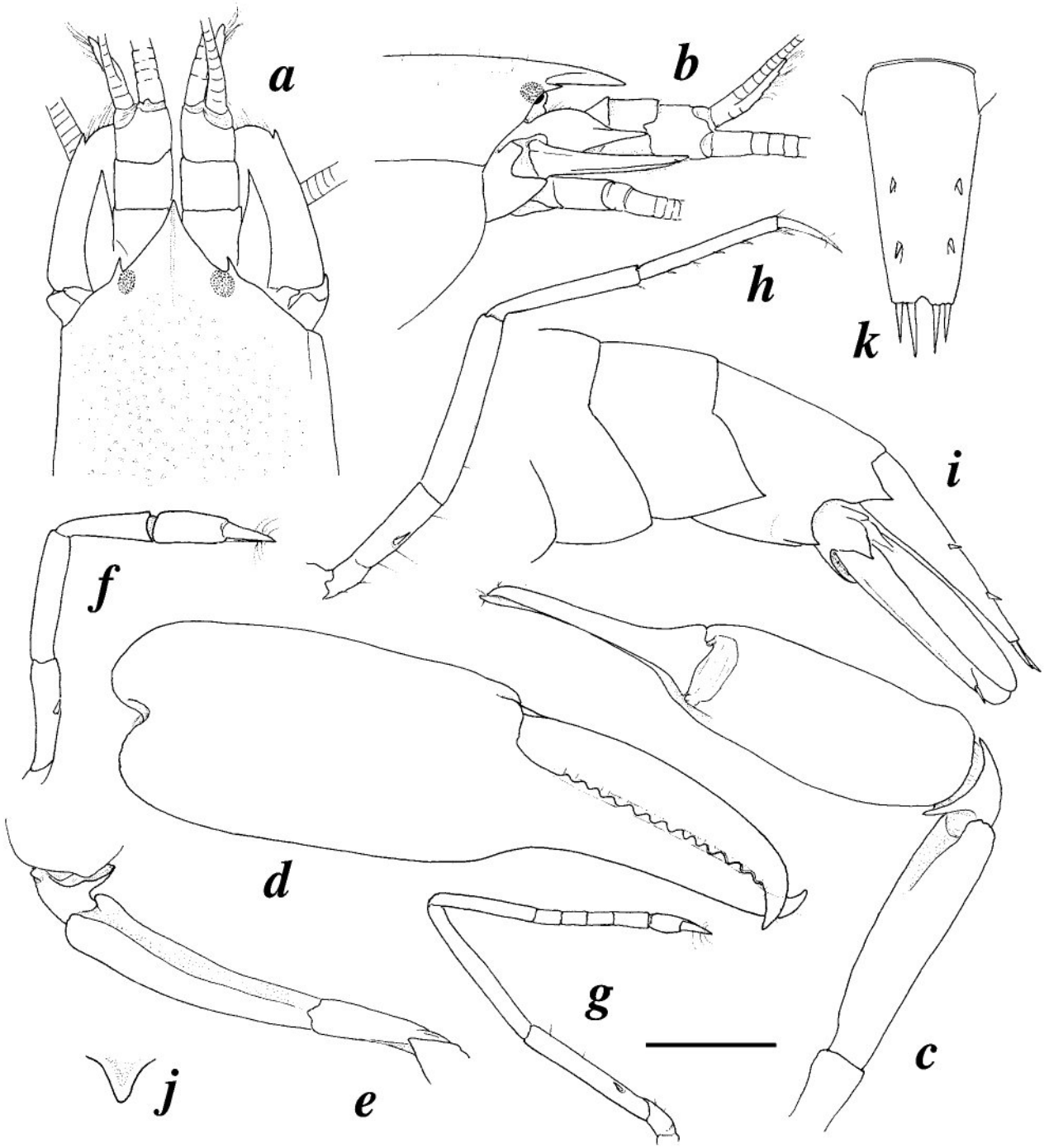

FIGURE 5. *Salmoneus teres* Manning & Chace, 1990: non-ovigerous specimen (male?) from Guadeloupe, French Antilles (MNHN-Na 13712): a—frontal region, dorsal view; b—same, lateral view; c—major cheliped, lateral view; d—same, chela, mesial view; e—same, ischium to carpus, mesial view; f—minor cheliped, lateral view; g—second pereiopod, lateral view; h—third pereiopod, lateral view; i—posterior abdominal somites and tail fan, lateral view; j—preanal plate of sixth abdominal somite, ventral view; k—telson, dorsal view. Scale bar = 1 mm.

Type locality: Ascension Island.

Distribution: Central Atlantic: Ascension Island (Manning & Chace, 1990). Western Atlantic: Brazil: Atol das Rocas and Fernando do Noronha (present study).

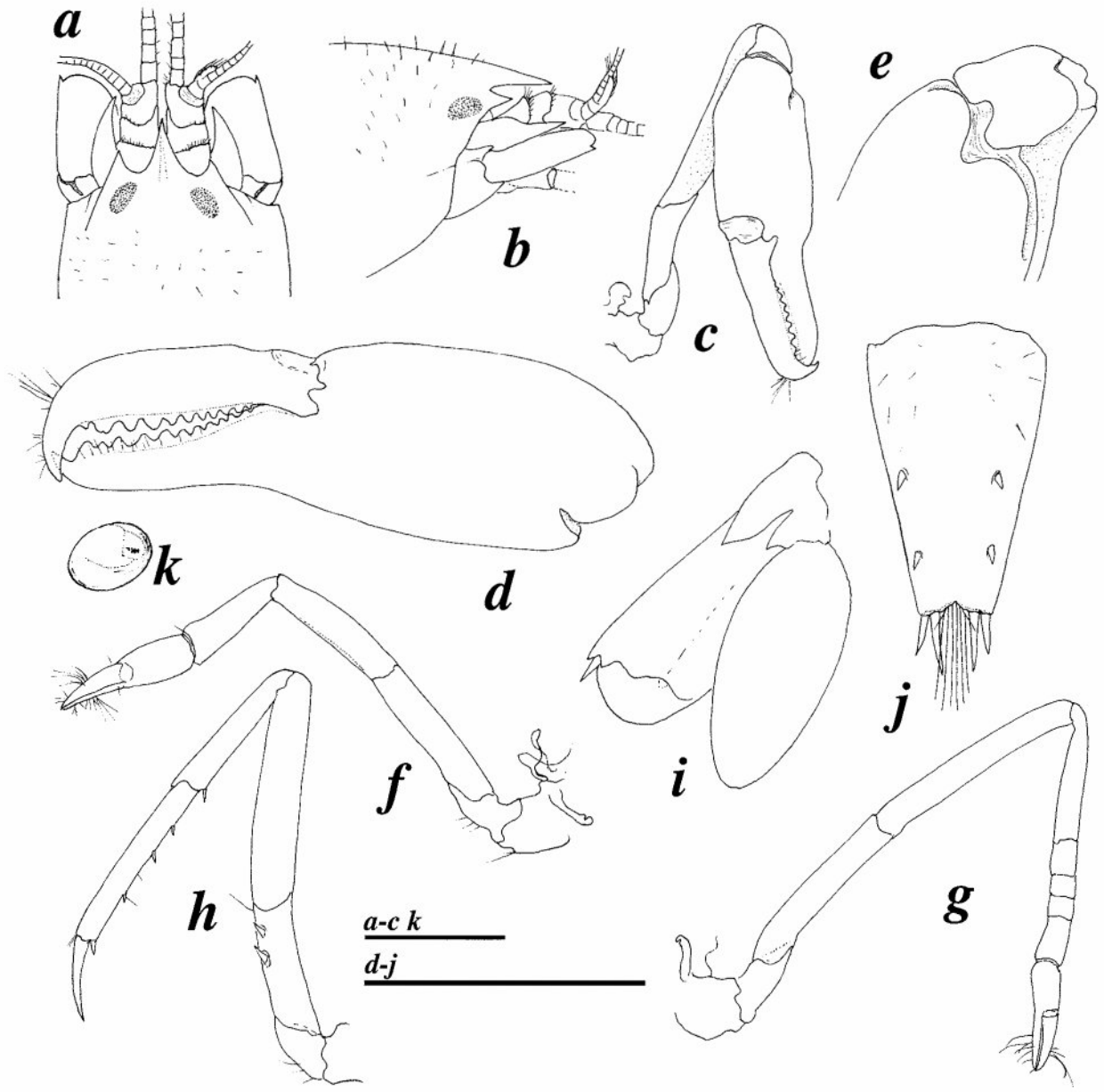

FIGURE 6. *Salmoneus setosus* Manning & Chace, 1990: ovigerous female from Atol das Rocas, Brazil (MNRJ 17890): a—frontal region, dorsal view; b—same, lateral view; c—major cheliped, lateral view; d—same, chela, mesial view; e—same, detail of carpus, mesial view; f—minor cheliped, lateral view; g— second pereiopod, lateral view; h—third pereiopod, lateral view; i—uropod, dorsal view, dorsal view; j—telson, dorsal view; k—egg. Scale bars = 1 mm.

Genus *Parabetaeus* Coutière, 1896

Synonym: *Neoalpheopsis* Banner, 1953

Parabetaeus hummelincki (Schmitt, 1936)

Fig. 7, 8b, c

Alpheopsis hummelincki Schmitt, 1936: 364.
Neoalpheopsis euryone – Manning & Chace, 1990: 17.

Neoalpheopsis hummelincki – Chace, 1972: 78; Rodríguez, 1980: 137.
Neoalpheopsis sp. –Rodríguez, 1986: 176.

Material examined: 1 ovig. female, MNRJ 20217, Brazil, Atol das Rocas, near Barretão, in tide pools and nodules of calcareous algae, coll. P.S. Young, P.C. Paiva and A.A. Aguiar, 27 Aug 2000 [specimen dissected]; 1 ovig. female (with missing chelipeds), USNM 310832, Brazil, off Vitória, Trindade, between Baixa do Sueste and Parcel das Tartarugas, 20°30'S, 29°20'W, in tide pool, rotenone, depth 1–2 m, collector unknown, 16 Jan 1976; 1 male, holotype of *Alpheopsis hummelincki*, USNM 67395, Bonaire, Kralendijk, under sandy coral debris, coll. P. Hummelinck, 6 Nov 1930; 1 female, MNHN-Na 16391, Dominican Republic, Bayahibe, from coral rocks, depth 1–2 m, coll. A. Anker, 2–3 Jan 2005; 1 male, USNM 256789, Ascension Island, McArthur Point, poisoned isolated tide pool, coll. R.B. Manning et al., 15 Jul 1976.

Comparative material: *Parabetaeus* cf. *euryone* (De Man, 1910): 1 female, USNM 216068, Galapagos, Isla Isabela, Bahía Cartago, R/V Velero III, 13 Feb 1933. *Parabetaeus euryone*: 1 female, MNHN-Na 13633, parasitized by rhizocephalan (*Thompsonia* sp. ?), Japan, Ryukyu Archipelago, Kerama group, Yakabi-jima, depth 10 m, coll. K. Nomura, 24 Apr 1994; 1 female, QM W-21828, Hawaii, Oahu, coll. R. Holcom, no further data, det. A. J. Bruce, 26 Oct 1996.

Description: See Schmitt (1936, as *Alpheopsis hummelincki*).

Colour: The young female from the DR (Fig. 8b) had pale red bands across the abdomen and was generally very similar to the ovigerous female from Bermuda (Fig. 8c). The obviously larger ovigerous female photographed *in situ* off St. Vincent had a more intense red banding and bright yellow eggs (Fig. 8d).

Size: The largest western Atlantic specimen examined is the ovigerous female from AR, with CL 6.9 mm, TL 22.0 mm.

Ecology: Coarse sand, sand/rubble and reef bottoms, from the lower intertidal to probably at least 10 m, under rubble and rocks, occasionally also in empty *Strombus* shells (Rodríguez, 1986). The AR specimen was found in a tide pool, among nodules of calcareous algae, whereas the DR specimen was extracted from a crevice of a coral rock collected at about 1–2 m.

Behaviour: *Parabetaeus* species may carry chelipeds either extended forward (Fig. 8c), like species of the presumably related genus *Alpheopsis* Coutière, 1896, or folded beneath the body (Fig. 8d).

Type locality: Bonaire, Netherlands Antilles.

Distribution: Western Atlantic: Bermuda (present study), southern Caribbean: Netherlands Antilles (Schmitt, 1936), Venezuela: Los Roques (Rodríguez, 1986); St. Vincent; Dominican Republic (present study); Brazil: Atol das Rocas and Trindade (present study). Central Atlantic: Ascension Island (Manning & Chace, 1990).

Remarks: Banner and Banner (1985) placed the western Atlantic *Alpheopsis hummelincki* Schmitt, 1936 (now *Parabetaeus hummelincki*) and the Hawaiian *Neoalpheopsis hiatti* Banner, 1953 (now *Parabetaeus hiatti*) in synonymy of the presumably pantropical *Neoalpheopsis euryone* De Man, 1910 (now *Parabetaeus euryone*), originally described from Indonesia. Nomura & Anker (2001) pointed out that the taxonomic status and synonymy of these two nominal species remain questionable. There appears to be some variation in the shape of the frontal margin (orbital spines, rostrum); the proportions of the telson and pereiopods; the development of the posteromedian triangular piece on the telson; the degree of asymmetry of the chelipeds; the dentition on the cheliped fingers; and some other features, all suggesting that there may be more than one variable pantropical species. Therefore, *P. hummelincki* and *P. hiatti* should be treated as valid species, awaiting a combined morphological/molecular revision of the entire *P. euryone* complex.

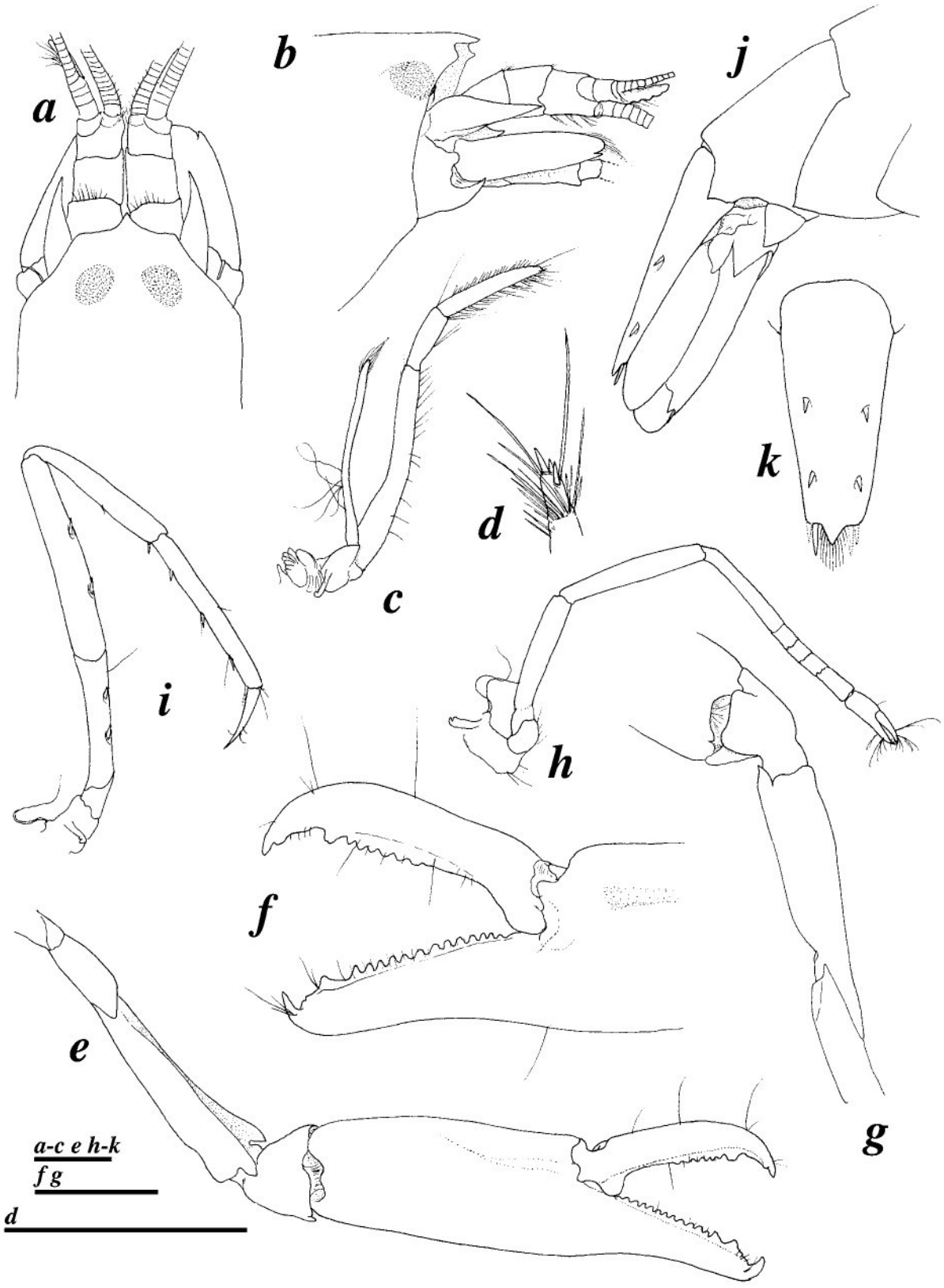

FIGURE 7. *Parabetaeus hummelincki* (Schmitt, 1936), ovigerous female from Atol das Rocas, Brazil (MNRJ 20217): a—frontal region, dorsal view; b—same, lateral view; c—third maxilliped, lateral view; d—same, tip of ultimate segment; e—right cheliped, lateral view; f—same, chela fingers, mesial view; g—same, ischium to carpus, dorsal view; h—second pereiopod, lateral view; i—third pereiopod, lateral view; j—posterior abdominal somites and tail fan, lateral view; k—telson, dorsal view. Scale bars = 1 mm.

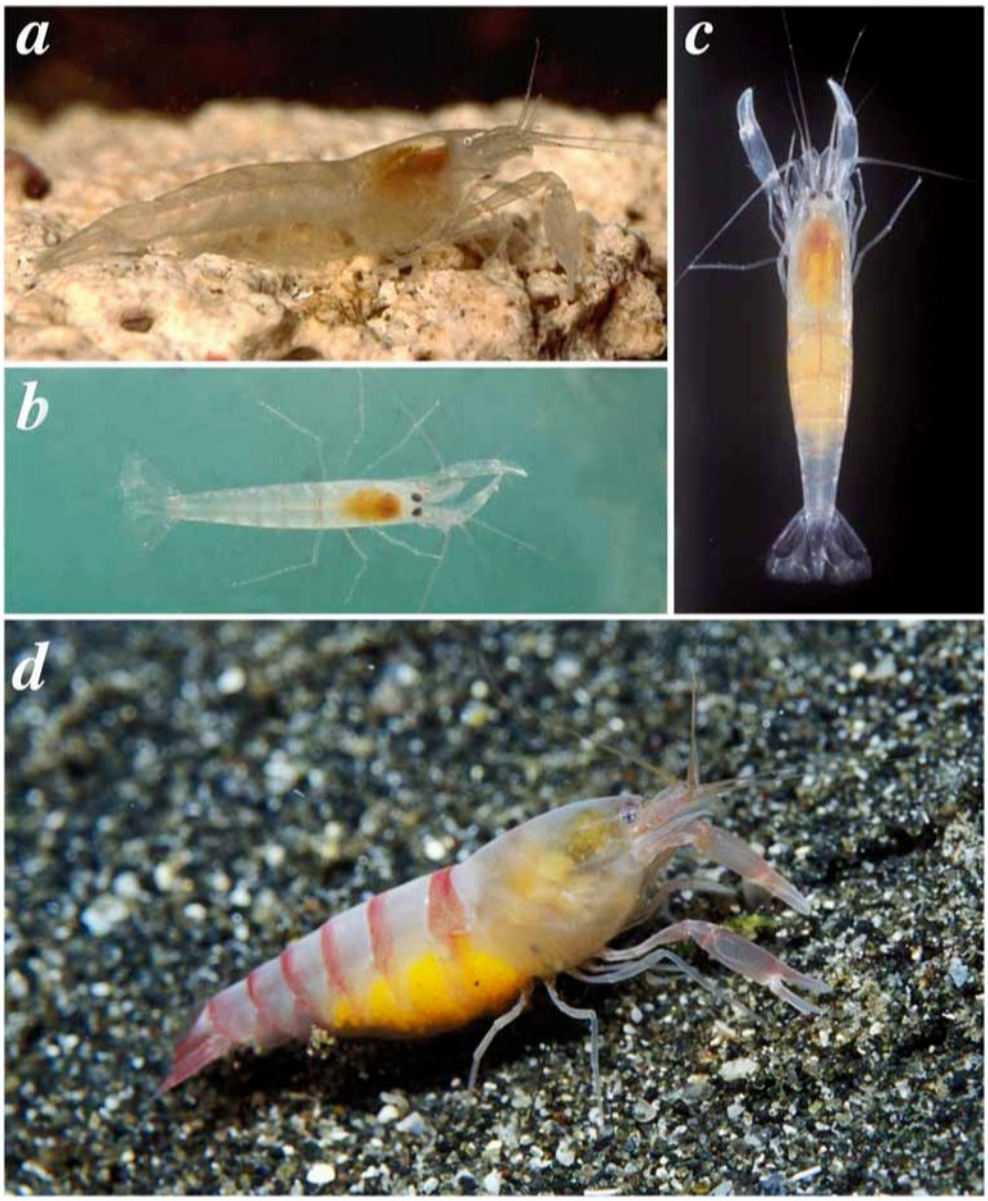

FIGURE 8. Habitus and colour patterns: a—*Salmoneus teres* Manning & Chace, 1990, non-ovigerous specimen (male?) from Guadeloupe (MNHN-Na 13712) (photograph by Frédéric Fasquel); b–d—*Parabetaeus hummelincki* (Schmitt, 1936): b—young female from Bayahibe, Dominican Republic (MNHN-Na 16391); c—ovigerous female from Bermuda (specimen in BAMZ [not examined], photograph by Wolfgang Sterrer); d—ovigerous female from St. Vincent, photographed *in situ* at a depth of about 8 m; specimen not collected (photograph by Andrew J. Martinez).

Acknowledgments

I am grateful to Paulo Young (late of MNRJ) and his collaborators for collecting the AR material and making it available for study. Mnica Moura (MNRJ/UFRJ) and Régis Cleva (MNHN) provided MNRJ and MNHN catalogue numbers, respectively. Frédéric Fasquel (Paris, France), Wolfgang Sterrer (BAMZ) and Andrew J. Martinez (Wenham, MA, USA) provided colour photographs. The taxonomic research on alpheid shrimps was supported by A. Richard Palmer (University of Alberta, Edmonton, Canada) from the NSERC operating grant A7245, Nancy Knowlton (Scripps Institution of Oceanography, La Jolla, CA, USA), and the Smithsonian Tropical Research Institute (STRI) in Panama City, Republic of Panama.

Literature

Anker, A. & Marin, I. (2006). New records and species of Alpheidae (Crustacea, Decapoda) from Vietnam. Part I. Genus *Salmoneus* Holthuis, 1955. *Raffles Bulletin of Zoology*, 54, 295–319.

Banner, D.M. & Banner, A.H. (1973) The alpheid shrimp of Australia, part I: the lower genera. *Records of the Australian Museum*, 28, 291–382.

Banner, D.M. & Banner, A.H. (1981) Annotated checklist of the alpheid shrimp of the Red Sea and Gulf of Aden. *Zoologische Verhandelingen, Leiden*, 190, 1–99.

Banner, D.M. & Banner, A.H. (1985) The alpheid shrimp of Indonesia, based upon J.G. de Man's "The Decapoda of the Siboga Expedition, Part II: Family Alpheidae" (1911). *Marine Research in Indonesia*, 25, 1–79.

Carvacho, A. (1979) Les crevettes carides de la mangrove guadeloupéenne. *Bulletin du Muséum National d'Histoire Naturelle*, serie 4, 1, section A, 2, 445–470.

Carvacho, A. (1989) Sur l'appendix masculina chez *Salmoneus* (Decapoda, Crustacea). *Crustaceana*, 57, 253–256.

Carvacho, A. & Ríos, R. (1983) Los camarones carídeos del Golfo de California. II. Catálogo, claves de identificación y discución biogeográphica. *Anales del Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónonoma de México*, 9, 279–294.

Chace, F.A. Jr. (1972) The shrimps of the Smithsonian-Bredin Caribbean expeditions with a summary of the West Indian shallow-water species (Crustacea Decapoda: Natantia). *Smithsonian Contributions to Zoology*, 98, i–x + 1–179.

Chace, F.A. Jr. (1988) The caridean shrimps (Crustacea: Decapoda) of the Albatross Philippine Expedition, 1907–1910, part 5: Family Alpheidae. *Smithsonian Contributions to Zoology*, 466, i–v + 1–99.

Christoffersen, M.L.(1980) Taxonomia e distribuição geográfica dos Alpheoidea (Crustacea, Decapoda, Natantia) do Brasil, Uruguay e norte da Argentina, incluindo considerações sobre a divisão do sul do continente em províncias biogeográficas marinhas. PhD Thesis, Universidade do São Paulo, São Paulo. 467 pp.

Christoffersen, M.L. (1982) Distribution of warm water alpheoid shrimp (Crustacea, Caridea) on the continental shelf of eastern South America between 23 and 35° lat. S. *Boletim do Instituto Oceanográfico, São Paulo*, 31, 93–112.

Christoffersen, M.L. (1998) Malacostraca. Eucarida. Caridea, Crangonoidea and Alpheoidea (except Glyphocrangonidae and Crangonidae). In: Young, P.S. (ed.), Catalogue of Crustacea of Brazil. pp. 351–372. Museu Nacional, Rio de Janeiro, 717 pp.

Christoffersen, M.L. & Ramos, G.E. (1988) A new species of *Alpheus* (Caridea, Alpheidae) from the Pacific coast of Colombia. *Revista Nordestina de Biologia*, 6, 61–65.

Coelho, P.A. & Ramos, M.A. (1972) A constituição e a distribuição da fauna de decápodos do litoral este da America do Sul entre as latitudes de 5°N e 39°S. *Trabalhos Oceanograficos da Universidade Federal de Pernambuco, Recife*, 13, 133–236.

Coelho dos Santos, M.A. & Coelho, P.A. (2001) Crustacea Decapoda of the Paripe River estuary, Pernambuco, Brazil. *Hydrobiologia*, 449, 77–79.

Coutière, H. (1900) Sur quelques Alpheidae des côtes américaines. (Collection de l'United States National Museum Washington). *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences*, 131, 356–358.

Felder, D.L. & Manning, R.B. (1986) A new genus and two new species of alpheid shrimps (Decapoda: Caridea) from South Florida. *Journal of Crustacean Biology*, 6, 497–508.

Hernández Aguilera, J.L., Toral Almazán, R.E. & Ruiz Nuño, J.A. (1996) Especies catalogadas de crustáceos estomatópodos y decápodos para el Golfo de México, Río Bravo, Tamps. a Progreso, Yuc. Dirección de Oceanografía, Dirección General de Oceanografía Naval, Secretaría de Marina, México, i–xiii, 1–132.

Holthuis, L.B. (1990) Notes on *Salmoneus arubae* (Schmitt, 1936) (Crustacea, Decapoda, Caridea). *Beaufortia*, 41, 109–113.

Kensley, B.F. (1988) New species and records of cave shrimps from the Yucatan Peninsula (Decapoda: Agostocarididae and Hippolytidae) *Journal of Crustacean Biology*, 8, 688–699.

Manning, R.B. & Chace, F.A. Jr. (1990) Decapod and stomatopod Crustacea from Ascension Island, South Atlantic Ocean. *Smithsonian Contributions to Zoology*, 503, i–v, 1–91.

Martínez-Iglesias, J.C., Carvacho, A. & Ríos, R. (1996) Catálogo de los carídeos marinos (Crustacea, Decapoda, Caridea) de las aguas someras de Cuba. *Avicennia*, 4/5, 27–40.

Nomura, K. & Anker, A. (2001) Redescription of *Parabetaeus cullierei* Coutière and status of the genus *Neoalpheopsis* Banner (Decapoda: Caridea: Alpheidae). *Crustacean Research*, 30, 43–54.

Rankin, W.M. (1898) The Northrop collection of Crustacea from the Bahamas. *Annals of the New York Academy of Sciences*, 11, 225–258.

Ríos R.G. (1989) Un catálogo de camarones carídeos de Mulegé y Bahía Concepción, B.C.S. con anotaciones acerca de su biología, ecología, distribución geográfica y taxonomía. Tesis, Ensenada, B.C., México. 208 pp.

Ríos, R. (1992) Camarones carídeos del Golfo de California. VI. Alpheidae del estuario de Mulegé y de Bahía Concepcion, Baja California Sur, México (Crustacea: Caridea). *Proceedings of San Diego Society of Natural History*, 14, 1–13.

Ríos, R. & Carvacho, A. (1983) Caridean shrimps of the Gulf of California. I. New records, with some remarks on amphi-American distribution. *Pacific Science*, 36, 459–465.

Rodríguez, B. (1986) Los camarones (Crustacea; Decapoda; Natantia) del Parque Nacional Archipiélago de los Roques. Trabajo especial de grado para optar al título de Licenciado en Biología, Universidad Central de Venezuela, Caracas, 350 pp.

Rodríguez, G. (1980) Crustáceos decápodos de Venezuela. Instituto Venezolano de Investigaciones Cientificas, Caracas, 494 pp.

Schmitt, W.L. (1936) Macruran and anomuran Crustacea from Bonaire, Curaçao and Aruba. Zoologische Ergebnisse einer Reise nach Bonaire, Curaçao und Aruba im Jahre 1930. Number 16. *Zoologische Jahrbücher, Abteilung für Systematik, Oekologie und Geographie der Tiere*, 67, 363–378, pls. 11–13.

Verrill, A.E. (1900) Additions to the Crustacea & Pycnogonida of the Bermudas. *Transactions of the Connecticut Academy of Arts and Sciences*, 10, 573–582.

Verrill, A.E. (1922) Decapod Crustacea of Bermuda. Part II. Macrura. *Transactions of the Connecticut Academy of Arts and Sciences*, 26, 1–179, pls. 1–48.

Villalobos, J.L. (2000) Estudio monográfico de los crustáceos decápodos no braquiuros de la zona intermareal de las islas del Golfo de California, México. Tesis de Maestría, Ciencias (Biología). Universidad Nacional Autónoma de México, México, 312 pp.

Villalobos Hiriart, J.L., Nates-Rodríguez, J.C., Cantu Díaz-Barriga, A., Valle Martínez, M.D., Flores Hernández, P., Lira Fernandez, E. & Schmidtsdorf-Valencia, P. (1989) Listados faunísticos de México. I. Crustáceos estomatópodos y decápodos intermareales de las islas del Golfo de California. Instituto de Biología, Universidad Nacional Autónoma de México, México, i–ix + 1–101.

Watling, L. (1989) A classification system for crustacean setae based on the homology concept. In: Felgenhauer, B.E., Watling, L. & Thistle, A.B. (eds.), Functional morphology of feeding and grooming in Crustacea. *Crustacean Issues*, 6, 15–26.

Wicksten, M.K. (1993) Caridean and stenopodid shrimp of the Galapagos Islands. In: James, M.J. (ed.), Galapagos marine invertebrates, chapter 6, pp. 147–156. Plenum, New York.

Wicksten, M.K. & Hendrickx, M.E. (1992) Checklist of penaeoid and caridean shrimps (Decapoda: Penaeoidea, Caridea) from the eastern tropical Pacific. *Proceedings of San Diego Society of Natural History*, 9, 1–11.

Wicksten, M.K. & Hendrickx, M.E. (2003) An updated checklist of benthic marine and brackish water shrimps (Decapoda: Penaeoidea, Stenopodidea, Caridea) from the eastern tropical Pacific. In: Hendrickx, M.E. (ed.), Contribuciónes al estudio de los crustáceos del Pacifico Este, pp. 49–76. Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, México.