

A new genus and three new species of alpheids (Decapoda: Caridea) associated with thalassinids

P.C. Dworschak¹, A. Anker² & D. Abed-Navandi³

Abstract

Sampling for infaunal decapods on a sublittoral sandy bottom in the Adriatic Sea and on a tidal flat at the Cape Verde Islands has yielded several members of the family Alpheidae, three of which were new species. A new genus near *Salmoneus* HOLTHUIS, 1955 and *Leptalpheus* WILLIAMS, 1965 is erected for *Deioneus sandizelli* gen.n. sp.n., based on two specimens, one collected from the burrow of the thalassinid *Neocallichirus pachydactylus* (A. MILNE-EDWARDS, 1870), the other from a *Corallianassa intesi* (DE SAINT LAURENT & LE LOEUFF, 1979) burrow. A single specimen of *Salmoneus caboverdensis* sp.n. was obtained from the burrow of *N. pachydactylus* at the same locality. *Salmoneus erasimorum* sp.n. is described from a single specimen collected from a burrow of *Callianassa tyrrhena* (PETAGNA, 1792) in Volosko, northern Adriatic Sea.

Key words: Alpheidae, *Deioneus*, new genus, *Salmoneus*, new species, Adriatic Sea, Cape Verde Islands, Thalassinidea, association

Zusammenfassung

Beim Aufsammeln grabender Krebse auf einem sublittoralen Sandboden in der Adria und auf Gezeitenwatten auf den Kapverden wurden einige Vertreter der Familie Alpheidae gefangen. Drei erwiesen sich als neue Arten. Für eine, die in jeweils einem Exemplar aus den Bauten der Maulwurfskrebse *Neocallichirus pachydactylus* (A. MILNE-EDWARDS, 1870) und *Corallianassa intesi* (DE SAINT LAURENT & LE LOEUFF, 1979) erbeutet wurde, wird eine neue Gattung errichtet. Diese ist nah verwandt zu *Salmoneus* HOLTHUIS, 1955 und *Leptalpheus* WILLIAMS, 1965. Ebenfalls im Bau von *N. pachydactylus* lebt *Salmoneus caboverdensis* sp.n. *Salmoneus erasimorum* sp.n. wird anhand eines Exemplars aus der Adria beschrieben, wo sie gemeinsam mit dem Thalassiniden *Callianassa tyrrhena* (PETAGNA, 1792) gefangen wurde.

Introduction

Thalassinidean burrows repeatedly prove to be a source of scientific innovation and information. They either yield new insights into the architects' biology (NICKELL & ATKINSON 1995, ASTALL & al. 1997, NICKELL & al. 1998, STAMHUIS & al. 1996, 1997, 1998a, b, PINN & al. 1998, 1999) or they act as habitats for numerous commensal macrofauna. Fish, bivalves, polychaetes and crustaceans are frequent symbionts in the burrows (PEARSE & al. 1942, POHL 1946, MACGINITIE 1934, PETERSON 1977, 1979,

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SWINBANKS & MURRAY 1981, HOFFMAN 1981, LAWRY 1987, ALVES & PEZZUTO 1998). Among the crustaceans, alpheid shrimp feature prominently as associates of thalassinideans (COUTIÈRE 1899, HART 1964, WILLIAMS 1965, SALOMAN 1974, DAWSON 1967, RÍOS & CARVACHO 1983, RÍOS 1992, FELDER & RODRIGUES 1993, CAMPOS & al. 1995, FELDER & MANNING 1997, HAYASHI 1998, DWORSCHAK & COELHO 1999).

Faunistic surveys for shallow-water thalassinideans in the Adriatic Sea and in the Cape Verde Islands revealed three new alpheid species, one of which represents a new genus. *Salmoneus erasimorum* sp.n. was caught during a survey of populations of *Callianassa tyrrhena* (PETAGNA, 1792) and *Necallianassa truncata* (GIARD & BONNIER, 1890) in the Kvarner region of the northern Adriatic Sea. *Salmoneus caboverdensis* sp.n. and *Deioneus sandizelli* gen.n. sp.n. were collected on Ilha do São Tiago of the Cape Verde Islands in burrows of *Corallianassa intesi* (DE SAINT LAURENT & LEOUEFF, 1979) and *Neocallichirus pachydactylus* (A. MILNE-EDWARDS, 1870).

Abbreviations

AN:	Acquisition Number	RMNH:	Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands
CL:	carapace length	USNM:	National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.
TL:	total length		
NHMW:	Naturhistorisches Museum in Wien, Austria		

Material and Methods

The sampling site in the northern Adriatic is situated on the east coast of the Istrian Peninsula, at Opatja, Croatia, (45°20'N, 14°18'E) in front of the Hotel Ambassador. The water depth here is between 1 and 3 m and the bottom consists of very fine sand. Nearshore, the sediment is inhabited by *Callianassa tyrrhena* (PETAGNA, 1792), while the deeper bottom is dominated by *Necallianassa truncata* (GIARD & BONNIER, 1890).

The sampling site at the Cape Verde Islands is situated on the east coast of Ilha do São Tiago north of the village Moia Moia (15°02'40"N, 23°27'30"W). Here, in a very protected bay an extensive tidal flat consisting of black fine sand of volcanic origin is exposed during low tides.

A yabby pump (MANNING 1975) was used to retrieve shrimps from their burrows. Animals were fixed in 4% buffered seawater-formaldehyde and later transferred into 70% ethanol. The specimens were examined and illustrated with the aid of a dissecting microscope (Nikon SMZ-10A) equipped with a camera lucida. Prior to the dissection the specimens were coloured with Chlorazole Black E (Sigma Aldrich, CAS-Nr. 1937-37-7).

Results

Deioneus gen.n.

Diagnosis: Carapace not particularly compressed, smooth. Rostrum and extra-corneal teeth present. Eyes concealed in dorsal view, but partially visible in lateral view. Ptery-

gostomial angle rounded. Antennular peduncles stout, antennular carina small, outer flagellum biramous. Carpocerite short and stout, not reaching anterior margin of scaphocerite. Mouthparts as usual in family, mandible with two-segmented palp. Ultimate segment of third maxilliped distally armed with small spines; coxa with lateral plate acutely produced. First pereopods asymmetrical; major cheliped more robust, but shorter than minor cheliped, both carried flexed against merus; carpus cup-shaped; palm with shallow ventral excavation; cutting edge of major chela with one prominent tooth on fixed finger and smaller acute teeth on proximal portion; cutting edges of minor chela with saw-like teeth; snapping mechanism, adhesive discs and linea impressa absent. Second pereopod with 5-segmented carpus. Third pereopod with ischium unarmed; dactylus simple. Sixth abdominal segment with articulated plate. Uropodal exopod with well-developed lateral spine and diaresis. Telson with two pairs of dorsal spines; posterior margin straight, with two pairs of lateral spines; anal tubercles absent.

Branchial formula as follows (* present, complete number uncertain):

	maxilliped			pereopod				
	1	2	3	1	2	3	4	5
pleurobranchs	-	-	-	1	1	1	1	1
arthrobranchs	-	-	1	-	-	-	-	-
podobranchs	-	-	-	-	-	-	-	-
lobiform epipods	1	1	-	-	-	-	-	-
strap-like epipods (mastigobranchs)	-	-	1	1	1	1	1	-
setobranchs	-	-	-	*	*	*	*	*
exopods	1	1	1	-	-	-	-	-

Type species: *Deioneus sandizelli* sp.n.

Etymology: In Greek mythology Deioneus is a brother of Salmoneus (both are sons of Aiolos and Enarete); the name is given to show the close relationship with *Salmoneus* HOLTHUIS, 1955. Gender: masculine.

Remarks: The new genus shows some affinities with *Salmoneus* HOLTHUIS, 1955 and *Leptalpheus* WILLIAMS, 1965. The first genus presently includes 18 species distributed in shallow waters of warm temperate and tropical seas. *Salmoneus* can be distinguished from *Deioneus* by the following features: (1) absence of articulated flap at postero-lateral angle of sixth abdominal segment, (2) absence of prominent tooth on fixed finger of major first pereopod, (3) lateral plate of third maxilliped rounded, not acutely produced, and (4) presence of an appendix masculina in females.

The shape of the lateral plate on the third maxilliped is never used as a diagnostic character for the genera of Alpheididae, and *Salmoneus* is not an exception (BANNER & BANNER 1981: 48-49). However, the shape of this plate seems to be remarkably constant in all species of *Salmoneus*, at least in all specimens personally examined by one of us (A.A.): *S. rostratus* BARNARD, 1962, *S. hilarulus* DE MAN, 1910, *S. serratidigitus* COUTIÈRE, 1897, *S. arubae* SCHMITT, 1936, *S. tricristatus* BANNER, 1959, and in species for which good figures of the third maxilliped have been published: *Salmoneus cavicolus* FELDER & MANNING, 1986, *S. teres* MANNING & CHACE, 1990, *S. setosus* MANNING & CHACE, 1990, *S. sketi* FRANSEN, 1992, *S. jarli* HOLTHUIS, 1951, and *S. ortmanni* RANKIN,

1898 (FELDER & MANNING 1986, MANNING & CHACE 1990, FRANSEN 1992, HOLTHUIS 1951, CHRISTOFFERSEN 1982).

CARVACHO (1989) examined several species of *Salmoneus* in the collections of the Muséum National d'Histoire Naturelle in Paris, and found that in all specimens, including ovigerous females, the appendix masculina was present. He concluded that in this genus the presence of an appendix masculina does not indicate the sex of specimens. In the holotype of *Deioneus* - which is an ovigerous female - as well as in the paratype, the second pleopod has only an appendix interna and no appendix masculina. We assume that the appendix masculina would be present in males of *Deioneus*.

The presence or absence of an articulated flap on the last abdominal segment is generally an important diagnostic feature, although in some exceptionally rare cases (*Nennalpheus* BANNER & BANNER, 1981) two situations can occur. In having this articulated flap and the acutely produced lateral plate of the third maxilliped, *Deioneus* is more distant from *Salmoneus* and approaches *Leptalpheus*, whose members exclusively inhabit burrows of various Thalassinidea. All species of *Leptalpheus* have an unusually elongated, acute lateral plate and a well-developed arthrobranch on the third maxilliped (WILLIAMS 1965, BANNER & BANNER 1974, RÍOS & CARVACHO 1983, DWORSCHAK & COELHO 1999, D. L. Felder pers. comm., A. Anker pers. obs.). It is interesting to note that this plate and the arthrobranch are also similarly developed in *Chelomalpheus* KIM, 1988 and *Fenneralpheus* FELDER & MANNING, 1986 (HAYASHI 1998, FELDER & MANNING 1986, A. Anker, pers. obs.), two other genera containing commensal species, reported exclusively from burrows of thalassinian mudshrimps. We therefore assume that the elongation of the lateral plate and the strong development of the arthrobranch are adaptations to this particular life-style. The enlarged arthrobranch could increase gas exchange in a hypoxic environment, while the lateral plate, projecting towards the arthrobranch, could protect the latter.

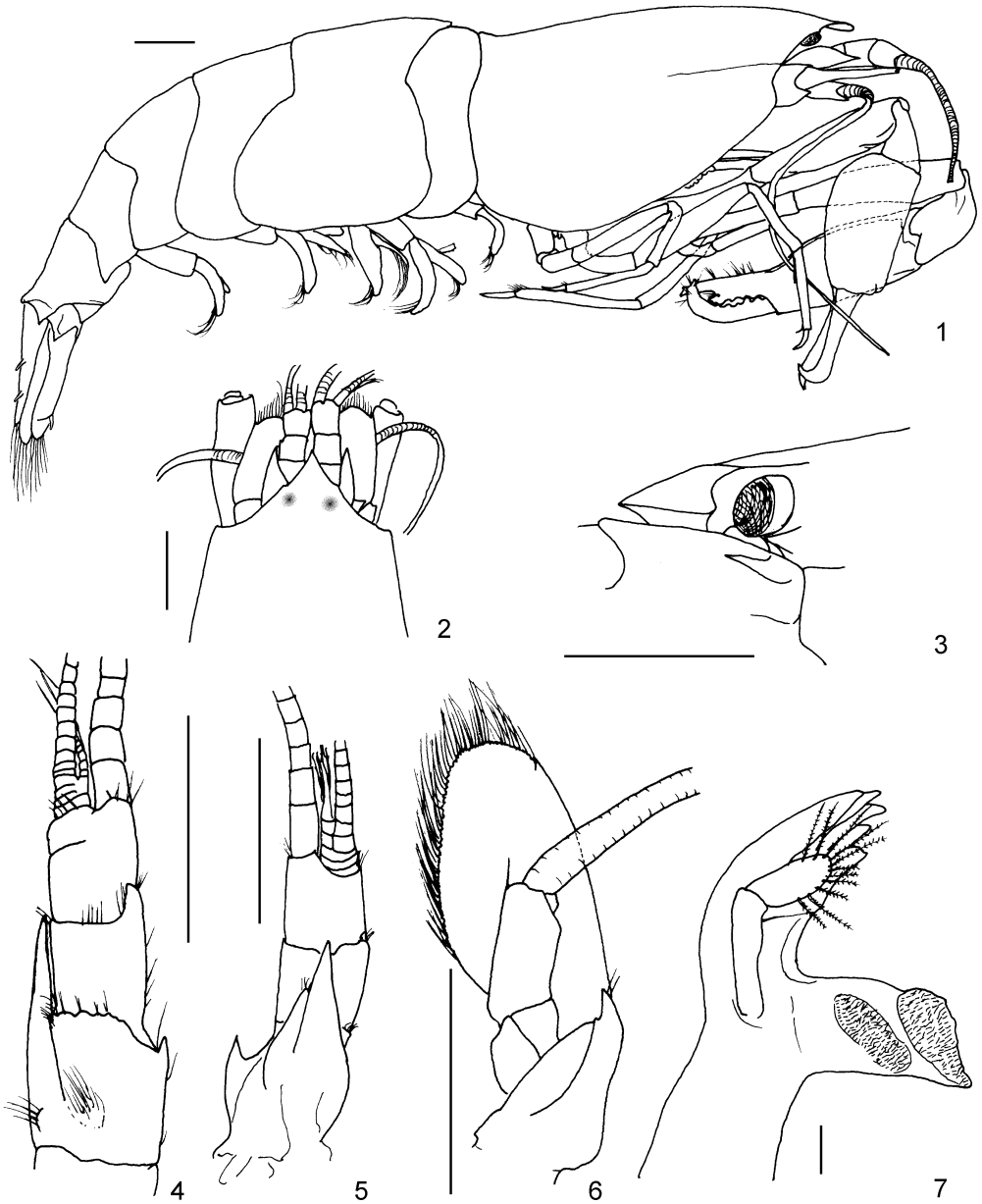
Deioneus can be easily separated from *Leptalpheus* - as redefined by RÍOS & CARVACHO (1983) - by the following features: (1) presence of subequal first pereopods, (2) presence of extra-corneal teeth, (3) third maxilliped distally armed with spines, (4) antennal peduncle much shorter than scaphocerite. The new genus can be also distinguished from *Leptalpheus* by the shape of the diarsis, lacking a deep median incision, typical for *Leptalpheus* and *Fenneralpheus* (A. Anker, pers. obs.), and by the straight posterior margin of the telson, which is broadly rounded in *Leptalpheus*.

Deioneus sandizelli sp.n. (Figs 1-26)

Holotype: NHMW 18796, 1 ovigerous female, Cape Verde Islands, Ilha do São Tiago, NE-coast, tidal flat at Moia-Moia, fine sand, D. Abed-Navandi coll. September 1999 with yabby pump together with *Corallianassa intesi* (DE SAINT LAURENT & LE LOEUFF, 1979) (NHMW 18800), AN. 1999 XXVIII.

Paratype: NHMW 18797, 1 female (dissected), same location and collector as holotype, collected together with *Neocallichirus pachydactylus* (A. MILNE-EDWARDS, 1870)(NHMW 18799).

Description: Carapace with sharply triangular front, forming rostrum projecting over eyes and reaching approximately to middle of second segment of antennular peduncle (Figs 1, 2). Extra-corneal teeth small, acute. Anterolateral border of pterygostomial region obtusely triangular; a well-developed cardiac notch present on posterior margin. Eyes completely covered by carapace in dorsal view, but visible in frontal and in side view;



Figs 1-7. *Deioneus sandizelli* gen.n. sp.n., female paratype NHMW 18797: 1: lateral aspect; 2: front in dorsal view; 3: front in ventrolateral aspect, left antennular peduncle removed; dorsal (4) and lateral (5) aspect of left antennular peduncle; 6: ventral aspect of antennular peduncle. 7: left mandible inner face. Scale is 1 mm in 1-6; 100 μ m in 7.

eyes triangular, as broad as antennal peduncle near basis; cornea situated on anterolateral margin of eyestalks, well developed (Fig. 3).

Antennular peduncles (Figs 4, 5) stout, somewhat broader proximally; all articles of nearly the same length. First article with stylocerite distally acute, reaching slightly beyond middle of second article; antennular carina on mesio-inferior margin prominent. Outer flagellum shorter than inner flagellum, biramous, fused portion bearing 4 segments. Antennal peduncle (Fig. 6) shorter than antennular peduncle. Basicerite with acute spine on latero-inferior margin. Scaphocerite 1.5 times as long as broad, twice as long as carpocerite; outer margin slightly concave; mesial and distal margin broadly rounded; lateral spine small; flagellum nearly as long as carapace.

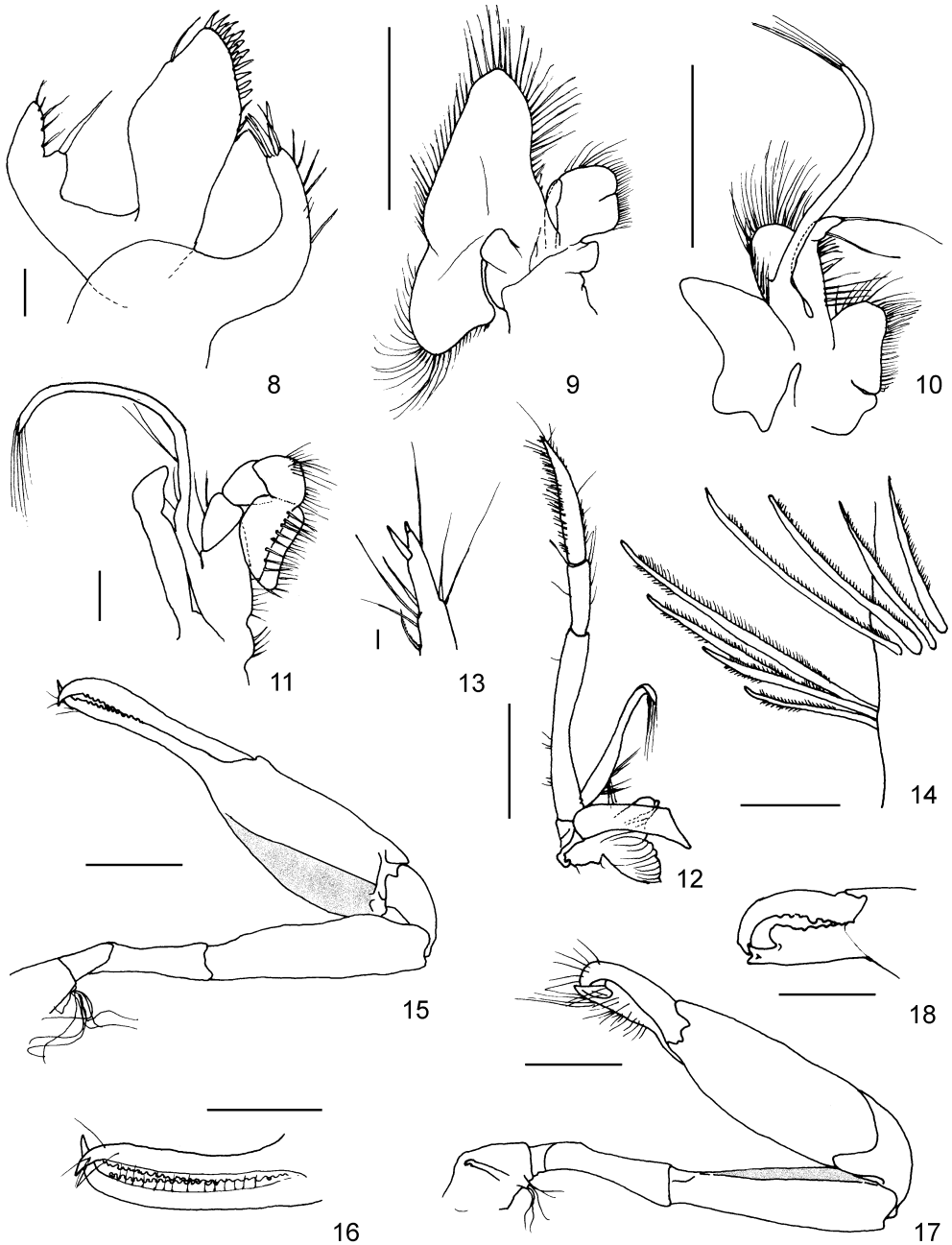
Mouthparts as illustrated. Mandible (Fig. 7) with incisor process armed with 5 teeth; molar process well developed, palp 2-segmented. First maxilla (Fig. 8) with upper endite broad, bearing spinules on distolateral margin; endopod bilobed, subterminal lobe bearing long spine, terminal lobe bearing 5 short seta. Second maxilla (Fig. 9) with upper endite broad, bilobed, edged with setae; lower endite small, with setae only on upper margin; scaphognathite well developed. All maxillipeds with well-developed exopod. First maxilliped (Fig. 10) with endite bilobed, distally with row of setae on marginal region; exopod with caridean lobe broad; endopod slender, unsegmented, with one long seta on distal and shorter seta on mesial margin; epipod broad. Second maxilliped (Fig. 11) of usual shape; epipod considerably elongated. Third maxilliped (Figs 12-14) reaching to end of antennular peduncle; ultimate segment with transverse rows of serrulated setae becoming longer distally, tip with one larger subdistal spine and one smaller distal spine; epipod and arthrobranch well developed, lateral plate acutely produced.

First pereopods unequal in shape, carried beneath cephalothorax with chelae flexed against meri (Fig. 1); right pereopod slightly larger in female holotype, vice versa in female paratype.

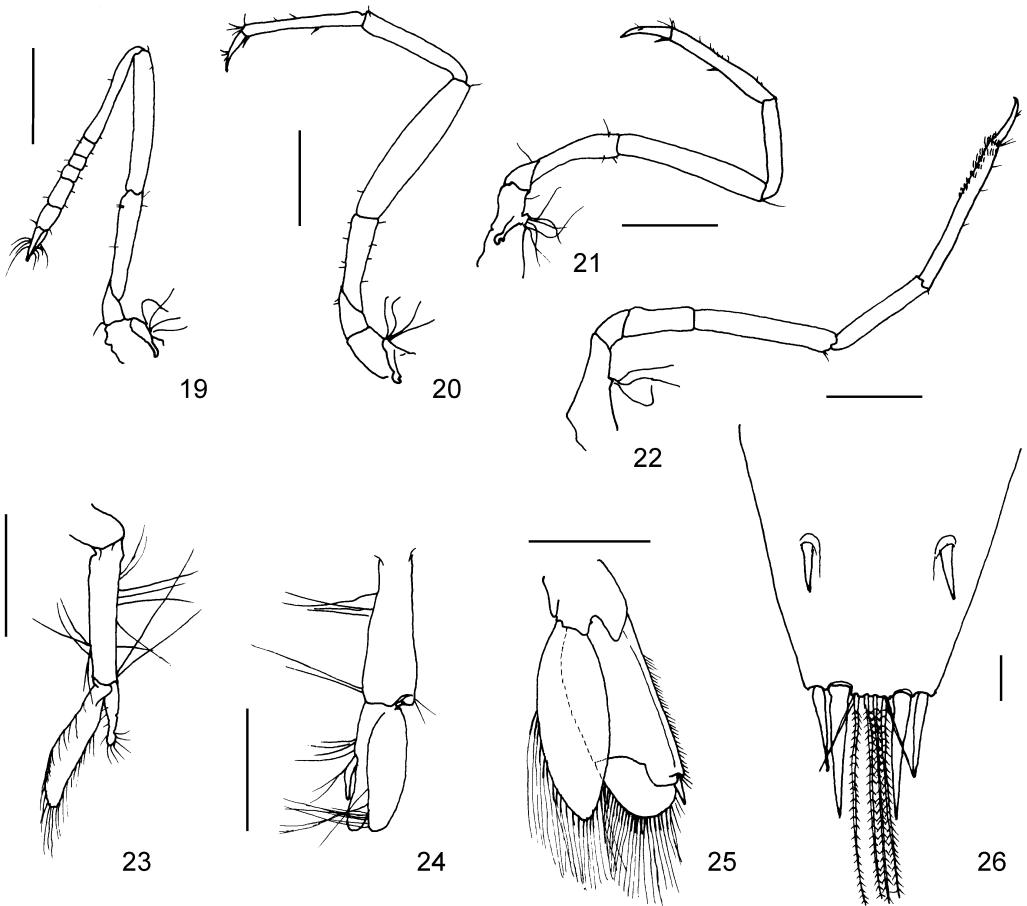
Major cheliped (Fig. 17) with propodus rounded, ventrally deeply excavated to accommodate merus; palm three times as long as broad; fingers very slightly curved in direction of chela flexure, slightly gaping, with tips crossing (Fig. 18). Fixed finger proximally with small rounded teeth, culminating in a large tooth followed by a deep hiatus; tip consisting of two acute teeth. Dactylus strongly curved; proximally with rounded teeth, distally unarmed; tip simple. Fingers reaching to coxa of first pereopod in flexed posture. Carpus cup-shaped, nearly as long as fingers; with a lateral and a mesial lobe. Merus as long as palm, slender, distally thicker, smooth, triangular in cross-section with flattened inferior margin.

Minor cheliped (Fig. 15) with propodus slightly longer and proximally wider compared to that of major cheliped. Propodus as long as merus, twice as long as broad proximally, thinner distally, rounded, ventrally excavated to accommodate merus. Fingers as long as palm, slightly curved in direction of chela flexure, gaping distally; tips strongly curved and crossing; cutting edge of fixed finger with row of small irregular, blunt teeth, distal-most portion toothless; cutting edge of dactylus similarly armed (Fig. 16). Carpus short, disto-mesially bilobed. Merus straight, triangular in cross-section, flexor surface flattened, distally excavated.

Second pereopods (Fig. 19) equal, shorter than all following pereopods. Chela with fingers longer than palm, fixed and movable fingers with scattered brushes of setae distally. Carpus 3 times as long as chela, subdivided into 5 articles, proximal article longest (longer than middle three combined, and almost three times longer than distal article. Merus shorter than carpus and slightly longer than ischium.



Figs 8-18. *Deioneus sandizelli* gen.n. sp.n., female paratype NHMW 18797: inner face of left first (8) and second (9) maxilla, first (10) and second (11) maxilliped; 12: outer face of third maxilliped; 13: tip of third maxilliped; 14: detail of setae on distal segment; 15: minor cheliped in mesial aspect and detail of fingers (16) in ventrolateral aspect; major cheliped in lateral aspect (17) and detail of fingers (18) in dorsolateral aspect. Scale is 1 mm in 9-10, 12, 15-18; 100 μ m in 8, 11, 13 and 14.



Figs 19-26: *Deioneus sandizelli* gen.n. sp.n., female paratype NHMW 18797: lateral aspects of left second (19), third (20), fourth (21) and fifth (22) pereiopod; left first (23) and second (24) pleopod; dorsal aspect of right uropods (25). Holotype NHMW 18796: 26: telson. Scale is 1 mm in 19-25; 100 μ m in 26.

Third pereiopods (Fig. 20) robust, slightly longer than fourth pereiopods. Dactylus 0.4 times as long as propodus, simple, slightly curved. Propodus as long as carpus, with one movable spine at distal end flanking dactylus and one movable spine on flexor margin. Carpus 0.7 times length of merus. Merus unarmed, 4.6 times as long as broad. Ischium unarmed, about 0.6 times as long as merus. Fourth pereiopod (Fig. 21) very similar to third pereiopod, slightly shorter, and with slightly different proportions of articles. Fifth pereiopods (Fig. 22) more slender but longer than third or fourth pereiopods. Dactylus simple, curved; propodus longer than carpus, flexor margin with transverse to oblique rows of setae distally, distal setae longest; merus longer than carpus.

Abdomen smooth. Pleura of 6th abdominal somite with articulated plate. Endopod of first pleopod (Fig. 23) less than half as long as exopod. Appendix interna present on

endopods of pleopods 2-5 (Fig. 24). Uropods (Fig. 25) slightly overreaching telson; lateral margin of exopod with a strong, ventrally originating spine; diaresis strongly developed, interrupted at half distance and continued as a weak suture to mesial margin; endopod as long as exopod, ovate, without specific features. Telson (Fig. 26) twice as long as proximal width; armed with two pairs of dorsal spines, the first situated at mid-length and the second at three-quarter length. Distal margin half as wide as proximal margin; straight, with 4 long, posteriorly directed setae, 2 short, obliquely outwards directed setae, and 2 pairs of postero-lateral spines; half as long as inner spines. Anal tubercles absent. Branchial formula as given in generic diagnosis. The number of setobranchs ranged from 3 on the left P5 to 7 on the right P1 (see Figs 15, 17, 19-22).

Size: Holotype TL = 12 mm, CL = 4.5 mm, very few eggs measuring $620 \times 380 \mu\text{m}$; paratype TL = 17 mm, CL = 6.3.

Colour: Creamy, translucent.

Etymology: Named after Nikolaus Graf Sandizell, CEO of Arqueonautas Worldwide - Arqueologia Subaquatica S.A., who enabled D.A.-N. to undertake work on the Cape Verde Islands.

Remark: The association of *D. sandizelli* with thalassinids is not very species-specific, as one specimen was found in the burrow of *Corallianassa intesi*, the other one with *Neocallichirus pachydactylus*.

Salmoneus HOLTHUIS, 1955

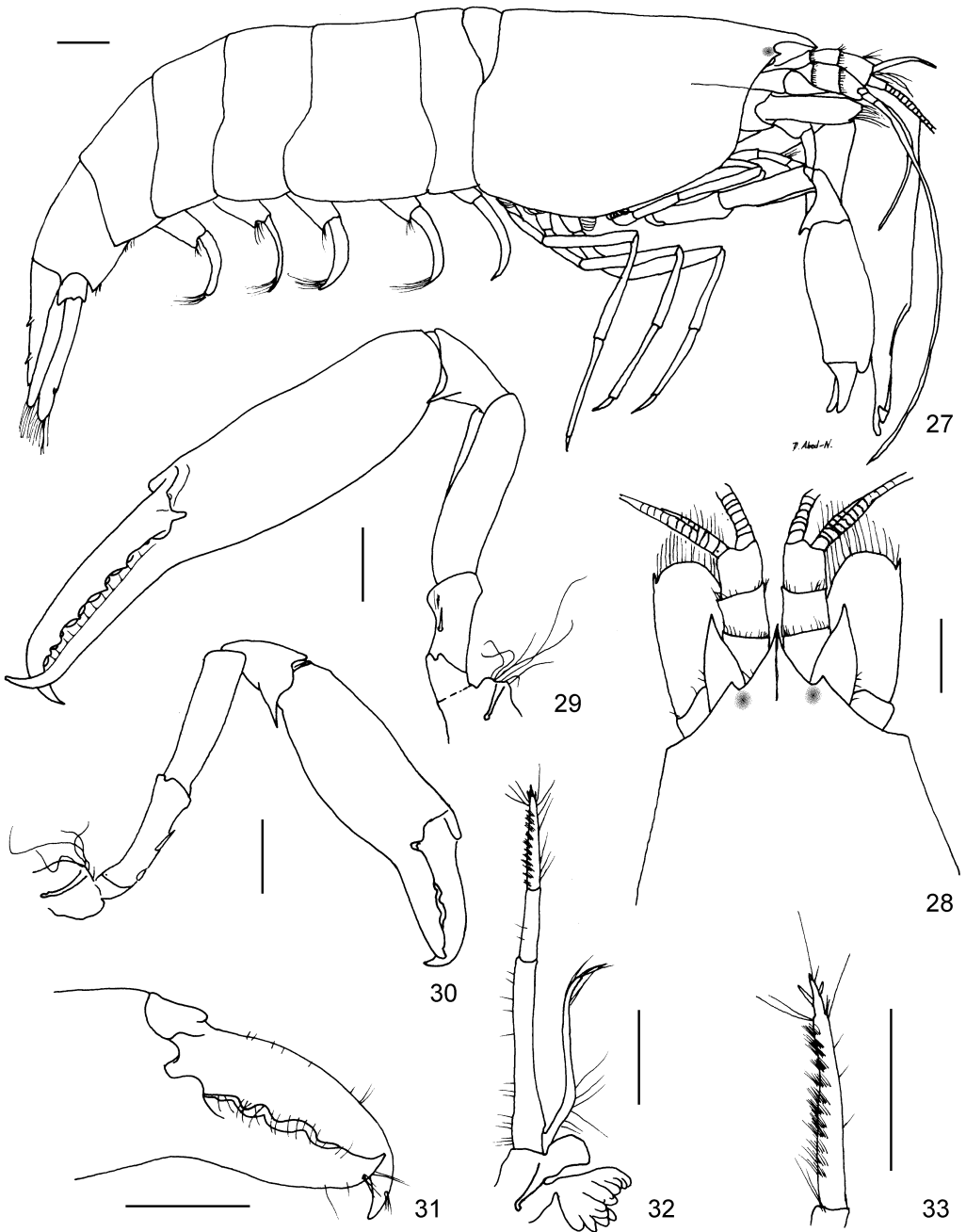
Salmoneus caboverdensis sp.n. (Figs 27-41)

Holotype: NHMW 18795, Cape Verde Islands, Ilha do São Tiago, NE-coast, tidal flat at Moia-Moia, fine sand, D. Abed-Navandi coll. September 1999 with yabby pump together with *Neocallichirus pachydactylus* (A. MILNE-EDWARDS, 1870) (NHMW 18798), AN. 1999 XXVIII

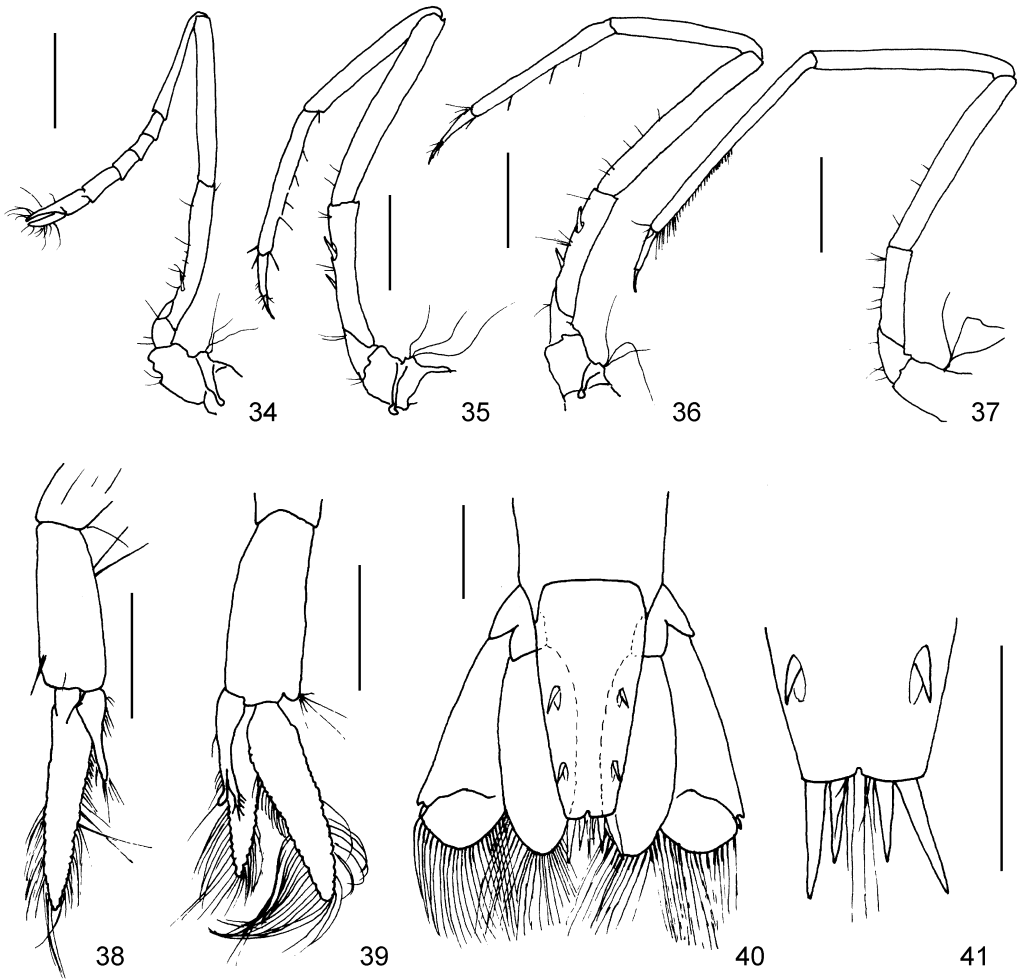
Description: Carapace with sharply triangular rostrum projecting over eyes and reaching approximately to first third of second antennular article (Figs 27, 28). Extra-corneal teeth acute. Rostral carina not very distinct, reaching only to postorbital area. Pterygostomial angle rounded; cardiac notch well developed. Eyes completely covered by carapace in dorsal view, but visible from anterior and side views.

Antennular peduncles stout; all articles of nearly the same length. Stylocerite distally acute, reaching slightly beyond middle of second article; antennular carina acute. Outer flagellum shorter than inner flagellum, biramous, with 4 segments proximal to bifurcation. Antennal peduncle shorter than antennular peduncle. Basicerite with acute spine on latero-inferior margin. Scaphocerite twice as long as broad, and more than twice as long as carapocerite; lateral margin slightly concave; anterior margin broadly rounded; lateral spine small; flagellum as long as carapace.

Mouthparts as usual in *Salmoneus*. Second maxilliped with elongated epipod. Ultimate segment of third maxilliped (Figs 32, 33) with usual rows of serrulated setae; tip armed with two subdistal spines and one small distal spine; epipod and arthrobranch well developed.



Figs 27-33: *Salmeoneus caboverdensis* sp.n., holotype NHMW 18795: 27: lateral aspect; 28: front in dorsal view; minor (29), major (30) cheliped with detail of fingers (31) in lateroventral aspect; 32: left third maxilliped outer face and detail of tip (33). Scale is 1 mm.



Figs 34-41: *Salmoneus caboverdensis* sp.n., holotype NHMW 18795: lateral aspects of left second (34), third (35), fourth (36) and fifth (37) pereopod; left first (38) and second (39) pleopod; dorsal aspect of tailfan (40) and detail of telson (41). Scale is 1 mm.

First pereopods strongly unequal; left cheliped longer, with chela distinctly larger than that of right cheliped; right cheliped shorter, chela robust.

Right (= functional major) cheliped (Fig. 30) with propodus 1.5 times as long as merus, round; palm 2.5 times as long as broad; fingers very slightly curved in direction of chela flexure, not gaping; tips crossing. Cutting edge of fixed finger with 4 rounded teeth. Dactylus slightly curved; cutting edge with 3 rounded irregular teeth (Fig. 31). Carpus cup-shaped, with a small blunt lateral lobe and a large, acute, ventral tooth. Merus shorter than palm, slender, smooth, triangular in cross-section, proximally with flattened flexor margin. Ischium as long as merus, with one movable spine on inferior margin.

Left (= functional minor) cheliped (Fig. 29), especially chela, much different in shape from right cheliped. Propodus twice as long as merus, rounded in cross-section, 3 times as long as broad in its middle, slightly thinner distally. Fingers about 0.7 times length of propodus, distally strongly curved, not gaping; tips crossing when chela closed. Cutting edges of fixed finger and dactylus each with 6 broadly triangular, spaced teeth. Carpus short, cup-shaped, with a strong acute tooth on disto-ventral margin. Merus straight, triangular in cross-section, flexor surface flattened, distally excavate. Ischium about half the length of merus, with one movable spine on inferior margin.

Second pereipods (Fig. 34) equal, shorter than third, fourth, and fifth pereipods. Chela with fingers as long as palm, fixed and movable fingers distally with brushes of setae in distal half. Carpus 3 times as long as chela, subdivided into 5 articles, proximal article longest, longer than middle three combined, and almost three times length of distalmost article. Merus shorter than carpus and slightly longer than ischium. Inferior margin of ischium with movable spine proximal to coxa.

Third pereipods (Fig. 35) robust. Dactylus about 0.4 times as long as propodus, simple, slightly curved. Propodus as long as carpus, with slender spiniform setae on inferior margin. Carpus 0.9 times length of merus; both carpus and merus unarmed. Ischium equal to merus, with 2 spines. Fourth pereipod (Fig. 36) very similar to third pereipods. Fifth pereipods (Fig. 37) longer than third or fourth, slightly longer than second. Dactylus simple, curved, 0.25 times as long as propodus. Propodus with flexor margin bearing distally transverse-oblique rows of setae. Carpus shorter than propodus, merus longer than carpus. Ischium about half length of merus, unarmed.

Abdomen without specific features. Endopod of pleopod 2 (Fig. 39) with appendix interna and appendix masculina. Uropodal exopod (Fig. 40) with diaresis and lateral spine; endopod as long as exopod. Telson (Fig. 41) shorter than uropods, two times longer than proximal width; armed with two pairs of dorsal spines positioned at mid-distance and three-quarter length from proximal margin. Distal margin equal to half of length of proximal margin, with small median incision, 4 long, posteriorly directed setae, 4 shorter, outwardly directed setae, and 2 pairs of postero-lateral spines, outer spines longer than inner spines.

Branchial formula as follows (* present, complete number uncertain):

	maxilliped			pereipod				
	1	2	3	1	2	3	4	5
pleurobranchs	-	-	-	1	1	1	1	1
arthrobranchs	-	-	1	-	-	-	-	-
podobranchs	-	-	-	-	-	-	-	-
lobiform epipods	1	1	-	-	-	-	-	-
strap-like epipods (mastigobranchs)	-	-	1	1	1	1	1	-
setobranchs	-	-	-	*	*	*	*	*
exopods	1	1	1	-	-	-	-	-

The number of setobranchs ranged from 3 on the left P5 to 7 on the right P1 (see Figs 29-30, 34-37).

Size: TL = 20 mm, CL = 6 mm.

Colour: Creamy, translucent.

Etymology: Named after the Portuguese name of the Cape Verde Islands where this species was collected.

Remarks: *Salmoneus caboverdensis* can be distinguished by the combination of the following five features: (1) unique shape of first chelae, (2) carpi of first chelipeds bearing a prominent acute tooth, (3) presence of a movable spine on ischium of both first chelipeds, (4) very small median notch on posterior margin of telson, and (5) reduced corneas.

Within the genus *Salmoneus*, the new species belongs to a small group of eastern Atlantic species having the minor cheliped longer than the major cheliped, although the latter is somewhat more stout than the former. The other three species from this group are *S. jarli* HOLTHUIS, 1951, *S. sketi* FRANSEN, 1992, and the herein described *S. erasimorum*. *Salmoneus jarli* from Nigeria can be easily distinguished from all other *Salmoneus* species by the stout and unarmed chelae of the first chelipeds. *Salmoneus sketi* has been reported only from marine caves in the northern Adriatic Sea (FRANSEN 1992), and can be separated from *S. caboverdensis* by the much longer rostrum, the elongated telson, and by the cutting edges of the minor cheliped having much narrowly spaced teeth. For the separation of *S. caboverdensis* from *S. erasimorum* see under the latter species.

The new species also shares many features with *S. teres* MANNING & CHACE, 1990, described from Ascension Island. The single ovigerous specimen was lacking the right first cheliped. MANNING & CHACE (1990) supposed that the attached left cheliped was the functional major cheliped. If their assumption is correct, *S. caboverdensis* is easily separated from *S. teres* by the shape of the major first cheliped. However, if the left first cheliped of *S. teres* is the minor cheliped, then it is comparable to the minor cheliped of *S. caboverdensis*. But even in this case, *S. teres* differs from *S. caboverdensis* in several important points, including the absence of a prominent, acute tooth on the carpus (cf. MANNING & CHACE 1990, fig. 10 n), the first cheliped with more slender and elongated merus and ischium, the latter lacking movable spine(s), the presence of more numerous saw-like teeth on the cutting edges of the chela, and the posterior margin of the telson having the outer spines shorter than the inner spines. Moreover, *S. teres* was collected in a tidepool (MANNING & CHACE 1990), while the new species from Cape Verde was obtained from a thalassinid burrow.

Salmoneus erasimorum sp.n. (Figs 42-56)

Holotype: NHMW 18794, Adria, Kvarner, Opatja, "Hotel Beach", ca. 1.5 m, D. Abed-Navandi coll. December 1998 with yabby pump together with *Callianassa tyrrhena* (PETAGNA, 1792).

Description: Carapace and frontal region as described for *S. caboverdensis* sp.n. Rostrum reaching approximately to first third of second antennular article (Figs 42, 43). Extra-corneal teeth acute. Rostral carina not very distinct, reaching to postorbital area. Pterygostomial angle rounded; cardiac notch well developed. Eyes completely covered by carapace in dorsal view, but visible from anterior and side views.

Antennular peduncles stout; all articles of nearly the same length. Stylocerite distally acute, slightly reaching almost to posterior margin of second article. Outer flagellum bifurcating at fourth segment. Antenna as described for *S. caboverdensis* sp.n. Antennal

peduncle shorter than antennular peduncle. Basicerite with acute spine on latero-inferior margin. Scaphocerite twice as long as broad, and more than twice as long as carapocerite; lateral margin slightly concave; anterior margin broadly rounded; lateral spine small; flagellum as long as carapace.

Mouthparts as in previous species. Third maxilliped (Fig. 48) with strap-like epipod; arthrobranch well developed.

First pereopods unequal; left cheliped shorter, but more robust than the slightly longer and slender right cheliped.

Left (= functional major) cheliped (Figs 44, 45) with propodus 1.5 times as long as merus, rounded; palm 2.5 times as long as broad; fingers very slightly curved in direction of chela flexure, not gaping, distally crossing. Cutting edges of fixed finger and dactylus bearing 4-5 large, rounded teeth. Carpus cup-shaped, with rounded distal lobes, without acute tooth. Merus shorter than palm, robust, smooth, triangular in cross-section, ventrally flattened ischium as long as merus, robust, with two movable spines on inferior margin.

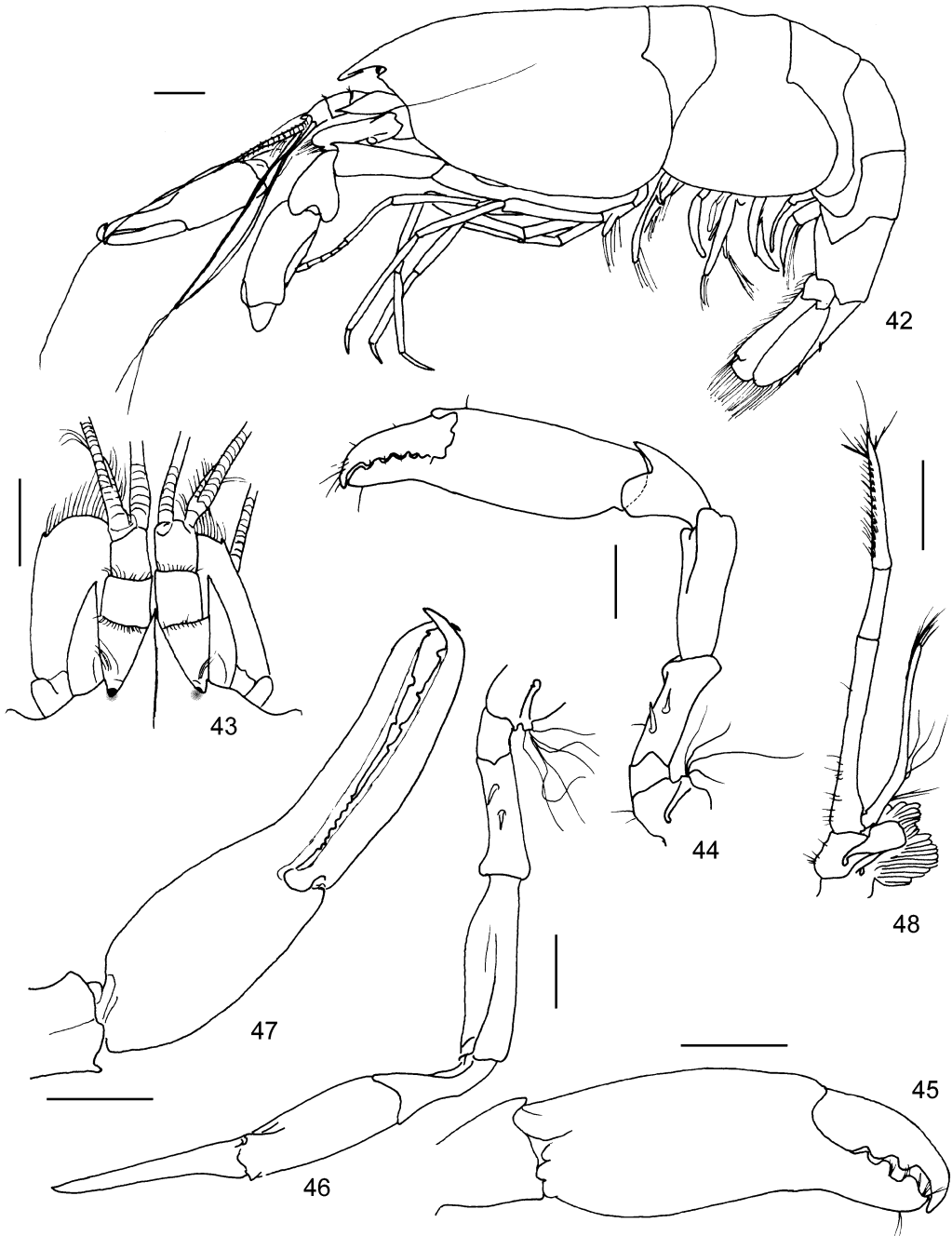
Right (= functional minor) cheliped (Figs 46, 47) different in shape from left cheliped. Propodus as long as merus, 3 times as long as broad in its middle, thinner distally, elliptical in cross-section; proximal portion of palm with distinct grooves. Fingers 1.2 times length of propodus, very slightly curved, not gaping; tips crossing. Cutting edge of fixed finger distally with 3 widely spaced teeth, middle part unarmed, proximally finely serrated. Cutting edge of dactylus similarly armed with 3 widely spaced teeth in its distal third. Carpus somewhat elongated, distal margin more or less straight. Merus straight, triangular in cross-section, with flexor surface flattened, distally somewhat excavated. Ischium about 0.6 times length of merus, with two movable spines on inferior margin.

Second pereopods (Fig. 49) very similar in all aspects to those of *S. caboverdensis* sp.n., including ratio of carpal articles and presence of movable spine on ischium.

Third pereopods (Fig. 50) slender. Dactylus about 0.4 times as long as propodus, simple, slightly curved. Propodus as long as carpus, with 3 spiniform setae on inferior margin. Carpus shorter than merus. Ischium shorter than merus, with 2 small spines. Fourth pereopod (Fig. 51) very similar to third pereopods, except for the absence of ischial spines.

Fifth pereopods (Fig. 52) longer and more slender than third or fourth pereopods. Dactylus simple, much more slender than in third and fourth pereopods, 0.33 times as long as propodus. Distal half of propodus with about 10 oblique-transverse rows of setae. Carpus shorter than propodus, merus as long as carpus. Ischium about half the length of merus, unarmed.

Abdomen without specific features. Endopod of pleopod 2 with appendix interna and appendix masculina (Fig. 54). Uropodal exopod with diuresis and lateral spine; endopod as long as exopod (Fig. 55). Telson shorter than uropods, 1.6 times longer than proximal width; armed with two pairs of dorsal spines positioned at mid-distance and three-quarter length from proximal margin. Distal margin only 0.5 length of proximal margin, straight, with 2 long, posteriorly directed, plumose setae, 2 shorter, outwards directed setae, and 2 pairs of postero-lateral spines, outer spines slightly longer than inner spines (Fig. 56).



Figs 42-48: *Salmoneus erasimorum* sp.n., holotype NHMW 18794: 42: lateral aspect; 43: front in dorsal view; major (44) cheliped in ventrolateral and mesial (45) aspect, minor cheliped in lateral aspect (46), palm and fingers (47) in laterodorsal aspect; 48: left third maxilliped outer face. Scale is 1 mm.

Branchial formula as in *S. caboverdensis* (see above). The number of setobranchs ranged from 2 (left P4) to 6 (right P1)(see Figs 44, 46, 49-52).

Size: TL = 18 mm, CL = 6.5 mm

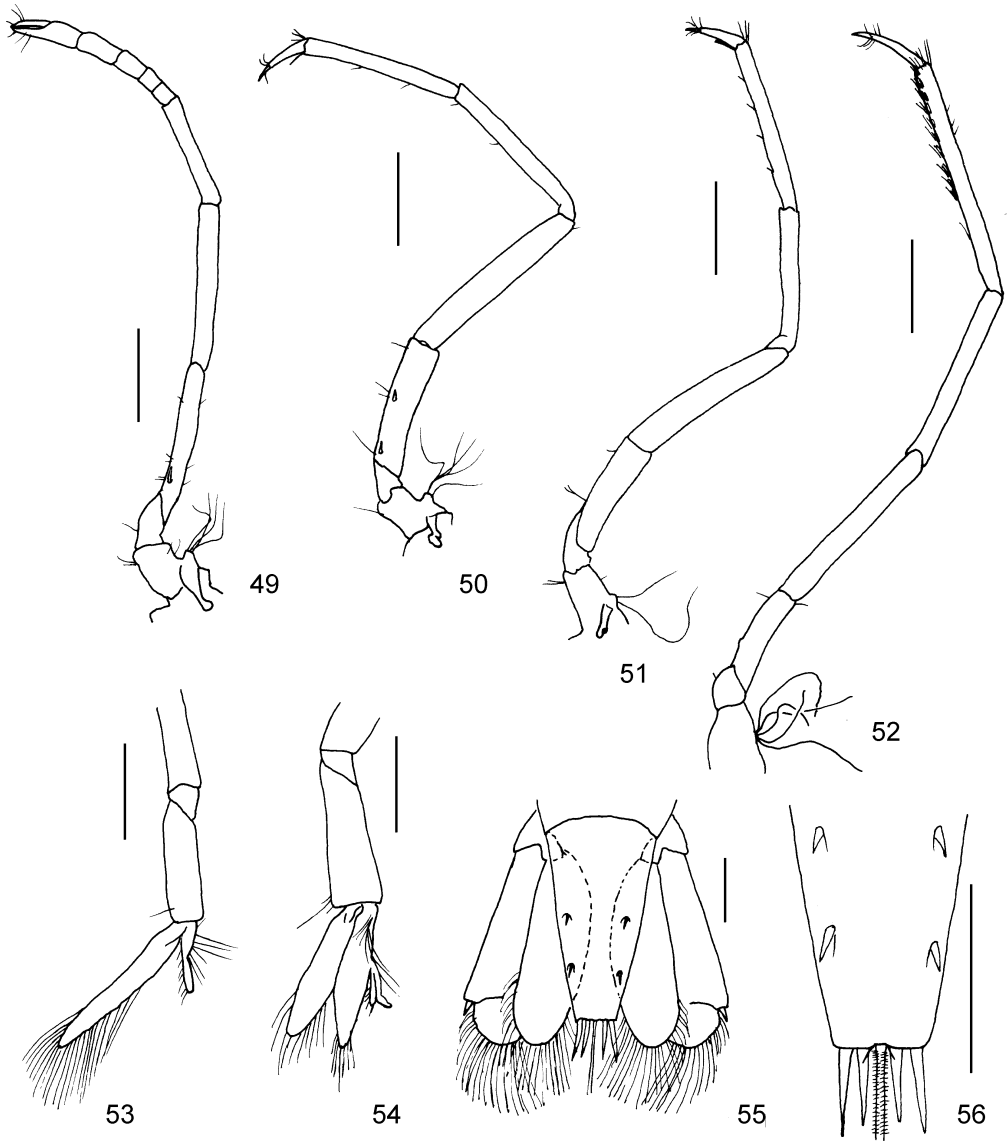
Colour: Greenish yellow.

Etymology: Named after the Erasim family, who supported D.A.-N. during several stays in the Kvarner region.

Remarks: Within the genus *Salmoneus*, the new species belongs to a group of species with the minor cheliped longer than the major cheliped (see *S. caboverdensis*). *S. erasimorum* can be separated from *S. jarli* HOLTHUIS, 1951 by the chelae armed with teeth, and from *S. sketi* FRANSEN, 1992 by the much shorter rostrum and less elongated telson. *Salmoneus erasimorum* is very close to the above-described *S. caboverdensis*. Both species have a very similar frontal region and telson, especially having the outer posterior spines longer than the inner spines (this feature is also shared by *S. sketi*). Both species have movable spines on the ischium of the first chelipeds, although *S. erasimorum* seems to have two spines, while *S. caboverdensis* has only one spine. Furthermore, *S. erasimorum* can be distinguished from *S. caboverdensis* by the ischium of third pereopod being armed with two movable spines (vs. unarmed in *S. caboverdensis*), and the carpi of the first chelipeds lacking the acute mesio-inferior tooth, characteristic for *S. caboverdensis*. Furthermore, the two new species can be separated by the shape of the dactylus of the third pereopod, being more slender and longer in *S. caboverdensis*. We believe these differences are important and justify the description of two species.

We suspected that the incomplete specimen (lacking all its pereopods) from Nabi Rubin, Israel, provisionally identified as *Salmoneus* ? *jarli* (HOLTHUIS & GOTTLIEB, 1958), could belong to the same species as the present one from the Adriatic Sea. HOLTHUIS & GOTTLIEB (1958) mentioned that the specimen from Israel was in general agreement with the description of *S. jarli* (HOLTHUIS, 1951). However, it presented several slight differences and was therefore identified as *S. jarli* with much reservation. Only the frontal region of this specimen was illustrated, and it also agrees well with that of *S. erasimorum*. HOLTHUIS & GOTTLIEB (1958) noted that "The rostrum reaches about to the end instead of about to the middle of the second segment of the antennular peduncle. The supra-corneal [actually extra-corneal] teeth are slightly longer. The dorsal carina is less distinct. Between the two inner of the four posterior spines of the telson only two hairs are visible. The external antennular flagellum has the two rami fused for one joint, while the free part of the shorter ramus consists of the two joints only." In *S. erasimorum*, the rostrum reaches to the middle of the second antennular segment, the extra-corneal teeth are slightly shorter and less acute than in the specimen from Nabi Rabin, the outer flagellum has the two rami fused for at least three joints, the shorter ramus bearing several joints, the dorsal carina is very slight, and there are only two long setae between the two inner spines of the telson. Unfortunately, the specimen from Nabi Rabin could not be examined, as it has not been located in the collections of the RMNH; it was probably deposited in the Sea Fisheries Research Station in Haifa (C. Fransen, pers. comm.).

Salmoneus erasimorum also shares several features with *S. teres* MANNING & CHACE, 1990, but can be separated from it by the shape of the first chelipeds, and by the posterior telson margin having longer outer than inner spines. The only other Atlantic species



Figs 49-56: *Salmoneus erasimorum* sp.n., holotype NHMW 18794: lateral aspects of left second (49), third (50), fourth (51) and fifth (52) pereopod; left first (53) and second (54) pleopod; dorsal aspect of tailfan (55) and detail of telson (56). Scale is 1 mm.

collected from the mudflats in immediate proximity of thalassinid and stomatopod burrows is *S. cavicolus* FELDER & MANNING, 1986, although specimens were not obtained directly from burrows. The second author examined the type-series of *S. cavicolus* (USNM 228054, 228055), and we conclude here that the paratypes are different from the holotype in several important features, which are unlikely accounted for by intraspecific

variability (cf. figures of the frontal region in FELDER & MANNING 1986: 504, figs 4b, c, g, j, k). Darryl Felder (pers. comm) confirmed that at least two species occur at the type locality for *S. cavicolus*. However, all specimens from the *S. cavicolus* type-series have the major cheliped very slender (especially the merus), the cutting edges bearing regular saw-like teeth, and the minor cheliped being much smaller in size, and having an elongated, cylindrical carpus.

Subsequent sampling of thalassinids [*Callianassa tyrrhena* (PETAGNA, 1792), *C. candida* (OLIVI, 1792) and *Necallianassa truncata* (GIARD & BONNIER, 1890)] at the type locality and nearby sublittoral sediments in May, July, and December 1999, as well as in March and May 2000 yielded no further specimens of *S. erasimorum*. This indicates that this species usually occurs in deeper water. Further support for this assumption is that *S. ? jarli*, which is probably identical with *S. erasimorum* (see discussion above), was collected on muddy bottom in 90 m (HOLTHUIS & GOTTLIEB 1958). Here, it is probably associated with other burrowing crustaceans like *Nephrops norvegicus* (LINNAEUS, 1758) or *Squilla mantis* (LINNAEUS, 1758). It is unlikely that an associate living in such deep burrows is captured with gears such as dredges or grabs. FROGLIA & ATKINSON (1998) were able to show with in-situ resin casting that *Athanas amazone* (HOLTHUIS, 1951), previously thought to be a rare species, regularly lives as a commensal facultative associate in the burrows of *Squilla mantis*.

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