



## ***Hirondellea sindhusagar* (Crustacea: Amphipoda: Lysianassoidea), a new deep-water scavenger species from the Indian Ocean, with a key to the genus *Hirondellea*\***

TAMMY HORTON<sup>#</sup> & MICHAEL THURSTON

National Oceanography Centre, Southampton, University of Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK

<sup>#</sup>Corresponding author: txh@noc.soton.ac.uk

\* In: Brökeland, W. & George, K.H. (eds) (2009) Deep-sea taxonomy — a contribution to our knowledge of biodiversity. *Zootaxa*, 2096, 1–488.

### **Abstract**

The amphipod genus *Hirondellea* Chevreux, 1889 is a cosmopolitan largely bathyal genus. This paper adds a new species from the bathyal Arabian Sea, Indian Ocean, based on material collected by baited traps at 1182, 1184 and 1864 m off the coast of Pakistan. The species can be distinguished from the most closely allied species, *Hirondellea brevicaudata* (Chevreux, 1910) by the subacute lateral head lobes, the very weakly cleft telson, and characters of the mouthparts. A key to the ten species in the genus is provided.

**Key words** Crustacea, Amphipoda, Lysianassoidea, hirondelleid, new species, deep-sea

### **Introduction**

During a recent cruise to the Pakistan margin (northern Arabian Sea, Indian Ocean), baited traps were set to collect and study the scavenging amphipod community at various depths (see Table 1). Three of the traps were successful in collecting specimens. Two of the traps were set at 1182–4 m, and collected only three species of amphipod; *Podoprion addyi* Horton, 2005, *Abyssorchomene abyssorum* Stebbing, 1888, and *Hirondellea sindhusagar* sp. nov., which is described here.

The third trap was set at 1864 m and collected six amphipod species including the new species of *Hirondellea*, two further undescribed species (*Paracallisoma* sp. nov. and *Cyclocaris* sp. nov., which are being described elsewhere), and three described species of amphipod, *Stephonyx arabiensis* Diffenthal & Horton, 2007, *Eurythenes gryllus* (Lichtenstein in Mandt, 1822) and *Abyssorchomene abyssorum*. The amphipod scavenging fauna from the bathyal Arabian Sea currently comprises several species; including *Hirondellea sindhusagar* sp. nov., *Paracallisoma* sp. nov. and *Cyclocaris* sp. nov., *Podoprion addyi*, *Stephonyx arabiensis*, *Eurythenes gryllus*, and *Abyssorchomene abyssorum* (see Horton 2005; Diffenthal & Horton 2007). Witte (1999) and Janssen *et al.* (2000) also recorded *Eurythenes gryllus*, *Paralicella* sp., *Abyssorchomene abyssorum* and *Paracallisoma* sp.

The genus *Hirondellea* currently belongs in the superfamily Lysianassoidea and the family Lysianassidae. However, the family arrangement within the Lysianassoidea is currently under review. For the purposes of this paper the genus has been placed into the informal group of hirondelleids (De Broyer *et al.* 2007), which is under review by Lowry, Stoddart and De Broyer.

**TABLE 1.** Station information and list of species recorded from each site.

Station	Depth / m	Latitude	Longitude	Species recorded
56137 # 5 site A1850	1864	22° 51.067' N	65° 59.916' E	<i>Abyssorhomene abyssorum</i> Stebbing, 1888 <i>Cyclocaris</i> sp. nov. <i>Eurythenes gryllus</i> (Lichtenstein in Mandt, 1822) <i>Hirondellea sindhusagar</i> sp. nov. <i>Paracallisoma</i> sp. nov. <i>Stephonyx arabiensis</i> Diffenthal & Horton, 2007 <i>Paralicella caperesca</i> Shulenberger & Barnard, 1976
56141 # 01 site A1200	1182	22° 59.784' N	66° 24.786' E	<i>Abyssorhomene abyssorum</i> Stebbing, 1888 <i>Hirondellea sindhusagar</i> sp. nov. <i>Podoprion addyi</i> Horton, 2005
56141 # 13 site A1200	1184	22° 59.776' N	66° 24.758' E	<i>Abyssorhomene abyssorum</i> Stebbing, 1888 <i>Hirondellea sindhusagar</i> sp. nov. <i>Podoprion addyi</i> Horton, 2005

## Methods

Material was fixed in 4% formaldehyde and then transferred to 80% Industrial Methylated Spirits (80% IMS) on return to the laboratory. A Leica™ MZ7.5 dissection microscope was used to examine the specimens, and carry out dissection. One female paratype was also dissected in order to provide detailed examination of parts which were not clear or differed from the holotype female. Dissected parts were mounted in Polyvinyl-lactophenol (PVL) stained with lignin pink. Using an Olympus™ BX51 compound microscope illustrations were prepared and were scanned and digitally inked using Adobe® Illustrator® and a WACOM™ digitiser tablet, as described in Coleman (2004). Setal and mouthpart classifications follow Watling (1989) and Lowry and Stoddart (1992, 1995). The description was prepared using DELTA (Descriptive Language for Taxonomy: Dallwitz et al. 1997).

Type specimens have been deposited at the Natural History Museum, London (NHM). The following abbreviations have been used: *A1–A2*, antennae; *E*, epistome and upper lip; *Ep*, epimeral plate; *G*, gnathopod; *H*, head; *IP*, inner plate; *L*, lower lip; *Md*, mandible; *Mx*, maxilla; *Mxp*, maxilliped; *P*, pereopod; *r*, right; *T*, telson; *U*, uropod; *US*, urosome; *Y*, paratype; All parts are left side unless otherwise indicated.

## Systematics

Superfamily Lysianassoidea

Hirondelleid family group

**Genus** *Hirondellea* Chevreux, 1889

*Hirondellea*. Chevreux 1889: 285; Barnard & Ingram 1990: 7; Barnard & Karaman 1991: 490.

*Tetronychia*. Stephenson 1923: 63.

*Type species: Hirondellea trioculata* Chevreux, 1889, original designation.

*Diagnosis.* Mouthparts well developed, forming quadrate bundle. Epistome and upper lip produced differentially, prominent, separate, both strongly projecting. Mandible incisor smooth, lacinia mobilis present on left side only, molar simple, large, conicolaminate or subconical, setose. Maxilla 1 with 7/4 or 7/4 crown setal tooth arrangement, inner plate weakly setose (2), in adults setae sickle-shaped, palp 2-articulate, large. Inner and outer plates of maxilliped well developed, palp strongly exceeding outer plate, dactyl well developed. Coxa 1 moderately to strongly shortened, partly covered by coxa 2, tapering or subrectangular.

Gnathopod 1 short, strongly subchelate, palm transverse, sometimes chelate, dactyl overlapping palm. Inner ramus of uropod 2 with or without large notch (modified after Barnard & Karaman 1991; Barnard & Ingram 1990).

*Species composition:* contains 10 species: *H. abyssalis* (Stephensen, 1923); *H. antarctica* (Schellenberg, 1926); *H. brevicaudata* Chevreux, 1910 (illustrated in Chevreux, 1935); *H. dubia* Dahl, 1959; *H. fidenter* Barnard, 1966; *H. gigas* (Birstein & Vinogradov, 1955); *H. glutonis* Barnard & Ingram, 1990; *H. guyoti* Barnard & Ingram, 1990; *H. trioculata* Chevreux, 1889 and *H. sindhusagar* sp. nov.

*Remarks.* *Hirondellea* is a shallow-Antarctic and deep-sea genus and currently holds the depth record for Amphipoda with *H. gigas*, which was collected between 10020 m and 10190 m in the Phillipine Trench. For a relatively small genus (only 10 species) *Hirondellea* is somewhat heterogeneous with a wide variation among the species for some characters (see Barnard & Karaman 1991) and probably warrants a full revision. There remains some ambiguity about the identity of *H. abyssalis* and *H. antarctica*, and despite much discussion in the taxonomic literature (Barnard 1930; Birstein & Vinogradov 1960; Andres 1983), the distinction of these two species is troublesome. Further study of more specimens of a variety of sizes and both sexes from the type localities is required before the distinction of these species can be assured. The remaining species in the genus can be distinguished by means of the key provided at the end of this paper.

### ***Hirondellea sindhusagar* sp. nov.**

Figures 1–3

*Holotype:* female, 5.8 mm, (NHM Reg. N<sup>o</sup>. 2008.3468). *Paratypes:* 3 males (NHM Reg. N<sup>o</sup>s. 2008.3469–3471), 11 females (NHM Reg. N<sup>o</sup>s. 2008.3471–3481), collected off the coast of Pakistan in the northern Arabian Sea, RRV *Charles Darwin*, (cruise 151), station number 56137#5, baited trap attached to Profilur autonomous lander; deployed at 1322 (UTC) 13/10/03, 22° 51.067' N, 65° 59.916' E at 1864m, recovered at 0448 hrs, 14/10/03; bottom time, 14.2 hrs; bottom temperatures max = 3.55°C, min = 3.52°C, mean = 3.53°C. 107 females (NHM Reg. N<sup>o</sup>s. 2008.3482–3491), 53 males (NHM Reg. N<sup>o</sup>s. 2008.3492–3501), 56141 # 01, site A1200, trap attached to Profilur autonomous lander, 16/10/03, deployed at 0108 (UTC) 22° 59.784' N, 66° 24.786' E at 1182m, recovered 16/10/03 @ 1240 hrs; bottom time, 10.5 hrs. Bottom temperatures max = 7.34°C, min = 7.28°C, mean = 7.31°C.

*Description.* Based on adult female, 5.8 mm. Head: exposed, deeper than long; lateral cephalic lobe large, broad, subacute; eyes present, subtriangular, grey, non-ocellate. Antenna 1: short, 0.17 x body; peduncular article 1 short, length 1.2 x breadth; peduncular article 2 short, 0.1 x article 1; peduncular article 3 short, 0.175 x article 1; primary flagellum 5-articulate; accessory flagellum long, 0.7 x primary flagellum, 3-articulate, forming cap partially covering callynophore; callynophore weak, 2-field; calceoli absent. Antenna 2: length 1.1 x antenna 1; peduncle without brush setae; peduncular article 1 not greatly enlarged; article 3 short, 0.9 x article 4; flagellum well-developed, 6-articulate.

Mouthpart bundle: subquadrate. Epistome and upper lip separate, upper lip dominant. Epistome slightly rounded. Upper lip: produced, rounded apically. Interantennal carina: notched proximally. Mandible: incisor ventral margin smooth; lacinia mobilis present only on left mandible, a small stemmed robust seta (difficult to make out on slides and not visible in illustration); left and right accessory setal rows with simple robust setae; molar subconical, setose; palp attached proximally; article 1 short, 1.3 x breadth; article 2 slender, 5.2 x breadth, with 10 distolateral A2 setae; article 3 slender, blade-like, with 8 D3 setae, 1 A3 seta and 3 E3 setae. Maxilla 1: (described from paratype female since the holotype maxilla 1 was in poor orientation for interpretation) inner plate narrow, with 2 apical setae; outer plate with setal teeth in unusual 7/4 arrangement (almost 8/3?), row with ST1–7 large and slender, ST1 3-cuspidate, ST2 3-cuspidate, ST3 4-cuspidate, ST4 4-cuspidate, ST5 4-cuspidate, ST6 6-cuspidate, ST7 7-cuspidate, STA–D large, broad, STA 2-cuspidate, STB 3-cuspidate, STC 3-cuspidate, STD 4-cuspidate; palp large, 2-articulate, article 1, short with 3 or 4 inner

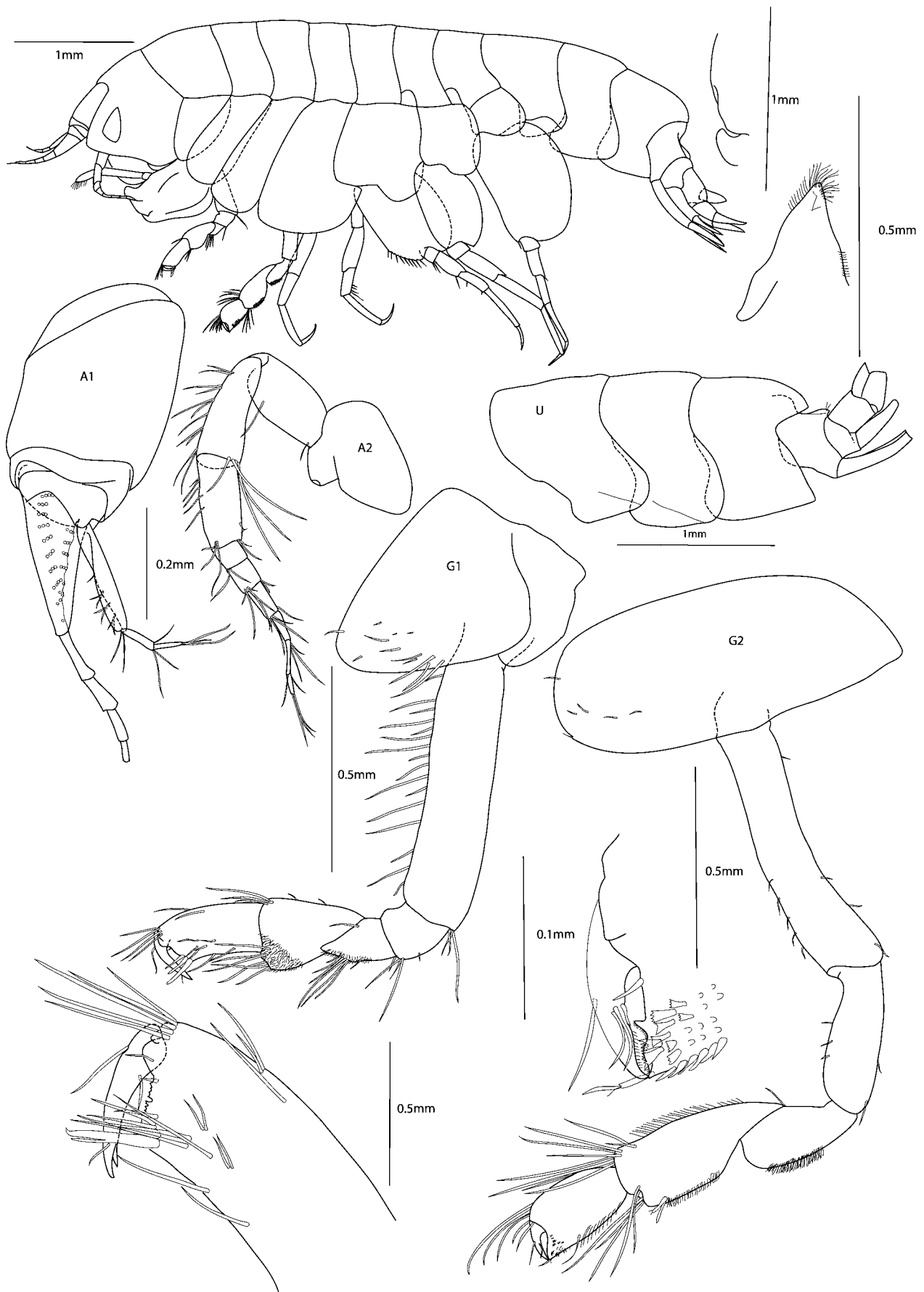
notches. Maxilla 2: inner plate broad, truncate distally, shorter than outer plate. Maxilliped: inner plate large, subovate, apical margin concave, with 3 teeth bearing robust nodular setae and 4 simple robust setae across apical margin; 2–3 setae in medial setal row; outer plate medium, subovate, with medial margin weakly crenulate and slightly concave distomedially; palp large, 4-articulate, article 2 slender, length 2.6 x breadth, article 3 long, slender, length 3 x breadth, article 4 well-developed, with 2 subterminal setae.

Gnathopod 1: subchelate; coxa reduced, shorter than coxa 2, straight, tapered, anteroventral corner subtriangular; basis moderately setose anteriorly, long, length 4.2 x breadth; ischium short, length 1 x breadth; carpus subtriangular, subequal in length to propodus, length 1.4 x breadth; propodus margins subparallel; palmar angle acute, palm straight, dactyl greatly overreaching palm edge. Gnathopod 2: minutely subchelate, coxa large, shorter than coxa 3; ischium long, length 2.7 x breadth; carpus length 2.6 x breadth; propodus subrectangular, palmar angle obtuse, palm straight, weakly pectinate distally; dactylus inserted at anterior corner of propodus, reaching palm edge. Pereopod 3: coxa large, subrectangular; basis slender, straight, margins subparallel, propodus posterior margin with simple setae, dactylus long, weakly curved. Pereopod 4: coxa deeper than wide, with posteroventral lobe broadly rounded, posterior margin sloping anteriorly; propodus posterior margin with simple setae. Pereopod 5: coxa lobate posteriorly (no lateral ridge); basis weakly expanded, posterior margin straight, posterior lobe rounded. Pereopod 6: coxa small, strongly lobate posteriorly; basis weakly expanded, proximal posterior margin concave, posterodistal lobe broadly rounded. Pereopod 7: coxa small, weakly lobate posteriorly; basis expanded and rounded, proximal posterior margin convex, posterodistal lobe broadly rounded.

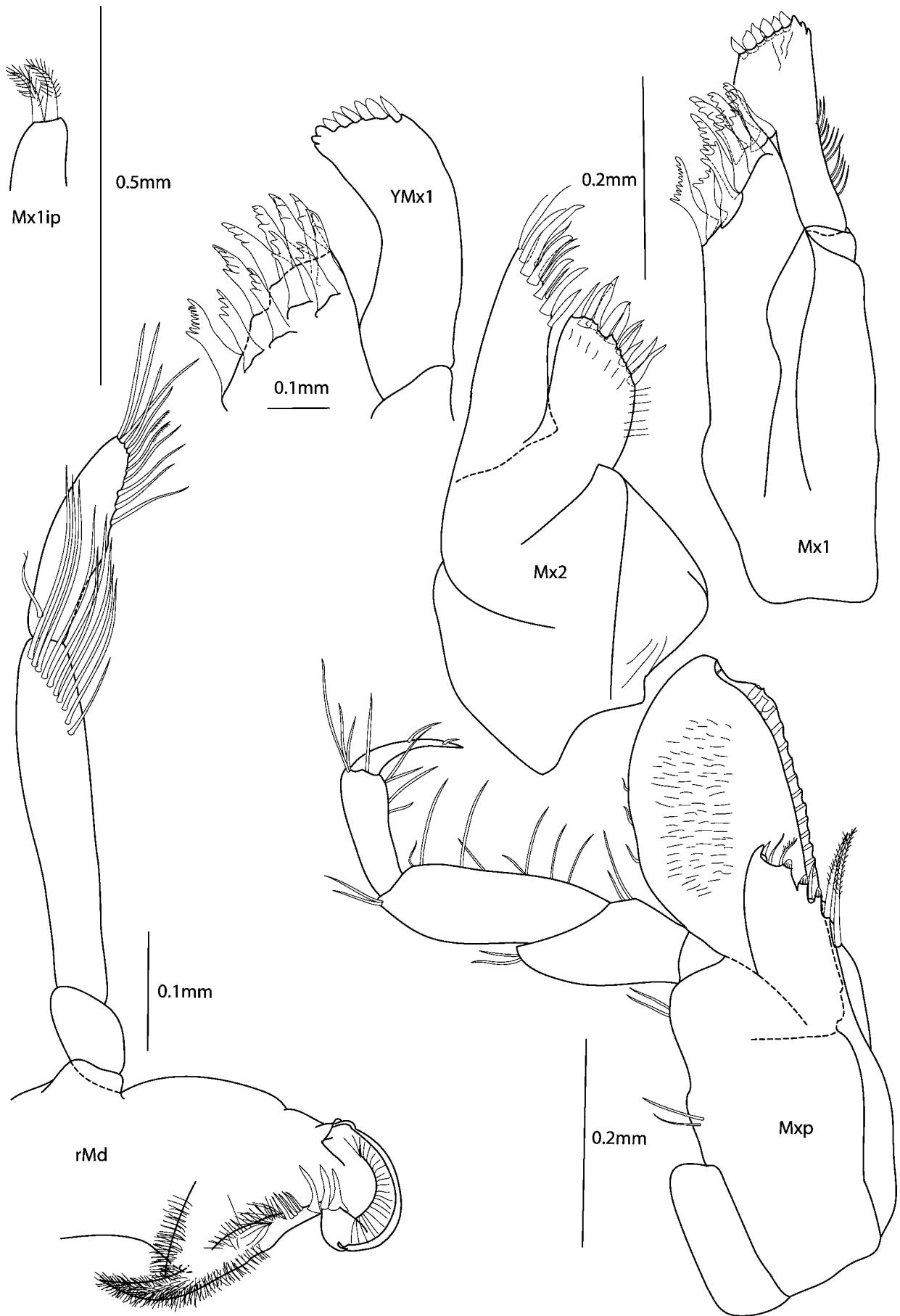
Pleonites 1 to 3: smooth dorsally. Pleonite 3: extended over urus. Epimeron 1: anterior margin slightly concave, anteroventral corner without tooth. Epimeron 2: posteroventral corner rounded, posterior margin convex. Epimeron 3: posteroventral corner subquadrate, ventral margin without short robust setae. Urosomite 1: anterior sinus present, boss a rounded hump. Uropod 1: peduncle 1.4 x inner ramus, without apicolateral robust setae, 1 apicomедial robust setae, and 7 dorsomedial setae; outer ramus slightly longer than inner ramus; inner ramus with 3 medial robust setae, without lateral robust setae and neither margin microsetose; outer ramus with 1 lateral robust setae, without medial robust setae. Uropod 2: peduncle 0.96 x inner ramus, without apicolateral robust setae, 1 apicomедial robust seta, without dorsomedial setae, and with 3 dorsolateral robust setae; outer ramus subequal to inner ramus. Inner ramus not constricted, with 4 medial robust setae, without lateral robust setae, and with neither margin microsetose; outer ramus without medial robust setae, 2 lateral robust setae, and with neither margin microsetose. Uropod 3: peduncle 0.84 x inner ramus, 2 apicolateral robust setae, 4 apicomедial robust setae and simple setae, and without medial simple slender setae; inner ramus slightly shorter than outer ramus, 0.9 x outer ramus, without medial robust setae or medial slender plumose setae; outer ramus 2-articulate, article 2 1.2 x article 1, with neither margin microsetose, article 1 without medial robust setae and slender plumose setae, and with 1 lateral robust seta. Telson: broad, slightly tapering, length 1.2 x breadth, weakly cleft 15 %; apices not incised, apices with 1 robust seta and 1 subapical robust seta per lobe.

*Male.* 3 male paratypes: As for female except with a greater number of aesthetascs on antenna 1; calceoli present on antenna 1 articles 5 and 6; longer antenna 2.

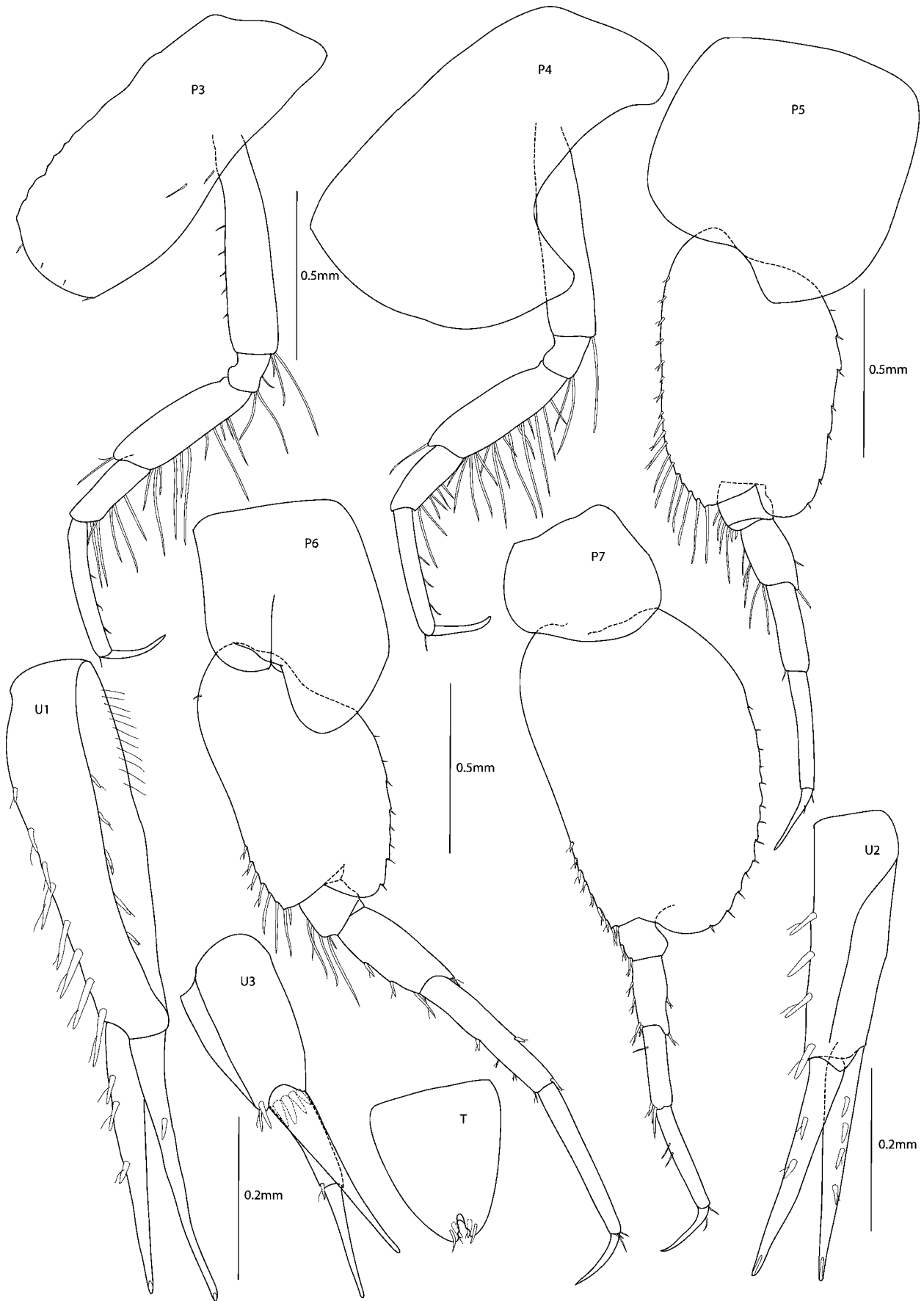
*Remarks.* This small species was collected in large numbers from the bathyal Arabian Sea (~1200–1800 m). It is a scavenging species attracted to the baited traps along with a number of other lysianassoid species. The species belongs to the group without a constriction on the inner ramus of uropod 2 and most closely resembles *Hirondellea brevicaudata*. It can be distinguished from that species by the very weakly cleft telson (15% in *H. sindhusagar*; 35% in *H. brevicaudata*); the finer and more elongate rami of uropod 3 (in particular the unusually elongate article 2 of the outer ramus), the more acutely produced posteroventral corner of epimeron 3 and the subacute lateral lobes of the head. In addition, the two species can be separated by the finer characters of the mouthparts, particularly the maxilliped inner plate which in *H. sindhusagar*, has three unusual nodular ‘teeth’.



**FIGURE 1.** *Hirondellea sindhusagar* sp. nov. Holotype female, 5.8 mm, habitus, antennae, and gnathopods.



**FIGURE 2.** *Hirondellea sindhusagar* sp. nov. Holotype female, 5.8 mm, mouthparts.



**FIGURE 3.** *Hirondellea sindhusagar* sp. nov. Holotype female, 5.8 mm, pereopods, uropods and telson.

*H. sindhusagar* can be separated from the other species with an unconstricted uropod 2 inner ramus (*H. gigas*, *H. dubia*) by the absence of a multi-toothed dactyl on gnathopod 1 (as in *H. gigas*) and the short, broad propodus of gnathopod 1 (c.f. elongate and strongly tapering gnathopod 1 in *H. dubia*).

*Distribution.* Off the coast of Pakistan in the northern Arabian Sea, Indian Ocean at depths between 1182 and 1864 m.

*Etymology.* This species is named after the collecting locality of the Arabian Sea, which was known as the Sindhu Sagar to Indians in the Vedic period of their history.

### Key to the species of *Hirondellea*

1	Inner ramus of uropod 2 constricted .....	2
-	Inner ramus of uropod 2 not constricted .....	7
2	Epimeron 1 with strong anteroventral tooth .....	<b>GUYOTI</b>
-	Epimeron 1 rounded anteriorly .....	3
3	Epimeron 3 sharply subquadrate posteriorly .....	<b>TRIOCULATA</b>
-	Epimeron 3 rounded posteriorly .....	4
4	Gnathopod 1 with strongly concave palm and distal palmar projection.....	5
-	Gnathopod 1 with slightly concave/transverse palm without palmar projection.....	6
5	Dactyl of gnathopod 1 strongly overlapping palm .....	<b>ANTARCTICA*</b>
-	Dactyl of gnathopod 1 scarcely overlapping palm, meeting palmar projection .....	<b>ABYSSALIS*</b>
6	Dactyl of gnathopod 1 strongly overlapping palm, dactyl strongly toothed .....	<b>FIDENTER</b>
-	Dactyl of gnathopod 1 scarcely overlapping palm, dactyl weakly toothed .....	<b>GLUTONIS</b>
7	Dactyl of gnathopod 1 multi-toothed.....	<b>GIGAS</b>
-	Dactyl of gnathopod 1 not multi-toothed .....	8
8	Gnathopod 1 propodus elongate, strongly tapering .....	<b>DUBIA</b>
-	Gnathopod 1 propodus short and broad, barely tapering.....	9
9	Lateral cephalic lobe rounded, telson cleft >25% .....	<b>BREVICAUDATA</b>
-	Lateral cephalic lobe subacute, telson cleft <20 % .....	<b>SINDHUSAGAR</b>

\* distinction between *H. abyssalis* and *H. antarctica* is unclear and awaits further specimens from the type localities and a thorough redescription of both entities.

### Acknowledgements

Thanks go to Andy Gooday for his hard work in collecting and preserving the specimens; and to all the scientists and crew on *Charles Darwin* cruise 151.

### References

- Andres, H.G. (1983) Die Gammaridea (Crustacea: Amphipoda) der deutschen Antarktis-Expeditionen 1975/76 und 1977/78. 3. Lysianassidae. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut*, 80, 183–220.
- Barnard, K.H. (1930) Amphipoda. British Antarctic (“Terra Nova”) Expedition, 1910 *Natural History Reports, Zoology*, 8, 307–454.
- Barnard, J.L. (1966) Submarine Canyons of southern California part V systematics: Amphipoda. *Allen Hancock Pacific Expeditions*, 27, 1–166.
- Barnard, J.L. & Ingram, C. (1990) Lysianassoid Amphipoda (Crustacea) from deep-sea thermal vents. *Smithsonian Contributions to Zoology*, 499, 1–80.
- Barnard J.L. & Karaman, G.S. (1991) The families and genera of marine gammaridean Amphipoda (except marine gammaroids). *Records of the Australian Museum*, Supplement 13, 419–866.
- Birstein, J.A. & Vinogradov, M.E. (1955) Pelagicheskie gammaridy (Amphipoda, Gammaridea) Kurilo-Kamchatskoi Vpadiny. *Akademiya Nauk SSSR, Trudy Instituta Okeanologii*, 12, 219–257.



- Birstein, J.A. & Vinogradov, M.E. (1960) Pelagicheskie gammaridy tropicheskoi chasti Tixogo Okeana. *Akademiya Nauk SSSR, Trudy Instituta Okeanologii*, 34, 165–241.
- Chevreaux, E. (1889) Amphipodes nouveaux provenant des campagnes de l'*Hirondelle*, 1887-1888. *Bulletin de la Société Zoologique de France*, 14, 284–289.
- Chevreaux, E. (1910) Diagnoses d'amphipodes nouveaux provenant des campagnes de la *Princesse-Alice* dans l'Atlantique nord. *Bulletin de l'Institut Oceanographique*, 156, 1–4.
- Chevreaux, E. (1935) Amphipodes provenant des campagnes du Prince Albert 1<sup>er</sup> de Monaco. *Résultats des Campagnes Scientifiques accomplies par le Prince Albert 1 Monaco*, 90, 1–214.
- Coleman, C.O. (2004) "Digital inking": How to make perfect line drawings on computers. *Organisms Diversity & Evolution*, 3, Electr. Suppl. 14, 1–14.
- Dahl, J.D. (1959) Amphipoda from depths exceeding 6000 meters. *Galathea Report*, 1, 211–240.
- Dallwitz, M.J., Paine, T.A. & Zurcher, E.J. (1997) User's guide to the DELTA system. A general system for processing taxonomic descriptions. 4.08. CSIRO Division of Entomology, Canberra, 160 pp.
- De Broyer, C., Lowry, J.K., Jazdzewski, K. & Robert, H., (2007) Volume 1: Part 1. Catalogue of the gammaridean and corophiidean Amphipoda (Crustacea) of the southern Ocean with distribution and ecological data. In: De Broyer, C. (Ed), *Census of Antarctic Marine Life. Synopsis of the Amphipoda of the Southern Ocean. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Biologie*, 77, Brussels, Belgium, pp. 1–324.
- Diffenthal, M. & Horton, T., (2007) *Stephonyx arabiensis* (Crustacea: Amphipoda: Lysianassoidea: Uristidae), a new deep-water scavenger species from the Indian Ocean, with a key to the genus *Stephonyx*. *Zootaxa*, 1665, 31–41.
- Horton, T. (2005) A new amphipod species from the Indian Ocean (Crustacea: Amphipoda: Lysianassoidea: Poprionidae). *Zootaxa*, 861, 1–11.
- Janssen, F., Treude, T., & Witte, U. (2000) Scavenger assemblages under differing trophic conditions: a case study in the deep Arabian Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, 47, 2999–3026.
- Lichtenstein, H. (1822) In: Mandt, M.W. *Observationes in historiam naturalem et anatomiam comparatam in itinere Groenlandico factae*, pp. 31–37.
- Lowry, J.K. & Stoddart, H.E. (1992) A revision of the genus *Ichnopus* (Crustacea: Amphipoda: Lysianassoidea: Uristidae). *Records of the Australian Museum*, 44, 185–245.
- Lowry, J.K. & Stoddart, H.E. (1995) New lysianassoid genera and species from south-eastern Australia (Crustacea: Amphipoda). *Records of the Australian Museum*, 47, 7–25.
- Schellenberg, A. (1926) Amphipoda 3: Die Gammariden der Deutschen Tiefsee-Expedition. *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia"*, 23 (5), 193–243.
- Shulenberger, E., & Barnard, J.L. (1976) Amphipods from an Abyssal trap set in the North Pacific Gyre. *Crustaceana*, 31, 241–258.
- Stebbing, T.R.R. (1888) Report on the Amphipoda collected by H.M.S. Challenger during the years 1873-76. *Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873–76, Zoology*, 29, 1–1737.
- Stephensen, K. (1923) Crustacea Malacostraca, V: (Amphipoda, I). *Danish Ingolf-Expedition* 3 (8), 1–100.
- 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, Balkema, Rotterdam, pp. 15–27.
- Witte, U. (1999) Consumption of large carcasses by scavenger assemblages in the deep Arabian Sea: observations by baited camera. *Marine Ecology Progress Series*, 183, 139–147.