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Glyptogidiella omanica gen. et sp. nov., an inland groundwater bogidiellid from Oman with enlarged coxal plate V (Crustacea, Amphipoda)

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Abstract

A new genus and species of Amphipoda is reported from inland ground waters of the Sultanate of Oman. Although *Glyptogidiella omanica* **gen. et sp. nov.** exhibits several features typical of the Bogidiellidae (i. e. combined display of distinct carpal lobe on first gnathopod, reduced pleopodal rami, and unsegmented exopodite of third uropod), its exceptionally large fifth coxal plate and short rami of third uropod do not fit in the restricted diagnosis of the family as recently presented elsewhere. In fact, the enlarged coxal plate V is a feature not reported in any other amphipod, whereas no other bogidiellid displays an expanded basis on pereopod VII. The habitus of *Glyptogidiella* is not typical for a dweller of a true interstitial niche, with its short antennae, large coxal plate and short and stubby rami on the third uropod. This suggests that the interstitial medium could not be the primary habitat for the species, and that the underground of wadis might contain interstices of large size and could also be in contact with karstic hollows.

Key words: Gammaridea, Bogidiellidae, stygofauna, subterranean waters, hyporheic, wadi, Arabian Peninsula

Introduction

In the spring of 1996 the Zoological Museum of the University of Amsterdam and the Oman Research Department of the Ministry of Water Resources conducted a biological ground water survey in the Sultanate of Oman (Stock *et al*., 1997). Several organisms living in subterranean waters were collected from wadis (= ravines that remain dry except in the rainy season), shores of lagoons, springs, wells, and anchialine and freshwater caves. In subsequent years most of this stygobiont fauna, ranging from water mites (Smit, 2003), water beetles (Wewalka & Biström, 1998), bristle- and earthworms (Glasby, 1997; Martínez-Ansemil *et al.* 2003) to amphipod (Ruffo *et al*., 2003; Iannilli *et al.*, 2006) and isopod crustaceans (Botosaneanu & Stock, 1997; Magniez & Stock, 1999; 2000) were studied by European, American, and Australian specialists, and new species were described.

Some crustaceans remained in the drawers of the museum in Amsterdam, as they were intended to be worked on by the late Jan H. Stock, initiator of the Oman survey. The present study re-examines this material and dislodges some more amphipod specimens, this time belonging to a new and morphologically rather aberrant species of the family Bogidiellidae. The specimens, 10 in number, were retrieved from the hyporheic flow (shallow groundwater) on several spots in a dry wadi placed in the Halban area some 15 km from the coast, and in one case from an open well in the vicinity of the city of Nizwa, 100 km from the coast. Both localities are situated in the North of Oman (Fig. 1). The specimens are characterised by an exceptionally large coxal plate of the fifth pereopod.

Earlier studies on the stygobiont crustaceans of this groundwater expedition in 1996 rendered new Bogidiellidae that were placed in two separate new genera *Stockigidiella* and *Omangidiella* (Iannilli *et al.*, 2006). Now, partially from the same locality as *Omangidiella*, another new taxon is described. As the foregoing two genera, the new genus was found only in freshwater.

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Material and methods

Samples were taken with a Cvetkov net in wells, or with a Bou-Rouch biophreatical pump (see Bou (1974) for a description of both devices) from hyporheic habitats at depths of 50 to 110 cm beneath streambeds. Specimens were fixed in the field in formalin and transferred to 70 % ethanol once in the laboratory. Before study, specimens were treated with lactic acid to soften the cuticle and remove internal tissues to facilitate observation. Drawings were prepared using a camera lucida on Olympus BH2 and Leica DM 2500 microscopes equipped with Nomarski differential interference contrast. Material preserved on slides was mounted in lactophenol and the coverslips sealed with nail varnish. Body measurements were derived from the sum of the maximum dorsal dimensions (including telescoped portions) of head, pereonites, pleosomites and urosomites, and exclude telson length. Material is deposited in the Crustacea collection of the Zoological Museum of the University of Amsterdam (ZMA). Following Watling (1989), the term "spine" in descriptions is restricted for rigid armature elements with a hollow central core that do not articulate basally to the body integument. Gnathopods I and II, and pereopods III to VII appear abbreviated elsewhere as G1–G2 and P3–P7, respectively; uropods I–III, as U1–U3.

Taxonomy

Order AMPHIPODA Latreille, 1816

Suborder GAMMARIDEA Latreille, 1802

Family Bogidiellidae Hertzog, 1936

Glyptogidiella gen. nov.

Diagnosis. Bogidiellidae with three pairs of long stalked coxal gills, present on pereopods IV to VI. Molar process of mandible non-triturative. Maxillule coxal endite (= inner plate) unarmed; basal endite (= outer plate) with six distal robust setae; endopodite (= palp) unsegmented. Maxilliped lacking coxal endite. Coxal plates I–V not reduced, I–IV longer than broad, each with anterior margin overlapping one in front. Coxa V very large, ovoid, covering almost completely plate VI, and partially plates IV and VII. Basis of pereopod VII expanded; medial margin of propodus provided with two long and stiff setae conferring limb acicular aspect. Pleopods uniramous, with anterodistal corner of medial margin of protopod produced into pointed process. Uropod III with short rami, each shorter than half length of protopod. Telson slightly longer than broad with strongly convex distal margin.

Type species. *Glyptogidiella omanica* sp. nov. described herein, by original designation.

Etymology. Genus name derived by combination of the Greek "glyptos", meaning deeply carved, alluding to the ostentatiously carved out coxal plate V displayed by the new taxon, and the ending of *Bogidiella*, the type genus of the family Bogidiellidae.

Glyptogidiella omanica sp. nov.
(Figs. 2–6)

Material examined. None of 10 specimens known display oostegites, penile papillae or any other trait indicative of gender. All collected by Jan H. Stock and co-workers.

Halban area, Wadi Taww (stations nos. 96–37, 96–48, 96–51, 96–52 and 96–67 of Stock *et al*., 1997). UTM coordinates 0604748/2606459. Several probes with Bou-Rouch pump on dry gravel banks of wadi, with pipe placed between 50 cm and 1 m below sediment surface. Conductivity range: 557–581 microS; temperature range: 28.3–28.7 ºC. Holotype 1.85 mm, completely dissected and mounted on single slide

[ZMA-206.071]. Paratypes: Seven specimens, of which one damaged and not measured; rest 1.81, 1.48 (juvenile?), 1.70, 1.15 (juvenile?), 1.56 and 1.83 mm; all preserved in single ethanol vial [ZMA-206.072]. Collected 28 March 1996. Accompanying fauna: *Omangidiella parvidactyla* (Bogidiellidae); Isopoda; Thermosbaenacea; Cyclopidae; Ostracoda; Chironomid larvae; Acari; Gastropoda; Oligochaeta.

Additional material: Nizwa, Al-Gumor (station no. 96–32 of Stock *et al*., 1997). UTM coordinates 0554894/2537653. Rectangular, shady open well with diesel pump. Conductivity: 743 microS; temperature: 28.3 ºC. Two specimens 1.88 and 1.70 mm, preserved in single ethanol vial [ZMA-206-073]. Collected with Cvetkov net, 26 March 1996.

Diagnosis. As for the genus.

Description. *Body* (Fig. 2) up to 1.88 mm long, compact, unpigmented, eyeless. Some portions of body integument micro-sculptured as shown in some figures. *Head* (Fig. 3A) with faint rostrum and with well-developed, slender lateral lobe. Tergites of *pleonites* and *urosomites* unarmed, lacking robust setae. *Epimeral plates* (Figs. 2; 6A) unarmed, with rounded posterodistal corners.

Antennule (Fig. 3A) short, about as long as head and first pereonite combined; relative length of peduncle segments as 100: 50: 30. Main flagellum clearly shorter than peduncle, 7-articulate, some articles provided with long aesthetasc. Accessory flagellum 2-articulate.

Antenna (Fig. 3A) about as long as antennule. Peduncle segments I and II completely fused into composite segment displaying slender gland cone; relative length of segments III-V as 30: 53: 100. Flagellum as long as peduncle segment V, 5-articulate; short aesthetasc present on articles 2 and 5.

Labrum (Fig. 3B) with shallow concave distal margin. *Paragnaths* with well-developed inner lobes (Fig. 3F).

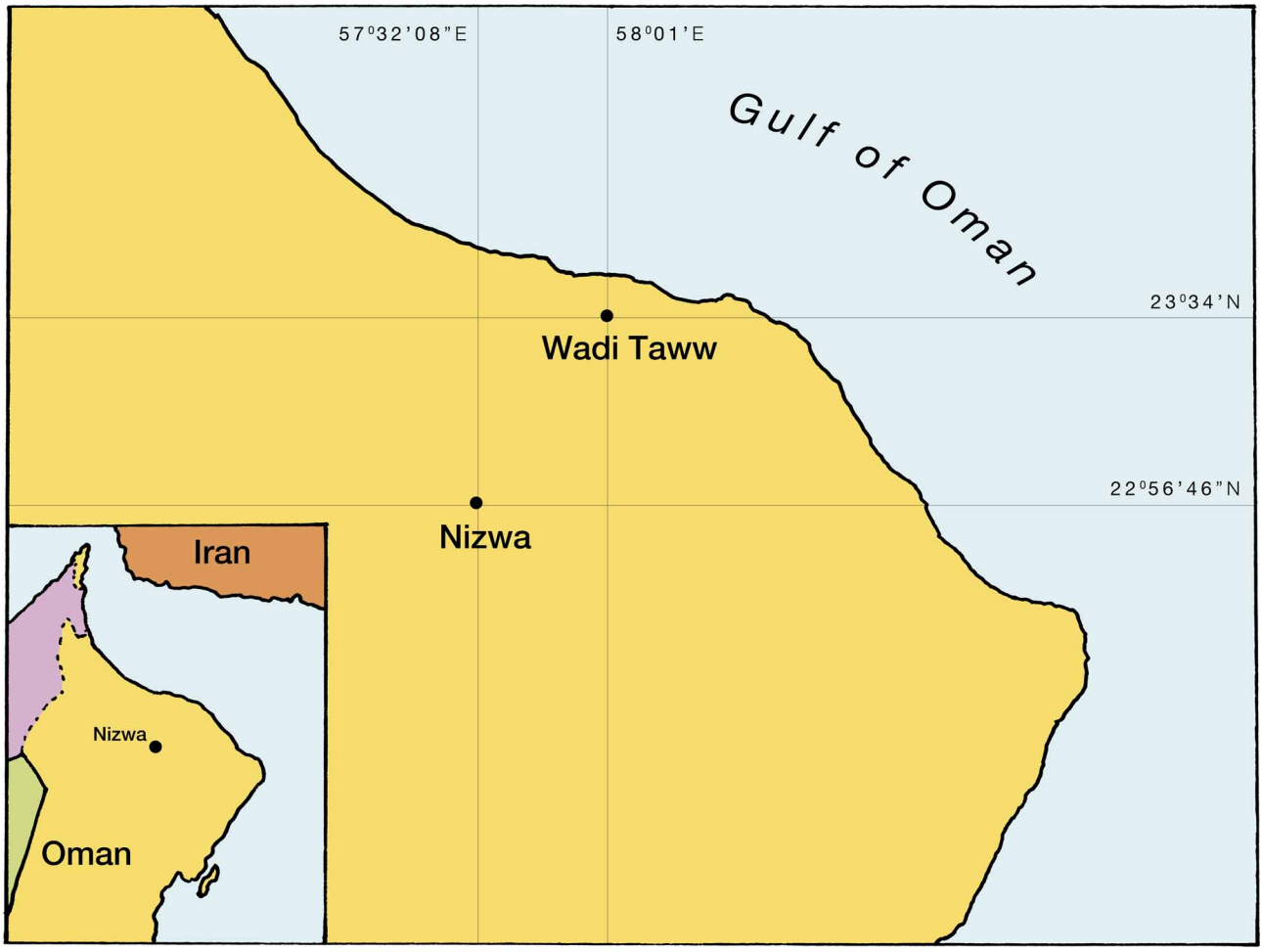

FIGURE 1. Locations of *Glyptogidiella omanica* **gen. et sp. nov.** in a wadi (Wadi Taww) and in a well (nearby Nizwa), Sultanate of Oman (Arabian Peninsula).

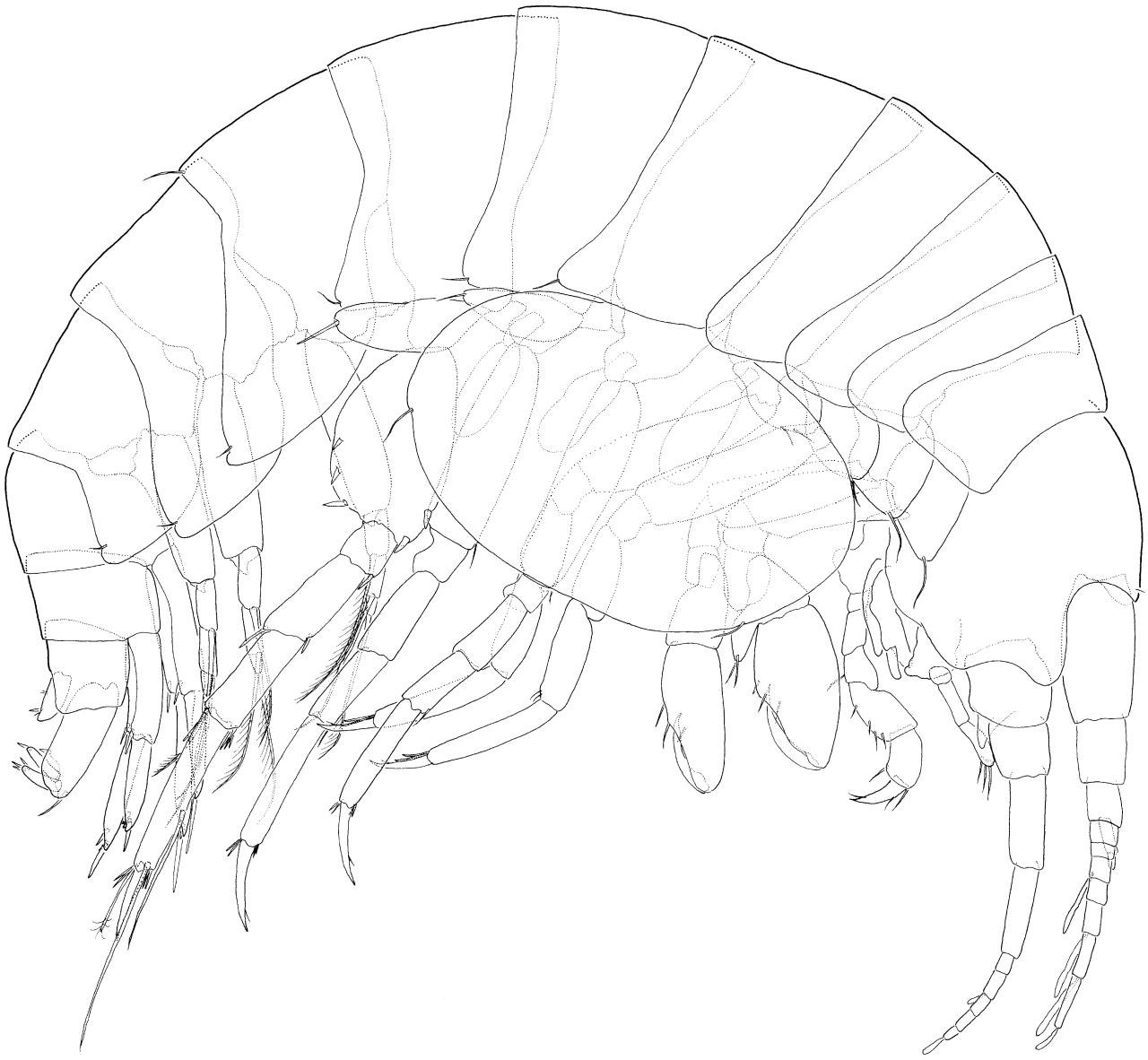

FIGURE 2. *Glyptogidiella omanica* **gen. et sp. nov.**, sex unknown. Habitus of paratype 1.70 mm.

Left mandible (Fig. 3B, E) with incisor broader than long; cutting edge hardly denticulated. Lacinia as large as incisor; distal margin provided with seven rounded dentices. Spine row consisting of three well-developed setulose elements plus two setulose bulges; two reduced setulose processes placed intercalated between three main setulose elements as figured. Molar process with armature and ornamentation reduced to short simple seta on distal margin aside of ordinary long molar seta.

Right mandible (Fig. 3B, D) with incisor cutting edge more sharply denticulated than left counterpart. Lacinia smaller than incisor, bifid, each branch with multi-denticulated distal margin; denticles rounded. Spine row as figured; molar process almost symmetrical to left counterpart but with setae more reduced.

Mandibular palp (Fig. 3B) 3-segmented, relative length of segments as 24: 100: 70; segments I and II unarmed, segment III with three unequal simple setae distally and with patch of densely-set long spinules on anterior surface (Fig. 3C).

Maxillule (Fig. 3G) basal endite (= outer plate) with two out of 6 slender robust setae simple. Endopodite (= palp) with two unequal simple setae distally.

Maxilla (Fig. 3H) reduced, outer plate with 4+1 simple setae distally, inner plate bearing four.

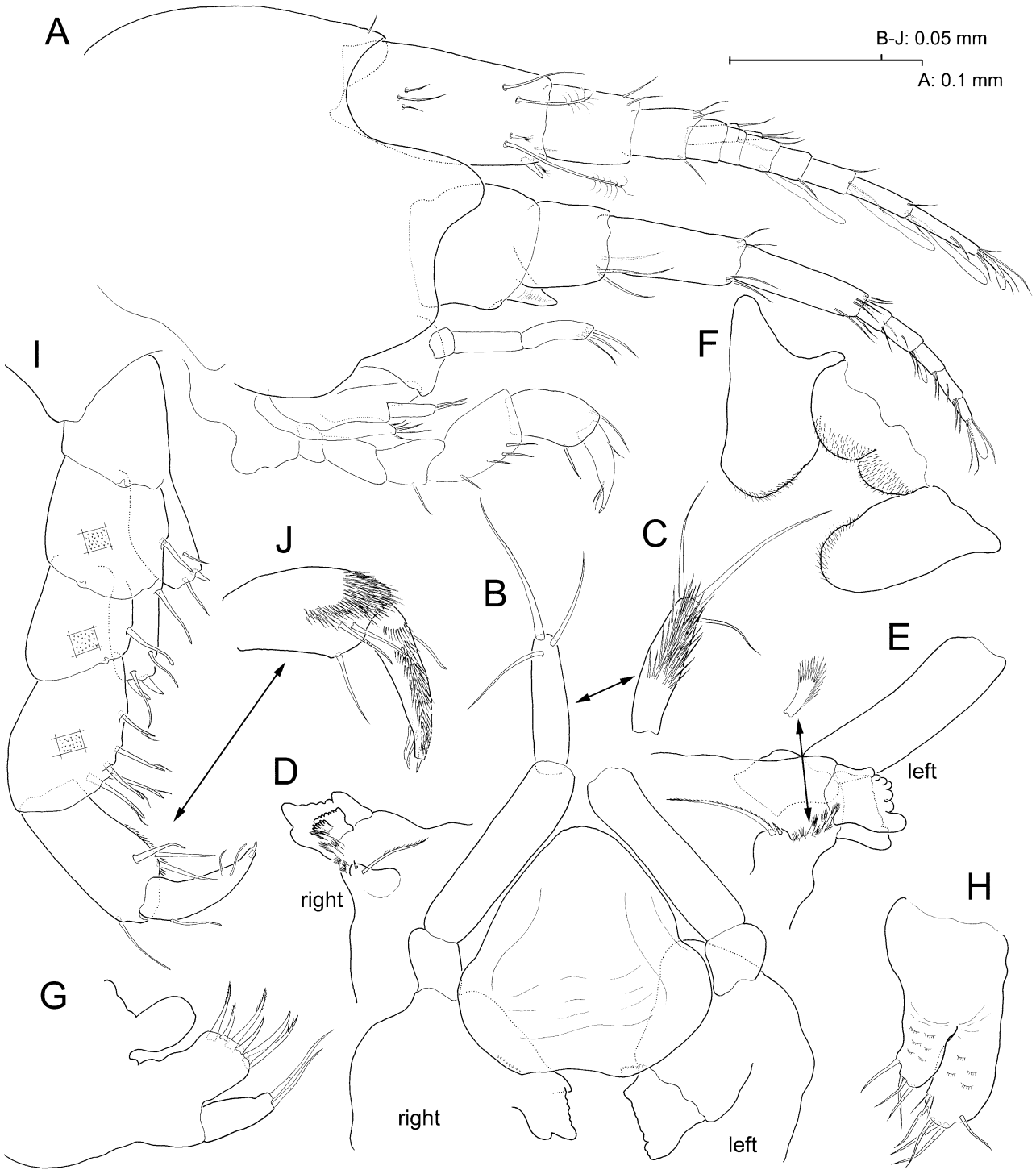

FIGURE 3. *Glyptogidiella omanica* **gen. et sp. nov.**, 1.85 mm, holotype, sex unknown. A, Head, lateral; B, labrum and both mandibles, right branch with mandibular palp attached, left branch with distal segment of mandibular palp wanting, ventral; C, detail of distal segment of right mandibular palp showing patch of spinules on anterior surface; D, distal portion of right mandible; E, same of left mandible, with inset showing one element of spine row; F, paragnaths; G, maxillule; H, maxilla; I, left maxilliped, posterior; J, distal segments of latter, showing spinulose medial surface.

Maxilliped (Fig. 3I, J) basal endite (= inner plate) weakly armed, with single short robust seta distally; ischial endite (= outer plate) with two. Nail with extremely reduced unguis. Other armature on limb as figured.

Coxal plates (Fig. 2) progressively shorter towards posterior from coxa I to IV. Coxa V (Fig. 5C) hypertrophied, 1.6 times broader than long, ovoid, evenly rounded. Coxal plates VI–VII much broader than

long, strongly produced posteriorly, lacking anteroventral lobe; coxa VI with slender simple seta on tip (Fig. 5D); coxa VII with robust seta on homologous position (Fig. 4C).

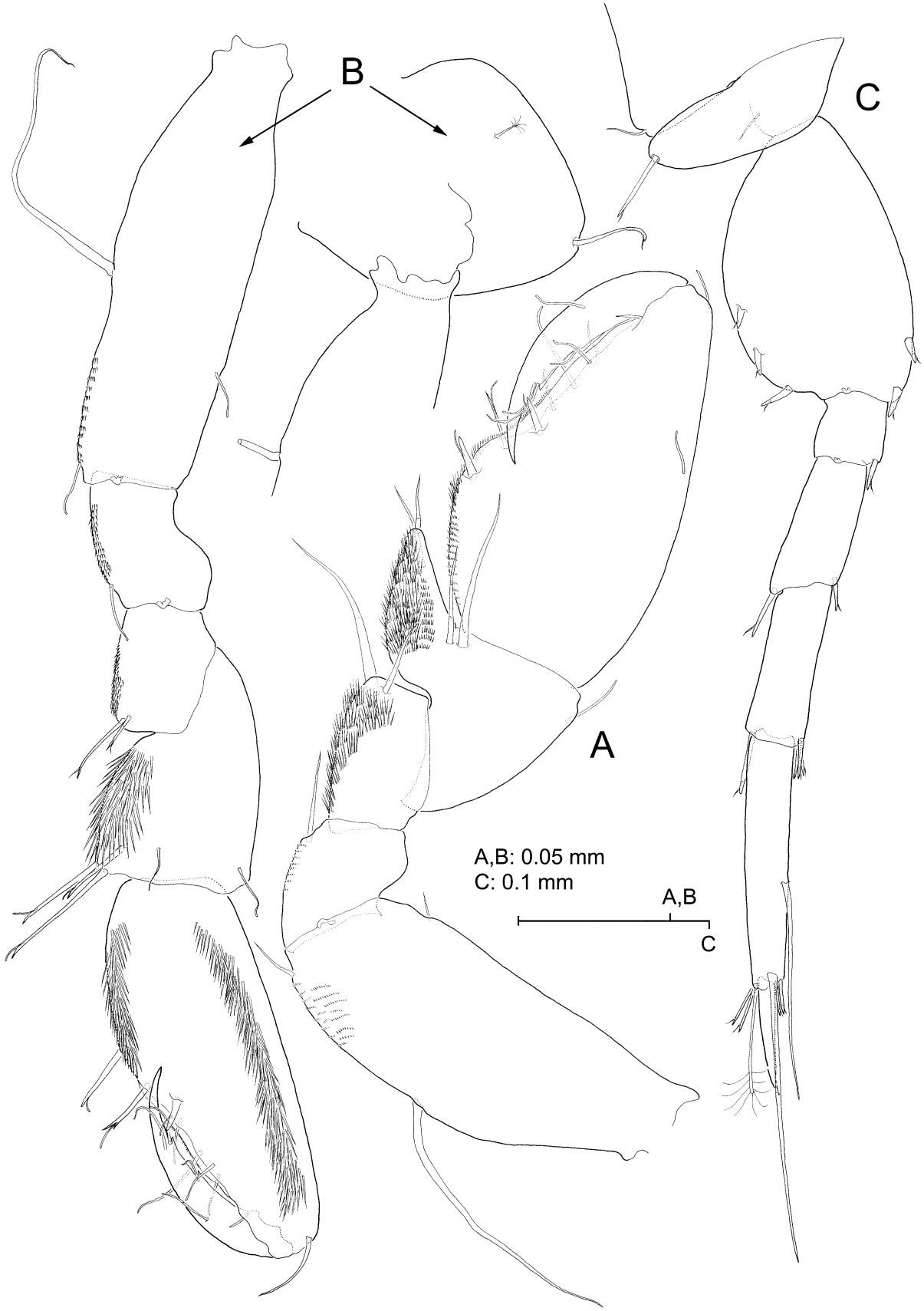

FIGURE 4. *Glyptogidiella omanica* **gen. et sp. nov.**, 1.85 mm, holotype, sex unknown. A, right gnathopod I, medial; B, left gnathopod II with corresponding coxal plate detached, medial; C, right pereopod VII, lateral.

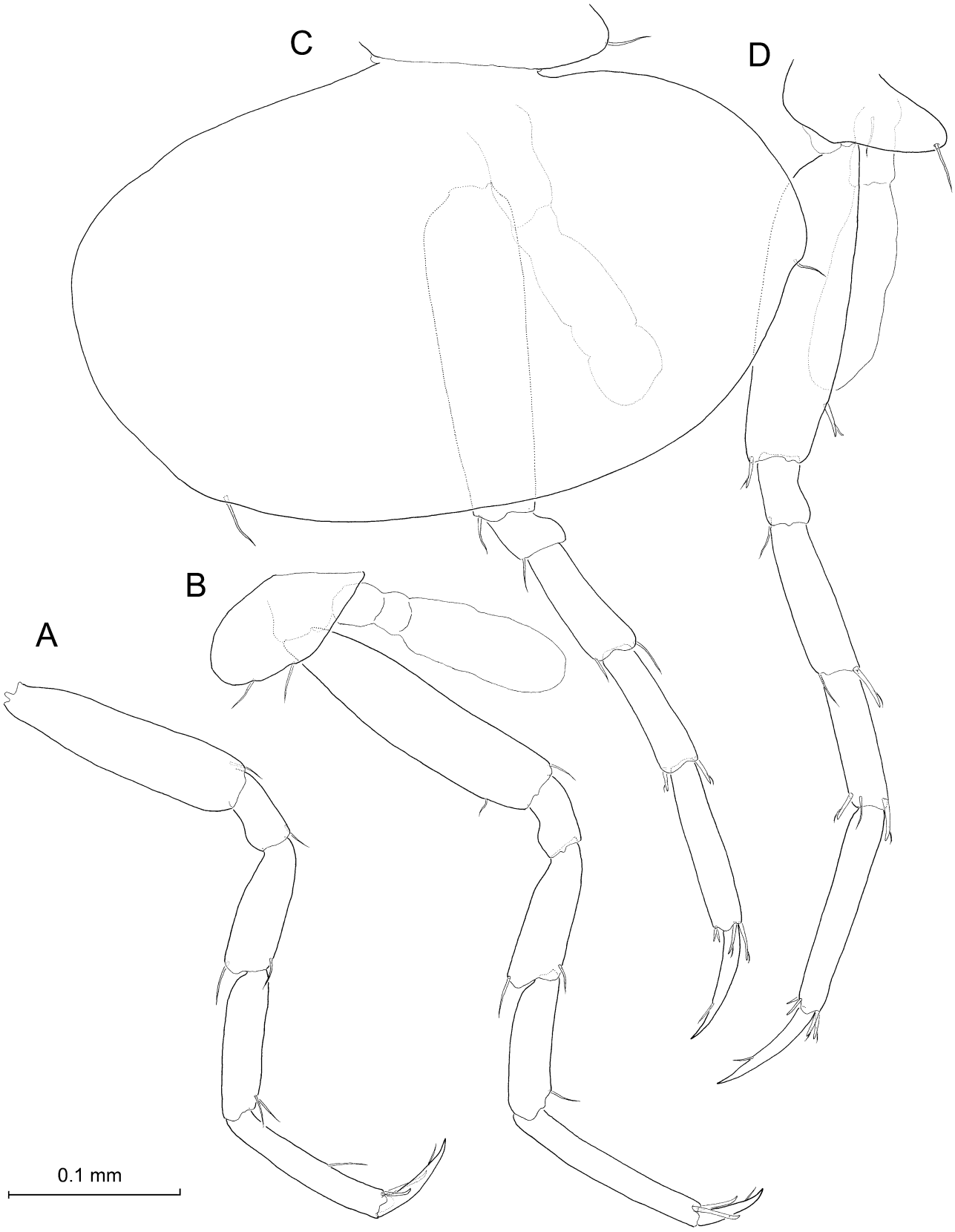

FIGURE 5. *Glyptogidiella omanica* **gen. et sp. nov.**, 1.85 mm, holotype, sex unknown. A, Left pereopod III; B, left pereopod IV; C, left pereopod V; D, left pereopod VI. All figures in lateral aspect.

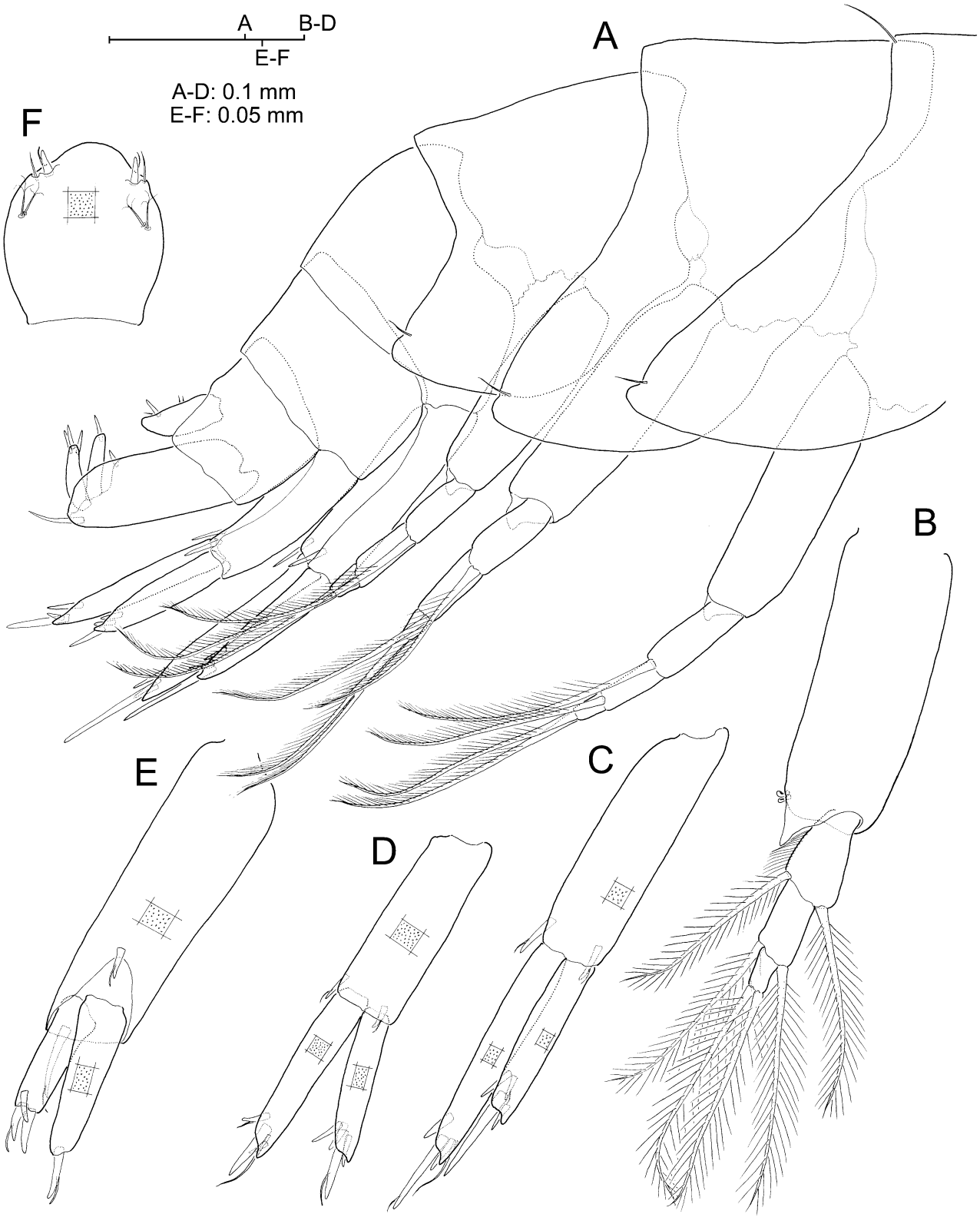

FIGURE 6. *Glyptogidiella omanica* **gen. et sp. nov.**, 1.85 mm, holotype, sex unknown. A, posterior portion of body showing epimeral plates and relative proportions of pleopods and uropods, lateral; B, left pleopod III, anterior; C, left uropod I, anterior; D, left uropod II, anterior; E, left uropod III, posterior (= dorsal); F, telson, posterior (= dorsal).

Coxal gills simple, provided with long stalk (Figs. 2; 5B–D).

Gnathopod I (Fig. 4A) larger than G2, all segments with posteromedial margin covered with patch of

spinules; those comprising patch on merus and carpus much longer than rest. Carpal lobe pointed, guarding almost entirely posterior margin of propodus. Propodus stout, subchelate, 1.9 times longer than broad, broadest at level of palm angle; palm margin strongly oblique, slightly concave beside palm angle, latter with short flagellate robust seta as only armature; relevant armature along palm margin reduced to short robust seta similar to that on palm angle plus more slender flagellate seta placed in between. Nail not reaching palm angle, with unguis completely incorporated into dactylus; latter with two notches on posterior margin.

Gnathopod II (Fig. 4B) slender, each segment provided with patch of spinules on posteromedial margin as in G1, but with additional patch along medial surface of propodus running subparallel to anterior margin of segment. Propodus long and slender (2.4 times longer than broad), narrow, not broader than carpus, subchelate with palm margin strongly oblique; anterior and posterior margins parallel; armature on palm angle reduced to long and stout flagellate seta; relevant armature on palm margin reduced to stout flagellate bifid seta plus shorter flagellate robust seta placed as figured. Nail as in G1.

Pereopods progressively longer towards posterior (Fig. 2). P3 to P6 hardly armoured, with slender, non-expanded basis; dactylus completely incorporated into unguis. P3 and P4 (Fig. 5A, B) bearing pair of stout setae curved at tip on posterodistal corner of propodus; these setae reduced in P5–P7 (Figs. 5C, D; 4C). Pereopod VII (Fig. 4C) longest, differing from preceding P5–P6 in display of expanded basis; latter lacking both posterodorsal and posteroventral lobes; anterior and posterior margin of segment armed with 2 and 3–4 stout robust setae, respectively. Pereopod remarkable also in display of long (more than twice length of nail) and stiff simple seta on distal margin of propodus; in addition, there is additional long and stiff seta placed about midway of medial margin of segment, plus long penicillate seta (as long as nail) on distal margin.

Pleopods (Fig. 6A, B) similar, each with exopodite shorter than protopod. Protopod provided with 2 retinacles. Exopodite 3-articulate, none of marginal setae on articles modified.

Uropods I-III biramous, each with exopodite clearly shorter than endopodite. *Uropod I* clearly longer than U2; U3 almost as long as U1. *Uropods I–II* (Fig. 6C, D) similar in armature and ornamentation: Each with protopod about as long as endopodite, bearing one posterodistal flagellate robust seta at each side; exopodite with four unequal robust setae, and endopodite with three robust setae plus slender simple seta distally; both rami ending into pointed process; one specimen, by exception, displays basofacial robust seta on peduncle of U1. *Uropod III* (Fig. 6E) with protopod more than twice length of rami, armature consisting of short flagellate robust seta on posterodistal corner of outer margin and long flagellate robust seta on anterodistal margin of segment; exceptionally, one of specimens displayed slender simple seta on posterodistal corner of medial margin of left uropod; exopodite with three robust setae distally, endopodite bearing only one.

Telson (Fig. 6F) with convex lateral margins. Armature consisting of flagellate robust seta plus simple seta subdistally at each side; pair of penicillate setules placed dorsolaterally at each side as figured.

Etymology. Species named after the Sultanate of Oman (Arabian Peninsula), the type locality of the species.

Remarks. The new taxon from Oman fits well in the Bogidiellidae *sensu lato* based on the combined display of a distinct carpal lobe on the first gnathopod, reduced pleopodal rami and unsegmented exopodite of third uropod. But the reduced rami of the third uropod and the modified coxal plate of pereopod V are remarkable autapomorphies of *Glyptogidiella* that impedes its accomodation in the restricted diagnosis of the family as presented by Koenemann & Holsinger (1999). In fact, the enlarged coxal plate V is a feature not reported in any other amphipod. Another remarkable feature of *Glyptogidiella* allowing its distinction from any other bogidiellid at first glance is the expanded basis of pereopod VII.

Glyptogidiella shares the presence of 6 robust setae on the basal endite (= outer plate) of the maxillule with the other two Bogidiellid species found in Oman, *Stockigidiella aequimana* Iannilli, Holsinger, Ruffo & Vonk, 2006 and *Omangidiella parvidactyla* Iannilli, Holsinger, Ruffo & Vonk, 2006 (see Iannilli *et al.*, 2006). This is a rare feature within the Bogidiellidae (Koenemann & Holsinger, 1999), but it is also noted in such far away genera as *Mexigidiella* Stock, 1981, from Mexico and Haiti, and *Racovella* Jaume, Gràcia & Boxshall, 2007 from the Balearic Islands (Jaume *et al.*, 2007). At this moment, no affinities based on character comparison can be suggested for the new taxon.

Hydrological conditions in the underground of arid coastal areas are complex, variable and often

influenced by groundwater extraction for human use. Natural conditions may have produced, over prolonged periods, a rich and biodiverse stygofauna in these ecosystems, but recent anthropogenic developments are changing the habitat characteristics. Regarding the local biogeography, we should distinguish between natural conditions that shaped the stygofaunal community over long periods of climatic stability, and environmental changes that occurred over the last decades due to large-scale groundwater extraction. For instance, Al-Mushikhi (2002) showed that in the Eastern Batinah region, where Wadi Taww is located and where *Glyptogidiella* and *Omangidiella* are found, the annual balance of groundwater in 1999 consisted of 21 % seawater intrusion as compared with 0.3 % in 1973. In the coastal region of North Oman groundwater pumping exceeds annual precipitation by one third, causing storage depletion and ensuing water table drop and concurrent intrusion of seawater (Kacimov *et al.*, 2009). Of course, other large fluctuations in hydrological conditions have played a role in the recent past. Only 6000 years ago, the sea level in the region was about 2 m higher (Bernier *et al.*, 1995); this might have enabled marine fossorial fauna to colonize the interstitial of alluvial deposits and the open pores of limestone cavities. In this respect it is noteworthy that exceptionally large coxal plates —such as the extraordinary coxa V of *Glyptogidiella*— is the type of feature encountered in some benthic marine amphipods, but not in groundwater forms. Large, shield-like coxal plates, although not the fifth, are seen in members of several amphipod families, such as Stenothoidae, Thaumatelsonidae or Nihotungidae (Krapp-Schickel & Koenemann 2006; Barnard & Karaman, 1991). The habitus of *Glyptogidiella* is not typical for a dweller of a true interstitial niche, with its short antennae, large coxal plate and short and stubby rami on the third uropod. This could not be the primary habitat of the new taxon: The underground of wadis might contain interstices of larger size and could also be in contact with karstic hollows, as discussed earlier by Magniez & Stock (2000) in commenting on the presence of large sized isopods (11 mm) in Wadi Taww.

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