RAFFLES BULLETIN OF ZOOLOGY **62**: 591–599
Date of publication: 8 August 2014
http://zoobank.org/urn:lsid:zoobank.org:pub:4B0A7B82-1507-4576-988A-7A0B3710B307

A new species of cavernicolous crab from Coron Island, Palawan, the Philippines (Decapoda: Brachyura: Varunidae)

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Abstract. Pukaway Cave, an anchialine cave on Coron Island (Palawan Province, Philippines) is shown to harbour three distinct species of *Orcovita* Ng & Tomascik, 1994. Two of these have been previously described elsewhere (viz. *O. angulata* Ng, Guinot & Iliffe, 1996, and *O. holthuisi* Ng & Ng, 2009). A new species, *O. tabiacoud*, as well as the male of *O. angulata*, are described for the first time here. The presence of three different species of *Orcovita* in the same biotope is discussed.

Key words. Varunidae, *Orcovita*, cave crabs, anchialine, Philippines

INTRODUCTION

In 1991, a scientific expedition, sponsored by the Italian National Council of Research, the Natural History Museum of Florence University, the Natural History Museum of Verona, and the French speleological club "Aven Club Valettois", was carried out in some karst areas in the Philippine islands of Coron, Palawan and Samar. This expedition resulted in the collection of a noticeable number of Decapoda from cave environments.

In subsequent years, specimens from Palawan, West Samar and Coron islands were studied, resulting in the identification of new species (respectively *Caridina gortio*, *C. minidentata*, *C. samar* and *Potamalpheos palawanensis* by Cai & Anker, 2004; *Orcovita holthuisi* by Ng & Ng, 2009). Cave-associated freshwater crabs, belonging to the Gecarcinucoidea (Rathbun, 1904) and Potamoidea (Ortmann, 1896), from Palawan and Samar are currently under examination by Stasolla et al. (in prep.).

Some specimens from this expedition were sent on loan and returned to the Museum in recent times, although they were not studied. Among the returned material, are some interesting crab specimens from Coron Island, a sacred place which is usually closed to visitors.

This paper reports the description of a new species, belonging to the genus *Orcovita* (Ng & Tomascik, 1994), and the first description of a male specimen of an already known species from Coron, *O. angulata* (Ng, Guinot & Iliffe, 1996).

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ISSN 2345-7600 (electronic) | ISSN 0217-2445 (print)

MATERIAL AND METHODS

The crabs were collected in March 1991, in Pukaway Cave, Coron Island, Palawan, Philippines, by Roberto Berti (Department of Biology, Florence University) and Stefano Meggiorini (Museo Civico di Storia Naturale, Verona). The island's exploration was organised in the framework of the scientific expedition "Palawan '91" in cooperation with the St. Paul Subterranean National Park Project, the Debt-for-Nature Swap Program and the Department of Environment and Natural Resources of the Philippines (Piccini & Rossi, 1994).

Coron Island is located in the central Philippines at 11.910000 N, 120.250000 E. It is situated off the southeastern corner of the larger island of Busuanga. The island is 20 km long with a width that never exceeds 9 km, its shape is irregularly triangular and its maximum altitude is 625 m a.s.l.

With the exception of a terrigenous rock outcrop in its northeastern portion, the island is completely carbonatic. The island is characterised by numerous karstic depressions and lakes, with altitudes ranging from 200 to 500 m a.s.l. The speleological activity in Coron is difficult in terms of both environmental and human factors. The former depend upon the extremely complex topography of the island, the inaccessibility of the coasts and the total lack of paths or roads reaching the inner parts of the island. Moreover, the island is granted to a local ethnic minority, the Tagbanua, a people very aware of the value of their territory. The presence of foreigners is therefore seen as a nuisance, as many caves have been used as burial sites or contain valued swiftlet nests, an important factor for the local economy.

Pukaway Cave is situated at 11.962502 N 120.229823 W, 15 m a.s.l. and it extends for 44 m. The entrance of the cave is characterised by subvertical, anastomosed fractures independently reaching the hall vault. This wide space is completely occupied by an 11 m deep lake with several

underwater stalactite formations. Water conductivity revealed a main salty body with a thin layer of freshwater on top, probably due to percolation (Piccini & Rossi, 1994).

All the specimens are held in the Natural History Museum, Zoological Section "La Specola", Florence University (catalogue numbers are indicated by the acronym MZUF). The systematic order follows Ng et al. (2008).

The abbreviations M, P, and D refer to the merus, propodus, and dactylus of the ambulatory legs, respectively; the number preceding it refers to the respective leg; G refers to gonopods and the number after it refers to the first or second gonopod.

TAXONOMY

Superfamily Grapsoidea MacLeay, 1838

Family Varunidae H. Milne Edwards, 1853

Subfamily Varuninae H. Milne Edwards, 1853

Orcovita Ng & Tomascik, 1994

Diagnosis. (Modified from Ng & Tomascik, 1994) Carapace subrectangular, distinctly broader than long (width ca. 1.4 times length); dorsal surface relatively smooth; regions poorly defined; epigastric cristae low; postorbital cristae not discernible. External orbital angle very broad, with one low epibranchial tooth; frontal median triangle present, formed by 3 granular ridges. Third maxilliped with very broad, stout exopod, as wide or slightly wider than ischium; anteroexternal angle of merus strongly auriculiform. Chelipeds relatively long, pulvinus with setose base sometimes present at base of fingers of both male chelae, tip of fingers occasionally have short, dense setae. Ambulatory legs subcylindrical in cross-section, articles long and slender. Telson of male short, ca. 1.4 times length of segment 6. G1 relatively short, stout, tip truncate from lateral view.

Orcovita holthuisi Ng & Ng, 2009
(Figs. 1, 2)

Orcovita holthuisi Ng & Ng, 2009: 1098, figs. 1–4.

Material examined. 3 females (12.3 × 10.0 mm; 10.9 × 9.4 mm; 10.1 × 8.7 mm) (MZUF 3922), Philippines, Coron Island, Pukaway Cave, coll. R. Berti & S. Meggiorini, 15 March 1991.

Remarks. The three females, collected from the type locality, are comparable with the specimens described by Ng & Ng (2009).

Orcovita angulata Ng, Guinot & Iliffe, 1996
(Figs. 3, 4)

Orcovita angulata Ng, Guinot & Iliffe, 1996: 129, figs. 2b, 16.

Material examined. 1 male (16.2 × 11.7 mm) (MZUF 4268), Philippines, Coron Island, Pukaway Cave, coll. R. Berti & S. Meggiorini, 15 March 1991.

Paratype – female, (15.8 × 12.2 mm) (ZRC 1996.112), Philippine, Coron Island, Raft Cave, Station 85-86, coll. T.M. Iliffe; 28 March 1985.

Description. Carapace (Figs. 3A, 4A) subrectangular, distinctly broader than long (width/length ratio ca. 1.4), dorsal surface finely punctate; cervical grooves indistinct; gastric grooves deep with rounded concavity each laterally (<1 mm); epigastric cristae poorly defined, postorbital cristae absent; anterolateral margin lined with small and feeble granules; not clearly distinct from posterolateral margin in the left side of the carapace; external orbital angle broad, with one broad, epibranchial tooth (Fig. 4C), separated from external orbital angle by narrow V-shaped cleft; posterolateral margin concave converging towards the almost straight posterior carapace margin; supraorbital margin clearly granulated, gently sinuous, parallel to sub-parallel with frontal margin; frontal margin sinuous; infraorbital margin feebly granulated, incomplete, not congruent with anterolateral margin; distinct

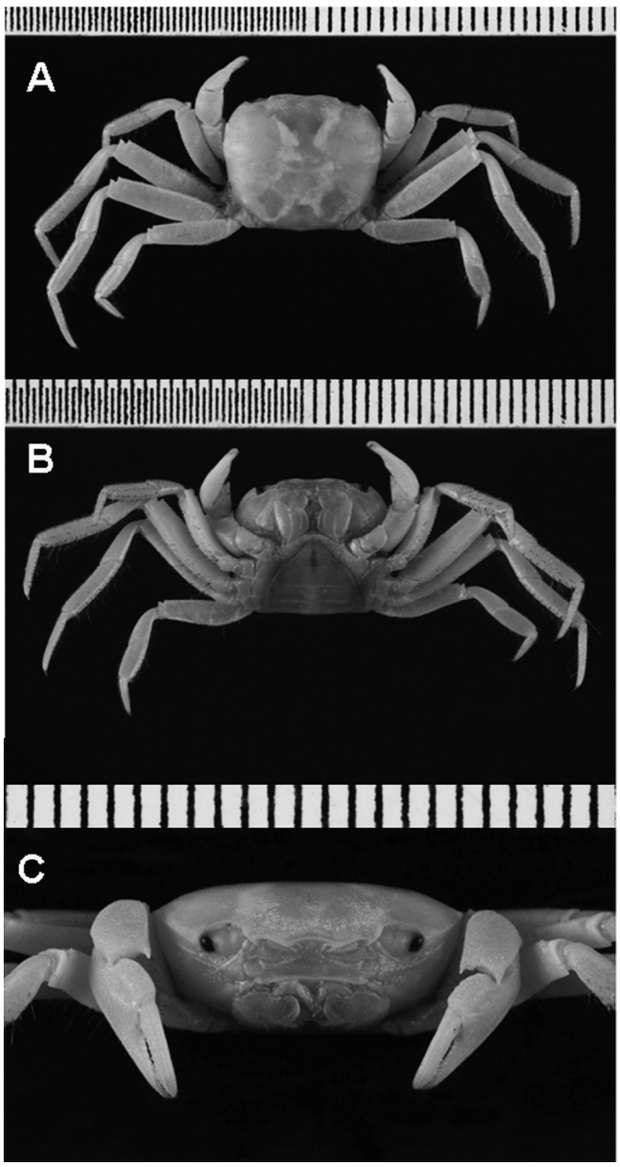

Fig. 1. *Orcovita holthuisi*, female (12.2 × 9.99 mm) (MZUF 3922). A, dorsal view; B, ventral view; C, frontal view.

row of rounded granules present just below infraorbital margin on suborbital region, extending to sub-branchial region. Antennules broad. Antennal articles entering orbital hiatus. Eyes developed, cornea pigmented.

Epistome (Fig. 3C) narrow, posterior margin with one lateral cleft, median part broadly triangular, margin smooth. Third maxilliped (Fig. 4F) with broad, stout exopod, as narrow as ischium of endopod, flagellum well developed; ischium stout; merus broad, antero-external angle edge gently granulate, auriculiform.

Male chelae (Fig. 4D, E) subequal, fingers as long as palm; proximal region of cutting edges of fingers with very small pulvinus. Margins of merus serrated. Carpus rounded, serrated, inner distal angle with low, obtuse tooth. Chelipeds relatively long, surface of articles smooth, without any traces of a longitudinal sulcus; tips of fingers corneous, spoon-like, outer surface of tips of finger with dense, short setae.

Ambulatory legs (Fig. 4G, H) flattened in cross section, all articles very long, slender; third ambulatory leg longest; surface smooth. Anterior dorsal margin of merus with acute, inconspicuous subdistal tooth; anterior, posterior margins of propodus with short and long setae, respectively; dactylus slender, with acute tip. Dactylus slightly rectangular in cross section, flexor margin comb-like in the first three pereiopods; 3M long, slender (length to width ratio 5.4), 3P long, slender (length to width ratio 5.1), 3D very long, slender (length to width ratio 12.4); 4M long, slender (length to width ratio 4.9), 4P long (length to width ratio 3.2), 4D long, slender (length to width ratio 7.3) (see Table 1). Male abdomen

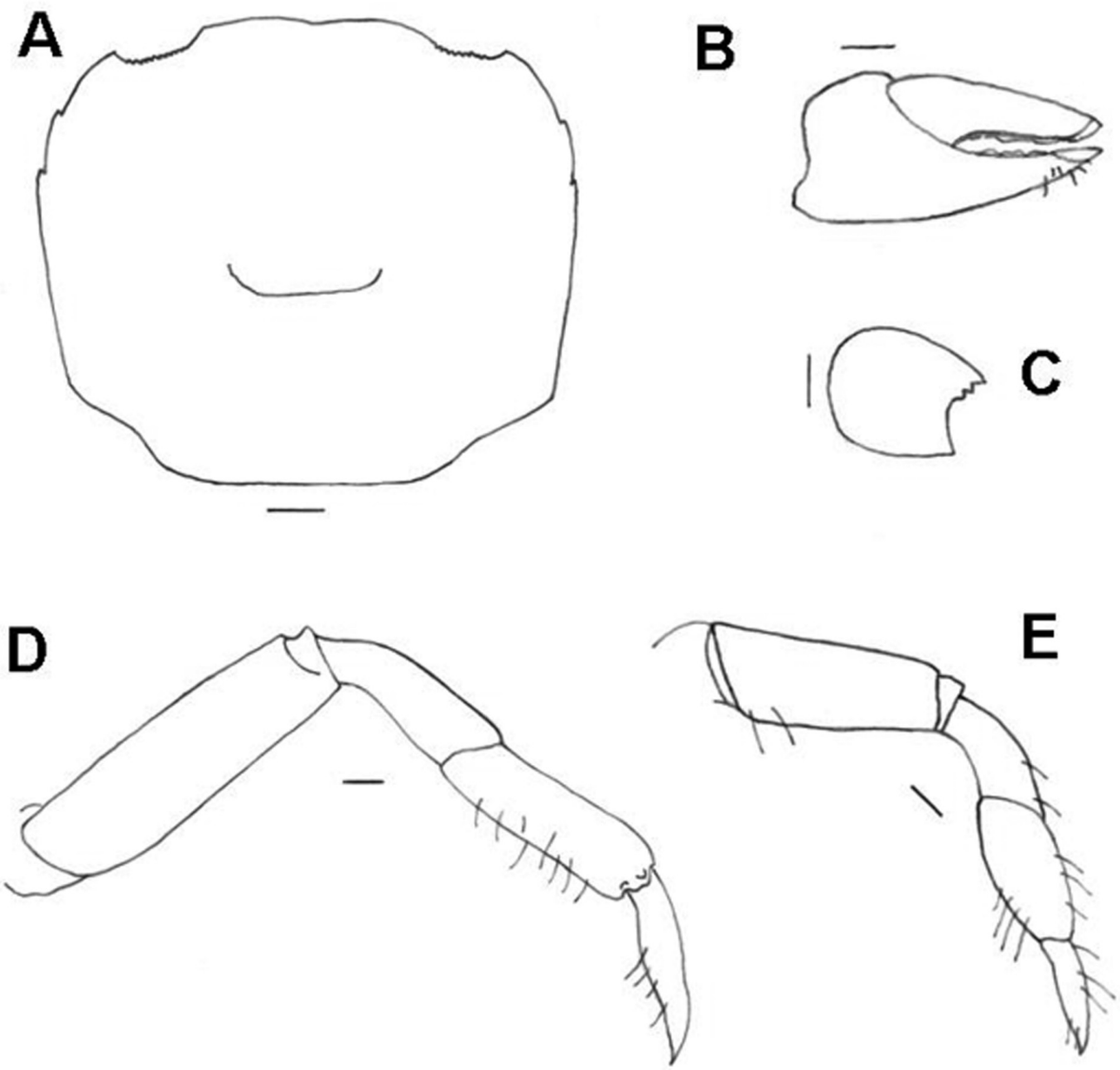

Fig. 2. *Orcovita holthuisi*, female (10.9 × 9.38 mm) (MZUF 3922). A, carapace; B, dorsal view of the right cheliped; C, dorsal view of the carpus of the right cheliped; D, fourth leg; E, fifth leg. Scale bars = 1.0 mm.

(Figs. 3B, 4B) narrowly triangular; lateral margins covered with short, rare setae; first abdominal somite, distal margin concave, swollen laterally lateral margin; second abdominal somite narrow, short, proximal margin concave; third abdominal somite broad; fourth abdominal somite broader; fifth abdominal somite with proximal and distal margins gently sinuously; sixth abdominal somite with proximal and distal margins slightly convex and concave medially respectively, lateral margins weakly convex; telson with lateral margins weakly concave, distal margin rounded. G1 (Fig. 4I) slender, gently curving outwards, reaching to or slightly beyond anterior margin of sternite 5, proximal part swollen; terminal lobe elongate; subterminal lobe densely setose. G2 (Fig. 4L) short, small.

Colour. Unknown. The preserved specimens are uniformly yellowish white.

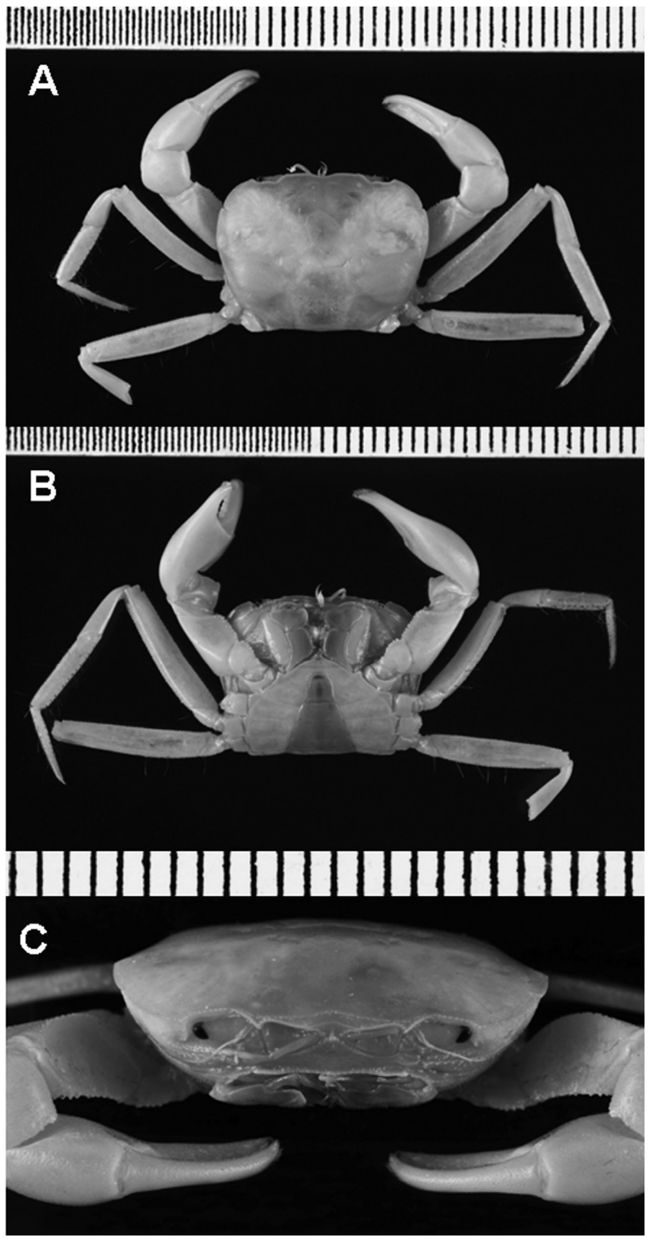

Fig. 3. *Orcovita angulata*, male (16.2 × 11.7 mm) (MZUF 4268). A, dorsal view; B, ventral view; C, frontal view.

Table 1. Comparisons among the known species of *Orcovita* from the Philippines of various morphological characters. For the 3rd and 4th legs (M=merus, P=propodus, D=dactylus) length/width ratio are indicated.

	O. fictilia	***O. holthuisi***	***O. angulata* (female)**	***O. angulata* (male)**	***O. tabiacoud* n. sp.**
Anterolateral teeth	2	3	2	2	2
Carapace shape	broad	narrow	broad	broad	broad
Anterolateral teeth	broad	acute and strong	very broad	acute and broad	very broad
Male chelipeds	short, soft setae	long dense setae on the pulvinus	short, soft setae	dense short setae on cheliped tips	no setae
Ambulatory legs	long and slender	relatively short and stout	long and slender	very long and slender	long but stout
Epigastric cristae	absent	present	weak and low	absent	absent
Inner margin of the male cheliped carpus	granular	smooth	serrated	serrated	smooth
Width to length carapace ratio	1.3–1.5	1.2	1.3	1.30	1.38
3M	5.3	4.3	5.4	5.44	4.33
3P	4.2	3.9	5.4	5.14	4.15
3D	9.1	8.1	16.1	12.48	6.69
4M	4.2–4.4	3.9	4.6	4.94	4.07
4P	2.6–3.0	2.7	3.7	3.22	3.04
4D	6.2–6.9	2.2	6.6	7.33	5.30

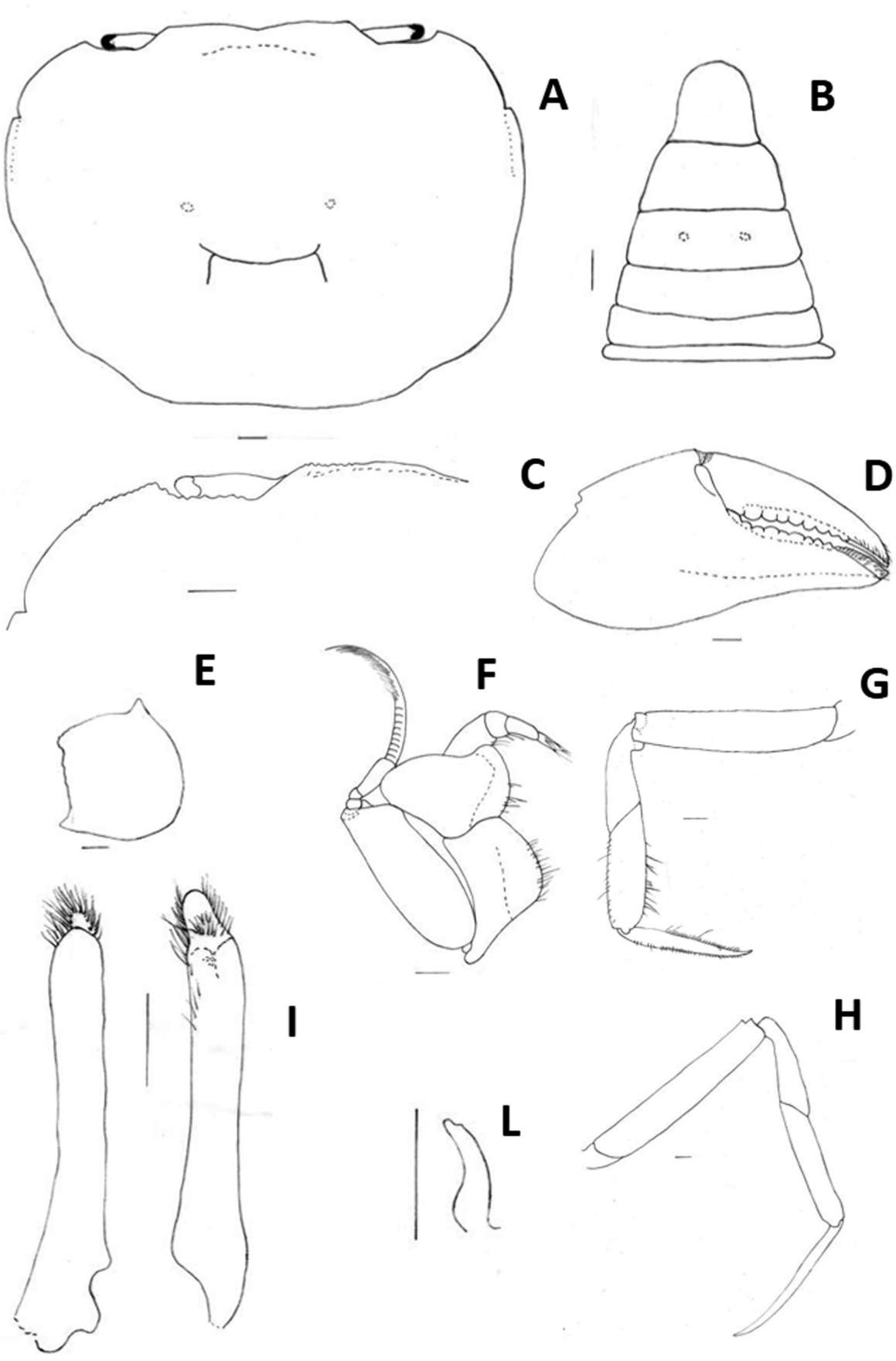

Fig. 4. *Orcovita angulata*, male (16.2 × 11.7 mm) (MZUF 4268); A, carapace; B, abdomen; C, epibranchial region; D, dorsal view of right cheliped; E, dorsal view of carpus of cheliped; F, third maxilliped; G, right third ambulatory leg; H, right fourth ambulatory leg; I, different views of G1; L, G2. Scale bars = 1.0 mm.

Remarks. *Orcovita angulata* is very distinctive among the known *Orcovita* species due to its proportionately narrower carapace, the peculiarly angular junction of the antero- and posterolateral margins of the carapace, even if clearly discernible on the right side of the carapace only, and the very elongated third and fourth ambulatory propodus and dactylus (proportionately the longest for the known *Orcovita* species). The length of the ambulatory legs in *O. angulata* is similar to those of *O. gracilipes*, but, in its proportions and other aspects, they markedly differ (Ng et al., 1996; Table 1). Our male specimen differs from the female paratype in the length of the 3D (which is shorter in the male, 12.5 vs 16.1, see Table 1), the presence of an acute subdistal tooth on the anterior dorsal margin of carpus of the chelipeds, that is apparently not evident in the female paratype figured by Ng et al. (1996), and the dense, short setae on the tips of the cheliped fingers, that in the female paratype are not so evident. These differences can be probably ascribed to sexual dimorphism, but in the general shape and proportions this male specimen matches with the female paratype.

Orcovita tabiacoud, new species
(Figs. 5–7)

Material examined. Holotype – male (26.2 × 18.9 mm) (MZUF 4269), Coron Island, Pukaway Cave, coll. R. Berti & S. Meggiorini, 15 March 1991.

Description. Carapace (Figs. 5A, 7A) subhexagonal, distinctly broader than long (width/length ratio ca. 1.3), dorsal surface finely punctate, regions poorly defined; cervical grooves poorly distinct; gastric grooves deep; epigastric, postorbital cristae absent; anterolateral margin lined with small, feeble granules; external orbital angle very broad, with one broad, epibranchial tooth (Fig. 7C), separated from external orbital angle by a small cleft; posterolateral margins concave before converging towards the posterior carapace margin; supraorbital margin granular, gently sinuous, parallel to sub-parallel with frontal margin; frontal margin sinuous, slightly concave; infraorbital margins granular, incomplete, not congruent with anterolateral margin; distinct row of rounded granules present just below infraorbital margin on suborbital region, extending to sub-branchial region. Antennules slender. Eyes developed, cornea pigmented.

Epistome (Fig. 6) narrow, posterior margin with 2 lateral clefts, median part sub-triangular, margin smooth. Third maxilliped (Fig. 7F) with broad, stout exopod, broader than ischium, flagellum well developed; merus broad, antero-external angle auriculiform.

Male thoracic sternum (Fig. 5B) with lateral margins of first two thoracic sternites smooth; suture between sternites 2, 3 slightly concave with sparse setae; lateral margins of sternites 3, 4 sinuous, with deep, broad notch; median longitudinal groove (median line) along sternites 5, 6, 7, 8 narrow.

Male chelae (Fig. 7D, E) swollen, subequal, fingers shorter than palm; proximal region of cutting edges of fingers with very small pulvinus. Inner, outer surfaces near inferior margin of merus smooth, inner surface of superior margin granular. Carpus rounded, smooth, inner distal angle with very low, obtuse tooth. Chelipeds relatively long, robust, surface of articles smooth without any trace of longitudinal sulcus; tips of fingers corneous, spoon-like, lacking setae.

Ambulatory legs (Fig. 7I) sub-circular in cross section, all articles but merus stout; second ambulatory leg longest; proximal surface finely granular. Anterior dorsal margin of merus with rounded subdistal tooth, sparse setae; outer surface of carpus with short setae, anterior and posterior margins of propodus with long and short setae, respectively; dactylus rectangular in cross section, with five rows of short and dense setae, tapering to slender, acute tip; posterior margin of the dactylus of the first four ambulatory legs with dense short setae interspersed with several long ones; 3M long, slender (length to width ratio 4.3), 3P long (length to width ratio 4.2), 3D long (length to width ratio 6.69); 4M short (length to width ratio 4), 4P long (length to width ratio 3), 4D long, slender (length to width ratio 5.4) (see Table 1).

Male abdomen (Fig. 7B) triangular; lateral margins covered with short dense setae with several long, pigmented setae interspersed; telson with lateral margins feebly convergent distally, distal margin rounded.

G1 (Fig. 7G) strong, gently curving outwards, reaching to or slightly beyond anterior margin of sternite 5; terminal lobe densely setose, sub-terminal lobe absent. G2 (Fig. 7H) short, small.

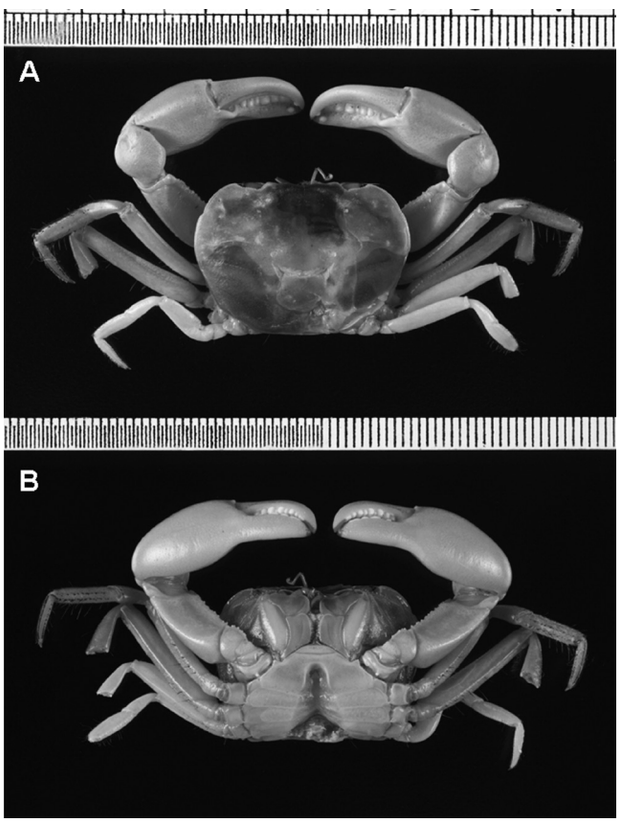

Fig. 5. *Orcovita tabiacoud* n. sp., holotype, male (26.2 × 18.9 mm) (MZUF 4269). A, dorsal view; B, ventral view.

Colour. Live colour not known. Preserved specimen uniformly dark cream.

Etymology. From the name of the Tagbanua god of the underworld, Tabiacoud, as an allusion to the type locality of this crab.

Remarks. Three species of *Orcovita* have been previously reported from the Philippines, *O. fictilia* Ng, Guinot & Iliffe, 1996 from Panglao (Bohol), and *O. angulata* and *O. holthuisi* from Coron Island (Palawan).

Orcovita tabiacoud, new species, is perhaps most similar to *O. gracilipes* Ng, Guinot & Iliffe, 1996 in the shape and proportions of its carapace (see Ng et al., 1996), but still *O. tabiacoud* has a more marked subexagonal shape.

Orcovita tabiacoud is markedly different from *O. fictilia* due to (a) the smooth inner margin of the male cheliped carpus (vs. granular in *O. fictilia* as reported by Ng et al., 1996); (b) the male cheliped is without setae on the pulvinus (vs. cheliped with short, soft setae on the pulvinus in *O. fictilia*); (c) the relatively stout ambulatory legs (vs. more slender ambulatory legs in *O. fictilia*, for proportions, see Table 1).

Orcovita tabiacoud is also clearly different from *O. angulata*, in (a) having a slightly broader carapace, with a width-to-length ratio of ca. 1.4 (vs. broader carapace, with a ratio of 1.3 in *O. angulata*); (b) presence of a rounded junction of the antero- and posterolateral margins of the carapace (vs. presence of a distinct angular antero-posterolateral junction in *O. angulata*); (c) the absence of low, distinct epigastric cristae (vs. weak and low epigastric cristae in *O. angulata*); (d) the inner margin of the male cheliped carpus is smooth (vs. serrated in *O. angulata*); (e) the male cheliped lacks setae (vs. cheliped with short, dense setae on cheliped tips in *O. angulata*); (f) the relatively stout ambulatory legs (vs. more longer and slender ambulatory legs in *O. angulata*).

The differences with *O. holthuisi* are (a) a broader carapace with a width to length ratio of ca. 1.4 (vs. narrow carapace with a ratio of 1.2 in *O. holthuisi*); (b) anterolateral margin with two broad teeth including the exorbital angle (vs. three acute and strong teeth including the exorbital angle in *O. holthuisi*); (c) absence of epigastric cristae (vs. low and distinct epigastric cristae in *O. holthuisi*); (d) male cheliped without setae (vs. cheliped with long dense setae on the pulvinus in *O. holthuisi*); (e) relatively longer ambulatory legs (vs. relatively shorter and stouter ambulatory legs in *O. holthuisi*).

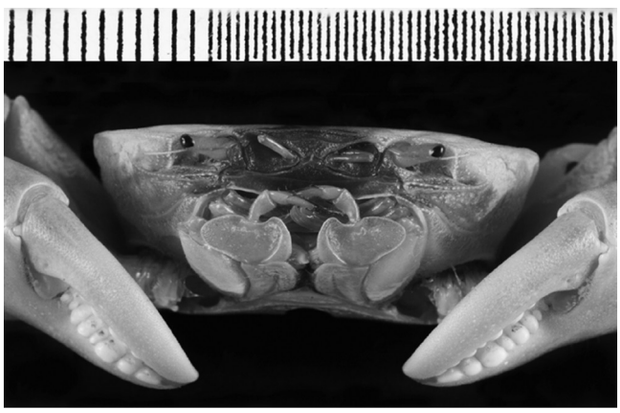

Fig. 6. *Orcovita tabiacoud* n. sp., holotype, male (26.2 × 18.9 mm) (MZUF 4269). Frontal view.

Davie & Ng (2012), who provided a key of the *Orcovita* species, recognised two separate species-groups of *Orcovita* that may represent distinct lineages, due to a probable ancient phylogenetic split. *Orcovita tabiacoud* seems to be assigned to Group II for the single epibranchial tooth, relatively long and slender legs, and lack of a prominent patch of setae on the chelae. Thus, in Pukaway cave, for the first time, there is the occurrence of one species belonging to Group I (*O. holthuisi*) and two (*O. angulata* and *O. tabiacoud*) ascribed to Group II.

DISCUSSION

There are several instances where more than one stygobitic crustacean species of the same genus occur in the same cave. *Orcovita orchardorum* Davie & Ng, 2012 and *O. hicksi* Davie & Ng, 2012, are sympatric in several caves of Christmas Island, eastern Indian Ocean, and are found in brackish anchialine habitats with probable subterranean connections (Davie & Ng, 2012). Other cases are also reported in Ng & Ng (2009) for brachyurans, remipedes and ostracods. Moreover, during the past decades many new species of cavernicolous organisms have been described from caves in the Philippines (e.g., Fosshagen & Iliffe, 1989; Ng et al., 1996; Ng & Sket, 1996; Kano & Kase, 2004; Ng & Guinot, 2001; Takeda & Ng, 2001; Ng, 2002; Sawicki et al., 2005; Husana et al., 2009, 2010). It is not currently known if the Raft and Pukaway caves in Coron Island are connected, but the presence of two congeneric species on the same island, and, moreover, of *O. holthuisi* in the same cave, can suggest a possible connection as the likeliest explanation for these occurrences.

Another possible explanation of the presence, in the same cave, of two species (i.e., *O. angulata* and *O. tabiacoud*) belonging to the same species-group (Group II; Davie & Ng, 2012) could be that a further and more recent ecological/phylogenetic division occurred in Coron Island, even if this fact is very difficult to confirm with the present data. Further explorations of Coron Island caves could shed light on this problem, with the collection additional specimens and comparative morphological and molecular studies.

Coron Island has steep limestone cliffs and numerous pit caves descending to deep freshwater, brackish or saltwater pools. Ropes and specialised vertical climbing techniques are required in order to enter many of the caves on the island, and permission is required to explore some parts of the island, although this is difficult to obtain. At water level it would be interesting to dive as the cave pools are quite deep and, due to salinity stratification, fully marine waters and associated fauna may be only found at greater water depths. For this reason a number of caves have not yet been

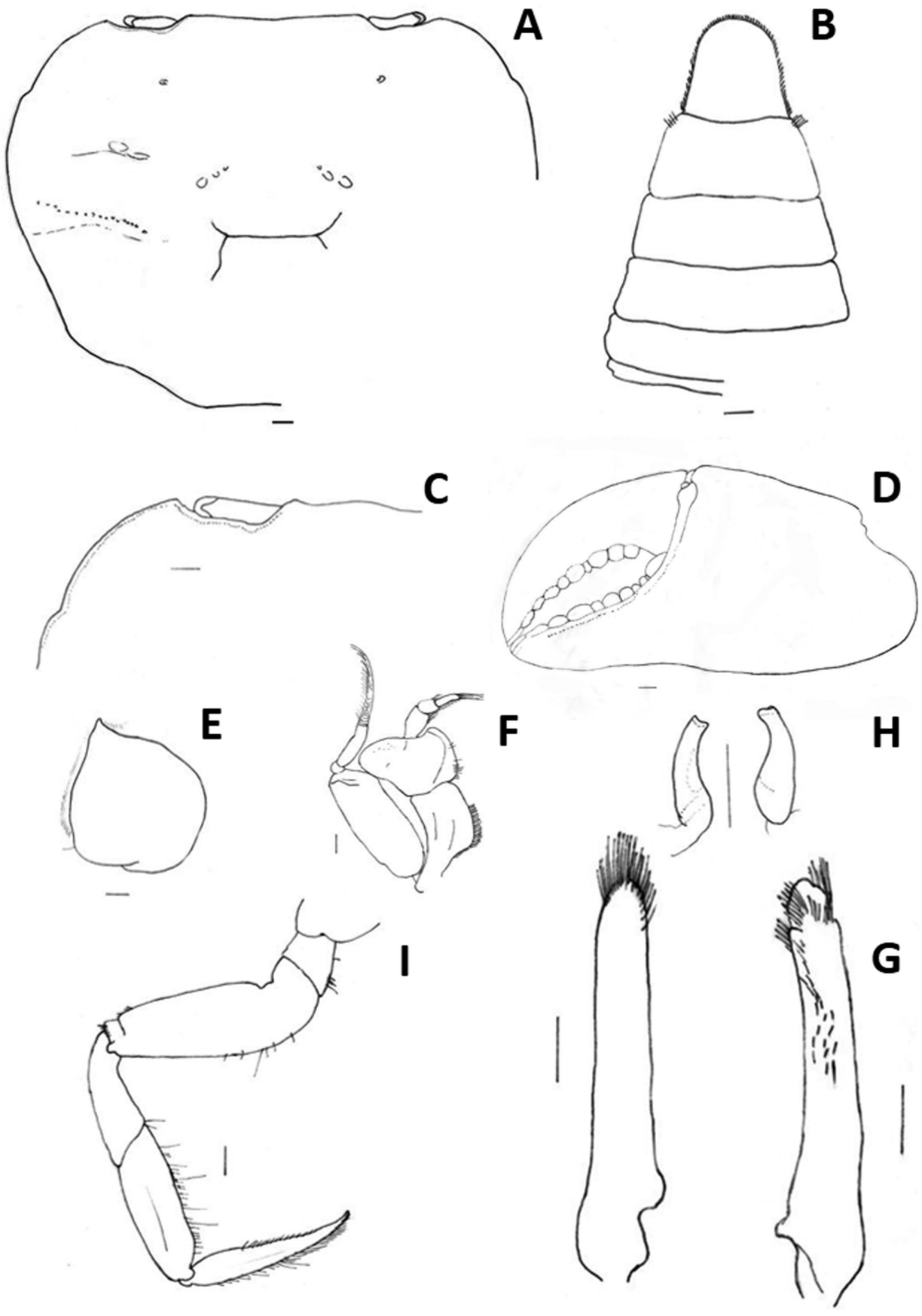

Fig. 7. *Orcovita tabiacoud* n. sp., holotype, male (26.2 × 18.9 mm) (MZUF 4269); A, carapace; B, abdomen; C, epibranchial region; D, dorsal view of left cheliped; E, dorsal view of carpus of cheliped; F, third maxilliped; G, different views of G1; H, different views of G2; I, right fourth ambulatory leg (the leg is probably regrown and has not reached the normal size). Scale bars = 1.0 mm.

investigated (also Ng & Ng, 2009), and the whole island is in need of a thorough exploration given that with its numerous karst caves and anchialine systems, it is likely to be a great source for the discovery of new cave-adapted organisms.

ACKNOWLEDGEMENTS

We wish to thank Saulo Bambi (Natural History Museum of Florence University) for the photographs. A special thank you goes to Paul Marcel, Giuseppe Messana, Leonardo Piccini, Michele Sivelli (Library of the Italian Speleological Society) for their assistance in locating papers and data on the caves. Peter K. L. Ng and Bella S. Galil helped in locating *O. angulata* paratype. A special thank to Jose C. E. Mendoza that with his useful remarks helped us to improve the manuscript.

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