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A new hermit crab species of the genus *Tomopaguropsis* Alcock, 1905 (Crustacea: Decapoda: Paguridae) from the Bohol Sea, Philippines

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Abstract. A new species of the pagurid genus *Tomopaguropsis* Alcock, 1905 is documented based on specimens collected during the PANGLAO 2005 expedition in deep waters (269–712 m) of the Bohol Sea, the Philippines. This new species, named *Tomopaguropsis rahayuae*, is the first record of a species of the genus in the Philippines region, and is fully described and illustrated. The most significant morphological character that distinguishes this new species from other congenerics is the symmetrical uropods. The holotype and paratype were found living in scaphopod tusk shells, an unusual type of housing for species of this genus. The morphology and affinities of this new species are discussed. An updated identification key to all species of *Tomopaguropsis* is also presented.

Key words. *Tomopaguropsis rahayuae*, Bohol Sea, Philippines, deep water, tusk shell, symmetrical uropods, identification key

INTRODUCTION

The pagurid genus *Tomopaguropsis* Alcock, 1905 was originally proposed for two species, the type *T. lanata* Alcock, 1905, from off the coast of southwestern India and Sri Lanka, and *Eupagurus* ?*problematica* A. Milne-Edwards & Bouvier, 1893, from the Caribbean Sea. Nine decades later, two more species were added to this genus, *T. crinita* McLaughlin, 1997 and *T. miyakei* McLaughlin, 1997, both from Indonesia, and then another was added more recently, *T. ahkinpechensis* Lemaitre, Vázquez-Bader & Gracia, 2014, from the Gulf of Mexico. During the PANGLAO 2005 deep-sea expedition in the Bohol Sea, Philippines, two female specimens were collected that proved to be yet another, and once again new species, of this deep-sea genus.

The diagnostic characters of species of *Tomopaguropsis* were discussed by McLaughlin (1997, 2003), and clarified further by Lemaitre et al. (2014), although some variation was acknowledged. The genus is diagnosed by 13 pairs of quadriserial gills; crista dentata with accessory tooth; subequal chelipeds (right slightly more robust); pereopod 4 with propodal rasp consisting of multiple rows of scales, dactyl with or without preungual process; and males and females with unpaired left pleopods 2–5, males often but not always, with paired pleopods 1 modified as gonopods. The new and sixth species of this genus discovered in the Bohol Sea, is fully described and illustrated herewith. The affinities of this new species discovered in the Bohol Sea with other congeneric species are discussed. An identification key to species of the genus provided by Lemaitre et al. (2014) is updated.

MATERIAL & METHODS

The PANGLAO 2005 expedition was conducted on the Philippine research ship MV DA-BFAR, in collaboration with: Philippine Bureau of Fisheries and Aquatic Resources, Manila (BFAR); Institut de Recherche pour le Développement, Centre de Nouméa; Raffles Museum of Biodiversity Research, National University of Singapore (now Lee Kong Chian Natural History Museum, National University of Singapore [LKCNHM]); Muséum national d'Histoire naturelle, Paris; National Taiwan Ocean University, Keelung; Philippines National Museum, Manila (NMCR); and University of San Carlos, Cebu. Details of the expedition can be found in Richer de Forges et al. (2009). The holotype and paratype specimens are preserved in 80% ethanol and deposited in the NMCR and ZRC (Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore), respectively.

All drawings were made with a dissecting microscope MZ8 (Leica, Wetzlar, Germany) equipped with a camera lucida attachment. Photographs were taken with a Nikon D200 digital camera, and processed with the focus stacking program Helicon Focus (Helicon Soft Ltd., Kharkov, Ukraine). Shield length (sl) is given to indicate size of the specimens, measured from the distal tip of the rostrum to the midpoint of the posterior margin of the shield, and was taken using a digital caliper CD6CSX (Mitutoyo, Kawasaki, Japan) to the nearest 0.1 mm. McLaughlin & Lemaitre (2001) and McLaughlin (2003) are followed for general terminology, and Tudge et

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al. (2012) for the specialised features of the branchiostegite and posterior carapace. The following abbreviations are also used: CP, beam trawl; DW, waren dredge.

TAXONOMY

Family Paguridae Latreille, 1802

Genus *Tomopaguropsis* Alcock, 1905

Tomopaguropsis rahayuae, new species
(Figs. 1–4)

Type examined. Holotype: female (sl 4.3 mm) (NMCR 40005), Philippines, Bohol Sea, station DW2367, 08°55.3′N, 123°17.6′E, 269–280 m, sandy substrate, 27 May 2005. Paratype: ovigerous female (sl 4.8 mm) (ZRC 2015.0505), Philippines, Bohol Sea, station CP2397, 09°34.9′N 123°41.7′E, 669–712 m, sandy substrate, 31 May 2005.

Description. Thirteen pairs of quadriserial gills.

Shield (Figs. 1A, 2A) well calcified, as long as broad; anterior margin between rostrum and lateral projection concave; anterolateral margin sloping; dorsal surface almost naked, slightly lustrous; dorsolateral and lateral margins with few tufts of setae. Rostrum shorter than lateral projections, broadly triangular, terminating subacutely. Lateral projection well-developed, triangular, ending in small spine. Carapace lateral lobe fused to shield. Posterior carapace with well calcified posteromedian and posterolateral plates. Branchiostegite membranous except for single, narrow calcified anterodorsal plate.

Ocular peduncle (Figs. 1A, 2A) short, about 0.4–0.5 times as long as shield, slightly narrowing distally; dorsomesial surface with longitudinal row of moderately long setae; cornea non-dilated. Ocular acicle well developed, subtriangular, terminating in strong acute spine reaching nearly to midlength of ocular peduncle; separated basally by about 0.2–0.3 basal width of 1 acicle.

Antennular peduncle (Figs. 1A, 2A) overreaching distal corneal margin by distal 0.5–0.6 of ultimate segment. Ultimate segment 3 times as long as penultimate segment. Basal segment with strong laterodistal spine. Ventral flagellum with 5–7 articles.

Antennal peduncle (Figs. 1A, 2A) overreaching distal corneal margin by 0.5 length of fifth segment. Third to fifth segments with scattered setae. Third segment with strong ventromesial spine distally. Second segment with dorsolateral distal angle prominently produced, terminating in strong spine and long setae dorsomesially; mesial margin with spine on dorsodistal angle. First segment with small spine and setae on lateral face distally. Acicle overreaching distal corneal margin by approximately 0.4–0.5 length, terminating in strong spine, with long setae distally. Flagellum distinctly exceeding chelipeds when fully extended, scattered with 3–4 flagellum articles-long setae.

Mandible with incisor process sinuous. Maxillule with external lobe of endopod slender, straight; internal lobe bearing long bristle distally. Maxilla with scaphognathite overreaching distal end of endopodite. Maxilliped 1 with exopod overreaching distal margin of endopodite. Maxilliped 2 without distinguishing characters. Maxilliped 3 with merus and carpus each armed with small, sharp dorsodistal spine; ischium (Fig. 2D) with crista dentata consisting of 12–15 small subequal corneous teeth, and 1 accessory tooth on right side only in holotype, or both sides in paratype. Basis with mesial spine.

Chelipeds (Figs. 1, 2B, 2C) subequal in shape, right cheliped slightly longer and stouter in holotype, left cheliped distinctly longer and slightly stouter in paratype (see Remarks). Right cheliped with dactyl and fixed finger each terminating in sharp, curved corneous claw; dorsal surfaces with numerous moderately long tufts of setae; cutting edges of dactyl and fixed finger each with row of fused corneous teeth on distal third and 1 or 2 large calcareous teeth. Palm slightly longer than fingers; dorsal surface weakly convex, unarmed except for 2 tubercles of proximolateral surface; dorsolateral and dorsomesial margins scattered with setae and irregular rows of small tubercles. Carpus 1.4–1.5 times as long as palm; dorsodistal margin armed with 2 or 3 tubercles; dorsal surface with shallow longitudinal groove and few small tubercles on lateral half; dorsomesial margin with row of strong tubercles; lateral and mesial surfaces with moderately long tufts of setae; ventral surface smooth. Merus with dorsodistal margin with moderately long setae and 1 or 2 small spines; dorsal, lateral and ventral surfaces with tufts of setae, scattered small tubercles; mesial surface unarmed; ventrolateral margin with moderately long setae and row of small spinules or tubercles; ventromesial margin with moderately long setae and small spinules. Ischium unarmed except for row of small spines on ventromesial margin.

Left cheliped (Figs. 1, 2C) similar in shape and armature to right, except for: cutting edge of dactyl and fixed finger each with longer row of fused corneous teeth on distal 0.5–0.6, presence of more minute spines on dorsal surfaces of merus, carpus and palm, and stronger spines on dorsomesial margin of carpus.

Right pereopod 2 and left pereopod 3 of holotype missing. Pereopod 2 and 3 (Figs. 1, 3A, 3B) with numerous long setae, setae missing in pereopod 2 of holotype. Dactyl gently curved, 1.6–1.9 times as long as propodus, terminating in sharp corneous claw; lateral and mesial surfaces with a shallow longitudinal groove; ventromesial margin unarmed. Propodus with or without small spine on ventromesial distal angles, but otherwise lacking conspicuous armature. Carpus 0.6–0.8 times as long as propodus; dorsodistal margin with small blunt spine, otherwise lacking conspicuous armature. Merus as long as propodus; dorsal margin with row of low protuberances; ventral margin unarmed. Ischium unarmed, but with few setae on dorsal and ventral margins.

Pereopod 4 (Fig. 3C) semichelate; carpus, merus and ischium with moderately long setae on dorsal margins; lateral

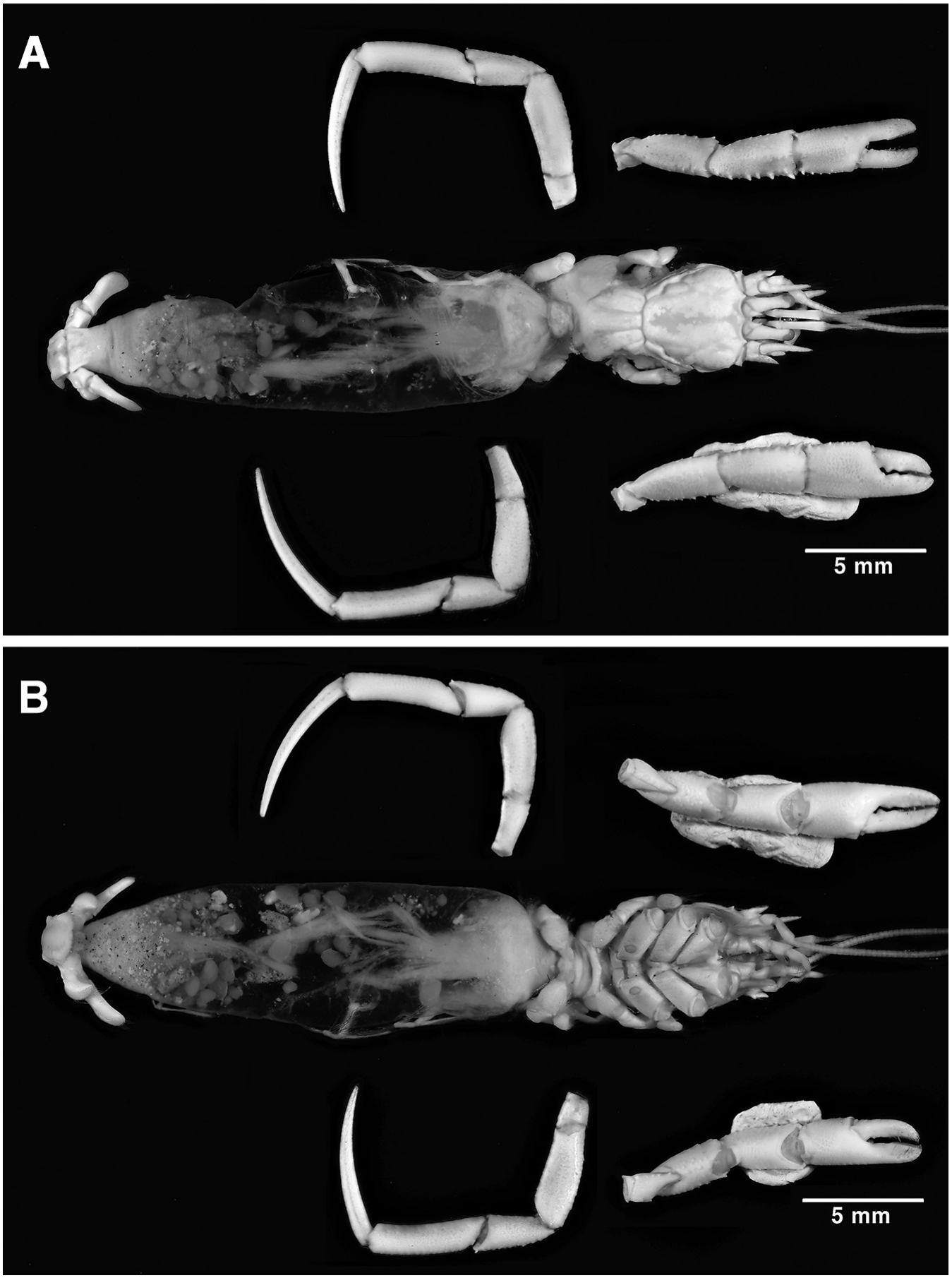

Fig. 1. *Tomopaguropsis rahayuae*, new species, holotype, female, sl 4.3 mm (appendages detached), NMCR 40005. A, body and chelipeds in dorsal view, and left pereopod 2 and right pereopod 3 in lateral view; B, body and chelipeds in ventral view, and left pereopod 2 and right pereopod 3 in mesial view.

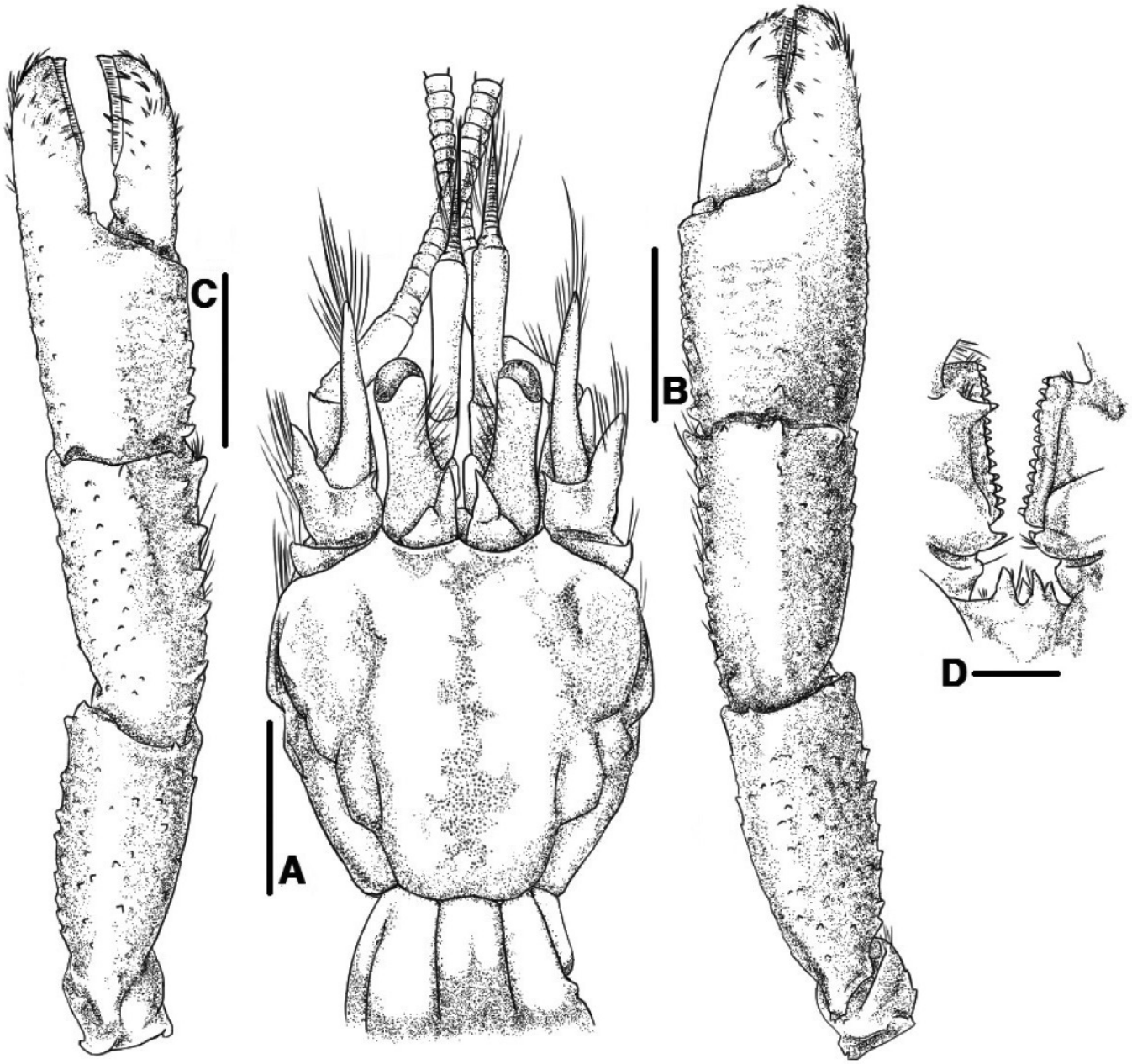

Fig. 2. *Tomopaguropsis rahayuae*, new species, holotype, female, sl 4.3 mm, NMCR 40005. A, shield, cephalic appendages, and part of posterior carapace, dorsal view; B, right cheliped, dorsal view; C, left cheliped, dorsal view; D, coxa and ischium of third maxilliped, and sternite IX, ventral view. B, C: Setae partially omitted. Scale bars: A–C = 2 mm; D = 0.5 mm.

and mesial faces glabrous. Dactyl elongate subtriangular, gently curved, terminating in sharp, corneous claw, lacking preungual process, bearing ventrolateral row of minute, fused corneous teeth. Propodal rasp consisting of 3 rows of ovate corneous scales proximally, becoming 2 rows distally. Carpus, merus and ischium without distinctive features.

Pereopod 5 chelate. Dactyl with dense setae. Propodus with dense setae and well developed rasp covering nearly half of lateral face of propodus. Carpus, merus and ischium without distinctive features.

Sternite IX (of maxillipeds 3) with strong spine on each side of midline (in holotype with additional shorter spine on left side). Sternite XII (of pereopods 3; Fig. 1B) divided into anterior and posterior portions by membranous hinge; anterior lobe semicircular, with setae distally; posterior portion divided into plates by deep median groove. Sternite XIV (of pereopods 5) weakly divided anteriorly into pair of setose lobes, and with low posteromedian rounded ridge. Pleon (Fig. 1) straight, slightly flexed. First somite (Figs. 1, 4A) fused to last thoracic somite, tergite weakly calcified, with pair of small calcareous plates.

Uropods (Figs. 1, 4B) symmetrical, endopod about 0.5 times as long as exopod. Telson (Figs. 1B, 4B) symmetrical or nearly so (each side differing slightly in spine number on terminal margins of posterior lobes), as long as broad, with distinct lateral indentations separating anterior and posterior lobes; posterior lobes separated by shallow median cleft, terminal margins armed with 5–8 strong, subequal spines interspersed with weak spines.

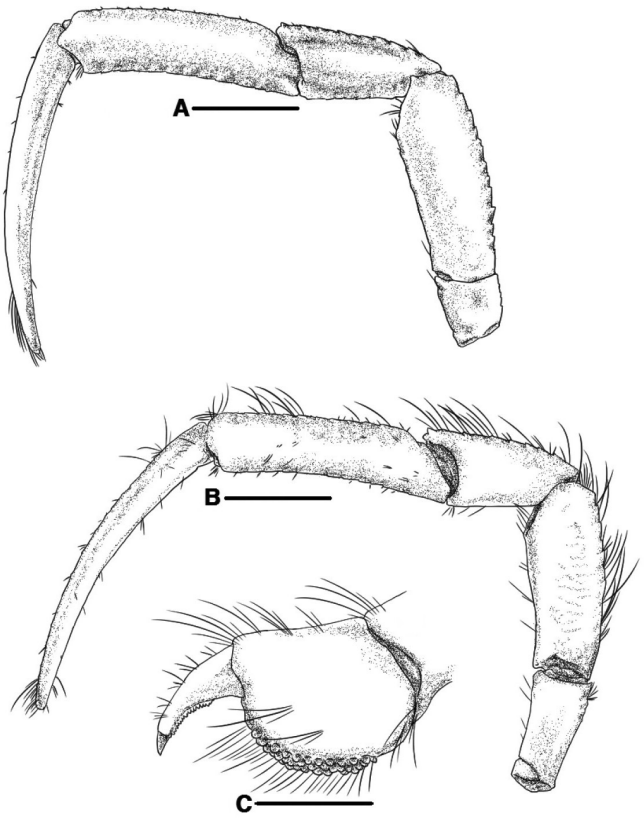

Fig. 3. *Tomopaguropsis rahayuae*, new species, holotype, female, sl 4.3 mm, NMCR 40005. A, left pereopod 2, lateral view; B, right pereopod 3, mesial view; C, dactylus and propodus of left pereopod 4, lateral view. A, B: Setae partially omitted. Scale bars: A–B = 2 mm; C = 1 mm.

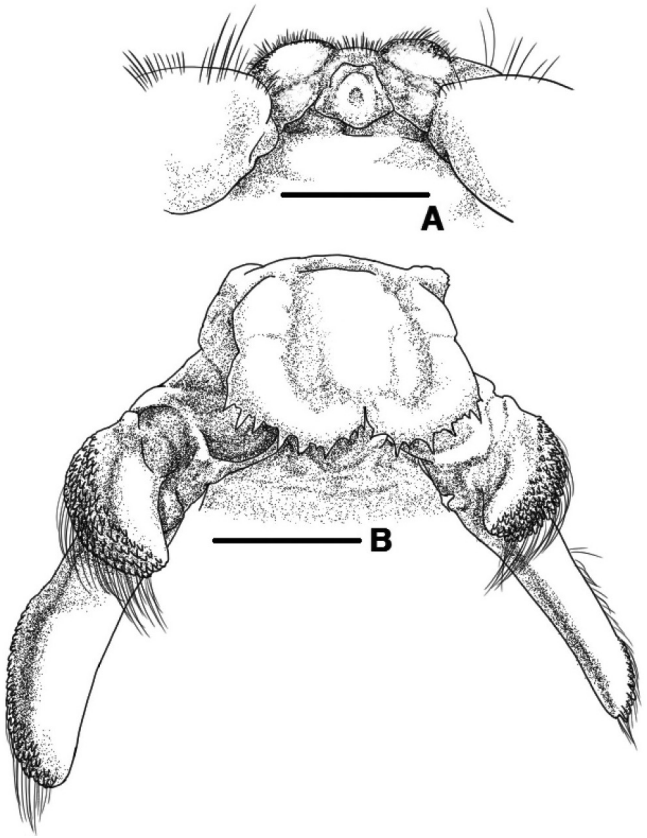

Fig. 4. *Tomopaguropsis rahayuae*, new species, holotype, female, sl 4.3 mm, NMCR 40005. A, sternite XIV, coxae and basis of pereopods 5, and anterior portion of pleon somite, ventral view; B, uropods and telson, dorsal view. Scale bar = 1 mm.

Female lacking pleopod 1, with left unpaired pleopod 2–5 biramous. Male unknown.

Colour. Living colour unknown. In ethanol preservative, straw with light or dark brown corneas.

Habitat. Both holotype and paratype were found using a scaphopod tusk shell as housing.

Distribution. Known so far only from the Bohol Sea, Philippines; depth: 269–712 m.

Etymology. The specific name is to honor Dr. Dwi Listyo Rahayu, Marine Bio-Industry Implementation Unit, Research Centre for Oceanography, Indonesian Institute of Sciences (LIPI), Indonesia, and acknowledge her important taxonomic contributions to the Paguroidea fauna, and who first discovered the specimen in the collections of LKCNHM.

Remarks. *Tomopaguropsis rahayuae*, new species, might seem distinguishable from other congenerics by the straight pleon (vs. coiled in all other congenerics) (Fig. 1). A straight pleon, however, is the result of housing in a scaphopod tusk shell. A number of paguroid species are known to use both straight and coiled shells, and thus the same species can have a straight or a coiled pleon (Komai et al., 2010) (R. Lemaitre, pers. observation). Whether the use of scaphopod shells is a strict preference by *T. rahayuae*, new species, cannot be ascertained at this time given that only two specimens are known and no field studies are feasible. Other Paguridae, known to live exclusively at least in adults, in straight types of housing (e.g., scaphopod or pteropod shells, and sabellarian or serpulid worm tubes) include species of *Pylopagurus* A. Milne-Edwards & Bouvier, 1891 (see McLaughlin & Lemaitre, 2001), *Discorsopagurus* McLaughlin, 1974 (see Gherardi & Cassidy 1994; Gherardi & McLaughlin 1995; Komai, 1995, 2003a; Komai & Takeda, 1996), *Pteropagurus* McLaughlin & Rahayu, 2006 (see McLaughlin & Rahayu, 2006; McLaughlin, 2007), *Dentalopagurus* McLaughlin, 2007 (see McLaughlin, 2007), and *Paguritta* Melin, 1939 (see McLaughlin & Leimatire, 1993; Komai & Nishi, 1996; Komai & Okuno, 2001).

The symmetry of the uropods in *Tomopaguropsis rahayuae*, new species, (Fig. 4B) is unique among species of *Tomopaguropsis*, and is the most conspicuous diagnostic morphological character for this new species as this structure is asymmetrical in all other congenerics. Symmetry of uropods has been studied for *Discorsopagurus schmitti* (Stevens, 1925) (see Gherardi & Cassidy, 1994; Gherardi & McLaughlin, 1995), and for *Lophopagurus* (*Australeremus*) *triserratus* (Ortmann, 1892) (see McLaughlin & Gunn, 1992). In these two species, the symmetry of the uropod is quite constant, and not influenced by type of housing, so it is reasonable to infer that the same symmetrical constancy occurs in this new species.

Tomopaguropsis rahayuae, new species, is most similar to *T. crinita*. Aside from the difference in uropod shape, the two differ in only relatively minor details. The rostrum is shorter than the lateral projections in *T. rahayuae*, new species (Figs. 1A, 2A), whereas the rostrum and lateral projections are similar in the length in *T. crinita*. The dorsolateral margins of carpi and ventral surfaces of meri of the chelipeds have small tubercles in *T. rahayuae*, new species (Fig. 2B, C), whereas those surfaces lack tubercles in *T. crinita*. The ventral margins of the dactyls of the pereopods 2 and 3 (ambulatory legs) are unarmed in *T. rahayuae*, new species (Fig. 3A, B), whereas there are 9 to 25 small corneous spines in *T. crinita*. The carpi of the ambulatory legs have a dorsodistal spine in *T. rahayuae*, new species (Fig. 3A, B), whereas the carpi are unarmed dorsodistally in *T. crinita*. The median region of the sternite of the first pleonal somite is concave in *T. rahayuae*, new species (Fig. 4A), whereas in *T. crinita* there is a median lobe.

Two asymmetrical morphological conditions were observed in the holotype of *Tomopaguropsis rahayuae*, new species, on the third maxillipeds and associated sternite IX (Fig. 2D): an accessory tooth is present only on the right ischium; and the sternite has a simple spine on the right side and a bifid spine on the left side of the midline. These conditions are not rare among the Paguroidea, although they have been rarely reported in the literature (R. Lemaitre, pers. observation). Komai (2003b), for example, has documented different number of accessory teeth on each side of the ischium of the third maxillipeds in *Pagurus japonicus* (Stimpson, 1858), *P. similis* (Ortmann, 1892), and *P. rubrior* Komai, 2003. We have found a similar asymmetrical condition in specimens deposited in the Smithsonian National Museum of Natural History of *P. prideaux* Leach, 1815 (USNM 121814), and *Lophopagurus* (*Lophopagurus*) *lacertosus* (Henderson, 1888) (USNM 244454).

In the paratype of *Tomopaguropsis rahayuae*, new species, the left cheliped is stouter and distinctly longer than the right cheliped. This condition may be due to regeneration as the holotype of *Tomopaguropsis rahayuae*, new species, and other species of the genus *Tomopaguropsis*, have subequal chelipeds (see A. Milne-Edwards & Bouvier, 1893; Alcock, 1905; McLaughlin, 1997; Lemaitre et al., 2014). We have found a similar condition in specimen deposited in the Marine Arthropod Depository Bank of Korea (MADBK) of *Pagurus constans* (Stimpson, 1858) (MADBK 160705_008). For example, a specimen of *P. constans* has a left cheliped longer and stouter than the right cheliped even though the normal condition in this species is for the right to be larger than the left (see Stimpson, 1858).

This is the first record of a species of *Tomopaguropsis* from the Philippines region, although *T. crinita* and *T. miyakei* are known from the not so distant Indonesian waters.

A KEY TO SPECIES OF TOMOPAGUROPSIS
(updated from Lemaitre et al., 2014)

1. Ocular peduncles decreasing in width distally; antennal peduncles distinctly exceeding distal margins of corneas by one-third or more length of fifth antennal segment 3
– Ocular peduncles not decreasing in width distally, subcylindrical; antennal peduncles not exceeding or at most slightly exceeding distal margins of corneas 2
2. Ventral margins of dactyls of ambulatory legs (pereopods 2, 3) armed with corneous spines; posterior lobes of telson nearly symmetrical, separated by V-shaped median cleft..... ..... *T. miyakei* McLaughlin, 1997 (Indonesia)
– Ventral margins of dactyls of ambulatory legs (pereopods 2, 3) unarmed, lacking corneous spines; posterior lobes of telson asymmetrical, separated by narrow slit .... *T. problematica* (A. Milne-Edwards & Bouvier, 1893) (Western Atlantic: southeastern United States, Bahamas, Gulf of Mexico, Caribbean)
3. Dorsal surfaces of chelae distinctly spinulose .... *T. lanata* Alcock, 1905 (Indian Ocean)
– Dorsal surfaces of chelae not spinulose or at most with scattered small tubercles 4
4. Branchiostegite with narrow, calcified posterior plate curving down, following sulcus verticalis, and bifurcated ventrally; propodus of pereopod 4 longer than high ..... *T. ahkinpechensis* Lemaitre, Vázquez-Bader & Gracia, 2014 (Gulf of Mexico)
– Branchiostegite without calcified posterior plate; propodus of pereopod 4 about as long as high..... 5
5. Uropods asymmetrical; ventral margins of dactyls of ambulatory legs (pereopods 2, 3) armed with 9 –25 corneous spines ....*T. crinita* McLaughlin, 1997 (Indonesia)
– Uropods symmetrical (Fig. 4B); ventral margins of dactyls of ambulatory legs (pereopods 2, 3) unarmed (Figs. 3A, B)..... .....*T. rahayuae*, new species (Bohol Sea, the Philippines)

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