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A NEW SPECIES OF THE HERMIT CRAB GENUS *CANCELLUS* (DECAPODA: ANOMURA: PAGUROIDEA: DIOGENIDAE) FROM THE PANGLAO EXPEDITIONS TO THE PHILIPPINE ISLANDS

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***ABSTRACT*. –** A new species of the diogenid genus *Cancellus*, *C. panglaoensis*, was collected during the Philippine PANGLAO Expeditions of 2004 and 2005. This species is described, fully illustrated and compared with the superficially very similar *C. mayoae* Forest & McLaughlin, 1998, from Japan and with the New Zealand *C. frontalis* Forest & McLaughlin, 2000. The specimens of the new species were found entrapped in tangle net fishing gear, lending strength to laboratory reports that *Cancellus* species are able to move about without abandoning their carcinoecia.

***KEY WORDS*. –** Decapoda, Anomura, Paguroidea, Diogenidae, *Cancellus*, new species, Panglao, Philippine Islands.

INTRODUCTION

During the PANGLAO Expeditions of 2004 and 2005, assessments of Philippine marine biodiversity were conducted jointly by scientists from the Muséum national d'Histoire naturelle, Paris (MNHN), the Raffles Museum of Biodiversity Research, National University of Singapore (ZRC), University of San Carlos, Cebu (USC), and the National Museum of the Philippines, Manila (NMCR). The 2004 expedition focused on the region surrounding Panglao Island, while additional areas of the Bohol Sea were added in 2005. During these explorations, numerous specimens of an undescribed species of the unusual hermit crab genus *Cancellus* H. Milne Edwards, 1836, were collected, most commonly from the tangle nets of local fishermen.

The genus was first described by H. Milne Edwards (1836), with the monotypic type species *C. typus* H. Milne Edwards, 1836, based on a single male specimen from an unknown locality. The species was subsequently reported from Australia by Whitelegge (1889). Of the seven species that were added to the genus during the following half century, one was from the eastern Atlantic, two from the western Atlantic, and one each from the eastern Pacific, Indian Ocean and South Africa. *Cancellus canaliculatus* (Herbst, 1804) continued to be known only from the general locality "East Indies." The first detailed and well illustrated study of species of the genus was that of Mayo (1973) who added an additional species from the western Atlantic. A second Australian species, *C. quadraticoxa* Morgan & Forest, 1990, was described from restricted localities in Western Australia. Mayo (1973) had based her interpretation of *C. investigatoris* Alcock, 1905 on a specimen identified as Alcock's taxon in the collections of the Kyushu University, Fukuoka, Japan. That specimen and a second Japanese specimen were subsequently shown not to represent *C. investigatoris* but an undescribed species (Forest & McLaughlin, 1998). In recognition of Mayo's (1973) landmark study, the Japanese species was reported as *Cancellus mayoae* Forest & McLaughlin, 1998. The geographical distribution of the genus was broadened still further when Forest & McLaughlin (2000) described four additional new species from New Zealand waters. The PANGLAO specimens appear morphologically most similar to *C. mayoae* in several important attributes and to a lesser extent to the New Zealand *C. frontalis* Forest & McLaughlin, 2000, but are clearly distinct from both taxa.

The genus is characterized by the symmetrical chelipeds and second pereopods of its species that together form very efficient opercula, and additionally by bulbous pleons; symmetrical uropods, and unpaired pleopods present only in females. Unlike the majority of hermit crabs, these female pleopods can develop on either the right or the left side of the pleon. The carcinoecia of choice for species of *Cancellus* typically are cylindrical cavities in calcareous rock, pumice, granular stones, siliceous sponges, calcareous algae, dead corals and serpulid worm tubes (Figs. 1, 2). Boas (1926) and Balss (1956) assumed that the animals left these shelters to feed; however Mayo (1973) reported that two specimens kept in the laboratory for eleven months were never observed to leave their stone carcinoecia. When walking in response to offered food, the crabs dragged the stones with them. Similarly, Hazlett (1969) had observed that in aquaria, *C. spongicola* Benedict, 1901 moved their stone carcinoecia in patterns similar to the shell movements of other diogenids. The majority of PANGLAO specimens of *Cancellus* were captured in tangle nets, but most were still in their shelters, suggesting that Hazlett's (1969) and Mayo's (1973) laboratory observations mirrored the activities of *Cancellus* species in their natural environments.

MATERIALS AND METHODS

Specimens from the PANGLAO 2004 expedition that were collected through entrapment in fishermen's tangle nets were provided to the scientific team during the latter part of May 2004, but the nets often had been set weeks or months before. Consequently, although the collection date is given as a particular day, labels accompanying some of the specimens indicate extended sampling periods.

The holotype and two paratypes are deposited in the National Museum of the Philippines. The remaining paratypes are distributed among the collections of the Muséum national d'Histoire naturelle, Raffles Museum of Biodiversity Research and National Museum of Natural History, Washington, D.C. (USNM) as indicated in the material examined. Comparative materials of *C. mayoae* and *C. frontalis* were borrowed from the National Museum of Natural History and the National Institute of Water and Atmospheric Research, Wellington (NIWA). The institutional abbreviation NMNZ refers to the National Museum of New Zealand (now Museum of New Zealand Te Papa Tongarewa). Terminology used in the description in part follows that of Forest & McLaughlin (2000) and in part that of McLaughlin (2007). One measurement, shield length, measured from the tip of the rostrum to the midpoint of the posterior margin of the shield is given in parentheses following the specimen's sex and provides an indication of animal size. The lengths of the ocular peduncles are based on measurements taken along the lateral surfaces of the ultimate segments of the left peduncles, including the corneas; corneal diameters represent the maximum dorsal widths of the corneas. All measurements have been rounded to the nearest 0.1 mm. The abbreviations stn, DW, and coll. refer to station, Warén dredge and collector, respectively.

TAXONOMY

Family Diogenidae Ortmann, 1892

Genus *Cancellus* H. Milne Edwards, 1836

Cancellus panglaoensis, new species

(Figs. 1–5)

Material examined. – Holotype male (11.7 mm), Panglao north coast, Philippine Islands, Jul.2004–May 2005, tangle nets of fishermen, coll. Jo Arbasto (NMCR). Paratypes: 1 male (3.3 mm), 5 females (6.8–16.0 mm) (MNHN-Pg 7782), Balicasag Island, 9°31.1'N 123°41.5'E, ca. 100 m, 31 May 2004, tangle nets of local fishermen; 1 female (8.1 mm) (NMCR), Bohol Island, Maribohoc Bay, stn P1, 9°36.1'N 123°45.0'E, 90–200 m, 30 May 2004, tangle nets of local fishermen; 3 males (5.8–12.0 mm), 1 specimen (damaged, 2.9 mm) (ZRC); stn P2, 9°39.0'N 123°43.8'E, 400 m, 30 May 2004, tangle nets of local fishermen; 1 female (7.4 mm) (USNM), stn DW 2374, 08°43.7'N 123°14.0'E, 101–109 mm, 28 May 2005; 1 male (9.7 mm) (USNM), Panglao, no specific data; 1 female (11.6 mm) (NMCR), Panglao, no specific data.

Description. – Shield (Fig. 1, 3A) broader than long, with breadth increasing with animal size; longer than posterior carapace; frontal margin tripartite, in form of obtuse "W", with postorbital fissures at inferior angles; postrostral dorsal surface smooth, somewhat depressed, often bordered posteriorly by median pair of distinct, moderately broad arcs and low, transverse ridges (Fig. 1), sometimes simply rugose. Rostrum triangular with subacute to acute summit, slightly to distinctly overreaching broadly obtuse lateral projections; latter unarmed or each occasionally with small terminal spinule.

Ocular peduncles 0.7–0.8 length of shield, dorsomesial surface proximally each with 3 spine-like protuberances in relatively small specimens, becoming less acute and ultimately inconspicuous in large individuals; corneal diameter 0.1–0.2 of peduncular length. Ocular acicles subquadrate, each with 2–4 small spines on anterior margin; broadly separated basally.

Antennular peduncles varying from not quite reaching bases of corneas to slightly overreaching distal corneal margins; ultimate and penultimate segments unarmed; basal segment with 2–5 small spines on distolateral margin, usually 1 or 2 small spines ventrally on distomesial margin.

Antennal peduncles reaching distal 0.3–0.7 of ocular peduncles. Fifth and fourth segments unarmed; third segment with prominent ventrodistal spine; second segment with dorsodistal angle produced, subtriangular, dorsomesial distal angle weakly produced, subacute or acute; first segment with 1 or 2 prominent spines on ventrodistal margin and additional, sometimes slightly hooked, spine above orifice of antennal gland. Antennal acicles short and broad, slightly overreaching proximal margins of fifth segments, terminal margins oblique, each with 3 acute or subacute spines, 1 or 2 tuberculate spines on each dorsal surface. Antennal flagella equal to or shorter than carapace. Epistome with small to prominent spine.

Mandible (Fig. 3B) with calcified cutting edge, palp (Fig. 3C) 3-segmented, penultimate segment with dorsal margin produced into moderately prominent lobe. Maxillule (Fig. 3D) with external lobe of endopod obsolete, 3 or 4 setae terminally on internal lobe. Maxilla (Fig. 3E) with endopod as long as distal lobe of scaphognathite. First maxilliped (Fig. 3F) with endopod incompletely 2-segmented; epipod absent. Second maxilliped (Fig. 3G) without distinguishing characters. Third maxilliped (Fig. 3H) with well developed crista dentata, no accessory tooth; basis with 2 or 3 small teeth; merus and carpus unarmed.

Chelipeds (Fig. 4A, B) symmetrical, similar; cutting edges each with few large calcareous teeth, terminating in hoof-like corneous claw; opercular surface of dactyl weakly tuberculate, tubercles largest marginally, inner surface with 3 rows of tubercles, uppermost largest. Inner margin of palm divided into 7 rectangular lobes, each with small marginal spines or tubercles and short setae; opercular surfaces covered with tubercles slightly larger toward outer margin; outer ventral surface with 5 or 6 broad, parallel, smooth or weakly granular striae largest proximally; outer surface of fixed finger with scattered setae; inner surface of palm with few granules or tubercles dorsodistally, otherwise unarmed, but with tufts of long setae ventrally on palm and fixed finger. Elevated upper margin of carpus divided into 3 or 4 lobes; free margins of each with small spines or tubercles, dorsal surfaces each with small spinules or tubercles; inner, outer and lower surfaces unarmed. Merus with few tubercles or protuberances proximally on somewhat produced ventrolateral margin. Ischium also often with 2 or 3 tubercles or protuberances on ventrolateral margin.

Second and third pereopods dissimilar. Second pereopods (Figs. 4C, 5A) with distal 3 segments rotated counterclockwise to form operculum with chelipeds. Dactyl 0.7–0.8 length of propodus, opercular surface flat or weakly concave, with irregular, vertical rows of small tubercles, each frequently with tiny corneous spinule; upper margin cut into 4 or 5 distinct lobes proximally, more tuberculate protuberances distally and with moderately dense setae; lower margin with row of prominent tubercles, 7–9 corneous spines, and row of moderately short setae; inner surface with few tufts of sparse setae. Propodus with opercular surface slightly concave and weakly tuberculate, upper margin cut into 5 nearly subquadrate lobes, each marginally spinulose or tuberculate, and accompanied by row of moderately long setae, lower margin with 7 or 8 smaller lobes accompanied by shorter setae; ventral margin with several tufts of setae. Carpus with opercular surface weakly tuberculate, upper margin divided into 5 or 6 lobes, each faintly tuberculate or spinulose marginally, lower margin with 6–8 smaller lobes; ventral margin with few tufts of setae. Merus with small spine or spinule on dorsodistal margin in small specimens, unarmed in larger individuals, sparse setae and 2–4 blunt or spine-like protuberances on dorsal surface; ventral margin with row of tuberculate spines. Ischium unarmed.

Third pereopods (Fig. 5B, C) with distal three segments somewhat compressed but without counterclockwise rotation. Dactyl 0.7–0.8 length of propodus; dorsal surface cut into 6 irregularly subquadrate, weakly tuberculate lobes accompanied by row of moderately dense setae; lateral face with numerous tufts of short setae; mesial face with median row of sparse setae; ventral margin with row of 7 or 8 corneous spines partially concealed by moderately dense setae. Propodus cut into 4 marginally tuberculate subquadrate lobes, and smaller subtriangular lobe proximally; lateral face with scattered sparse tufts of short setae; ventral margin with tufts of longer setae. Carpus with 3 or 4 blunt or subacute protuberances in distal half and row of moderately short setae. Merus with 2 or 3 protuberances on distal half of dorsal surface and few tufts of setae; ventral surface with row of protuberances and tufts of setae. Ischium with few tufts of setae dorsally and ventrally. Fourth pereopods (Fig. 5D) semichelate; dactyl quite short; propodal rasp large, ovate. Fifth pereopods (Fig. 4D) chelate; dactyl and fixed finger slender, approximately 0.3 length of palm; latter also quite slender, with narrowly ovate rasp.

Coxae of male fifth pereopods (Fig. 3 I, J) not approximate, but widely separated only distally, varying in shape from almost globular distally but drawn out proximally, to ovate and deeply concave; inner margins weakly to prominently convex, anterior margins rounded; gonopores opening on anterior margins at nearly midlength.

Sixth pleomere (Fig. 3L, M) shorter than broad, divided by transverse suture, somewhat elevated to form similarly transverse ridge increasing in prominence with increased animal size; lateral and terminal margins frequently with 2—4 small, sometimes corneous tipped spines or tubercles. Telson

Fig. 1. *Cancellus panglaoensis*, new species, female from PANGLAO stn DW 2374 (7.4 mm, USNM).

Fig. 2. *Cancellus panglaoensis*, new species, female from PANGLAO stn P1 (8.1 mm, NMCR).

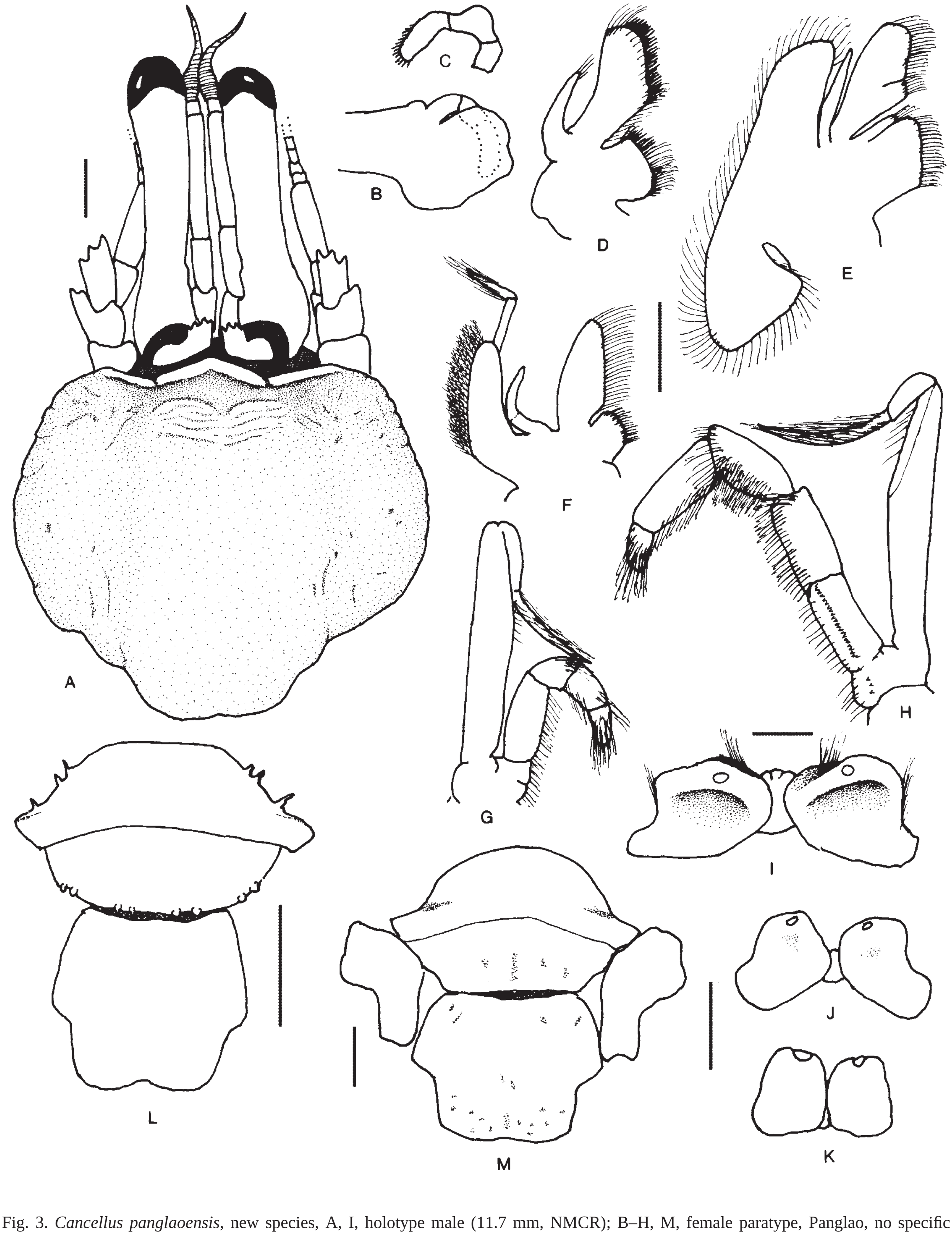

Fig. 3. *Cancellus panglaoensis*, new species, A, I, holotype male (11.7 mm, NMCR); B–H, M, female paratype, Panglao, no specific locality (11.6, NMCR); J, L, male paratype, PANGLAO stn P2 (6.2 mm, ZRC); *Cancellus mayoae*, K, male paratype (4.9 mm, USNM 285521). A, shield and cephalic appendages (aesthetascs and setae omitted); B, right mandible (external view); C, palp of right mandible (internal view); D, right maxillule (external view); E, right maxilla (external view); F, right first maxilliped (external view); G, right second maxilliped (external view); H, right third maxilliped (internal view); I–K, coxae and sternite of male fifth pereopods (ventral view, setae omitted); L, M, sixth pleonal tergite and telson (dorsal view, setae omitted). Scale bars = 2 mm.

(Fig. 3L, M) divided into anterior and posterior portions of approximately equal length, but posterior portion appreciably narrower. Anterolateral lobes roundly triangular, posterior lobes roundly subquadrate, separated by faint to prominent concavity; dorsal surface often weakly to distinctly pitted, and frequently with covering of short, dense setae.

Colouration. – Overall tan to pink (Figs. 1, 2).

Etymology. – Named for the type locality off Panglao Island.

Distribution. – Presently known only from the Bohol Sea, the Philippine Islands; 90–400 m.

Variation. – As may be seen in the description, size related variation is characteristic of *C. panglaoensis*, new species. This is particularly noteworthy in the increased breadth of the shield, the increased length and reduction in spination on the ocular peduncles, the increased length of the antennular peduncles, and the concave development of the coxae of the fifth pereopods in males with increasing animal size. Variations in the armature of the sixth pleonal tergite and in the concavity of terminal margin of the telson do not seem clearly correlated with growth, but the present sample size is insufficient for confident assessment.

Affinities. – *Cancellus panglaoensis*, new species is, as previously indicated, morphologically very similar to *C. mayoae*, sharing with that species the very distinctive spination of the proximal dorsomesial surfaces of ocular peduncles not found in other species of the genus. Additionally, the ocular acicles of both species are provided with two or more terminal spinules; the sixth pleonal tergite

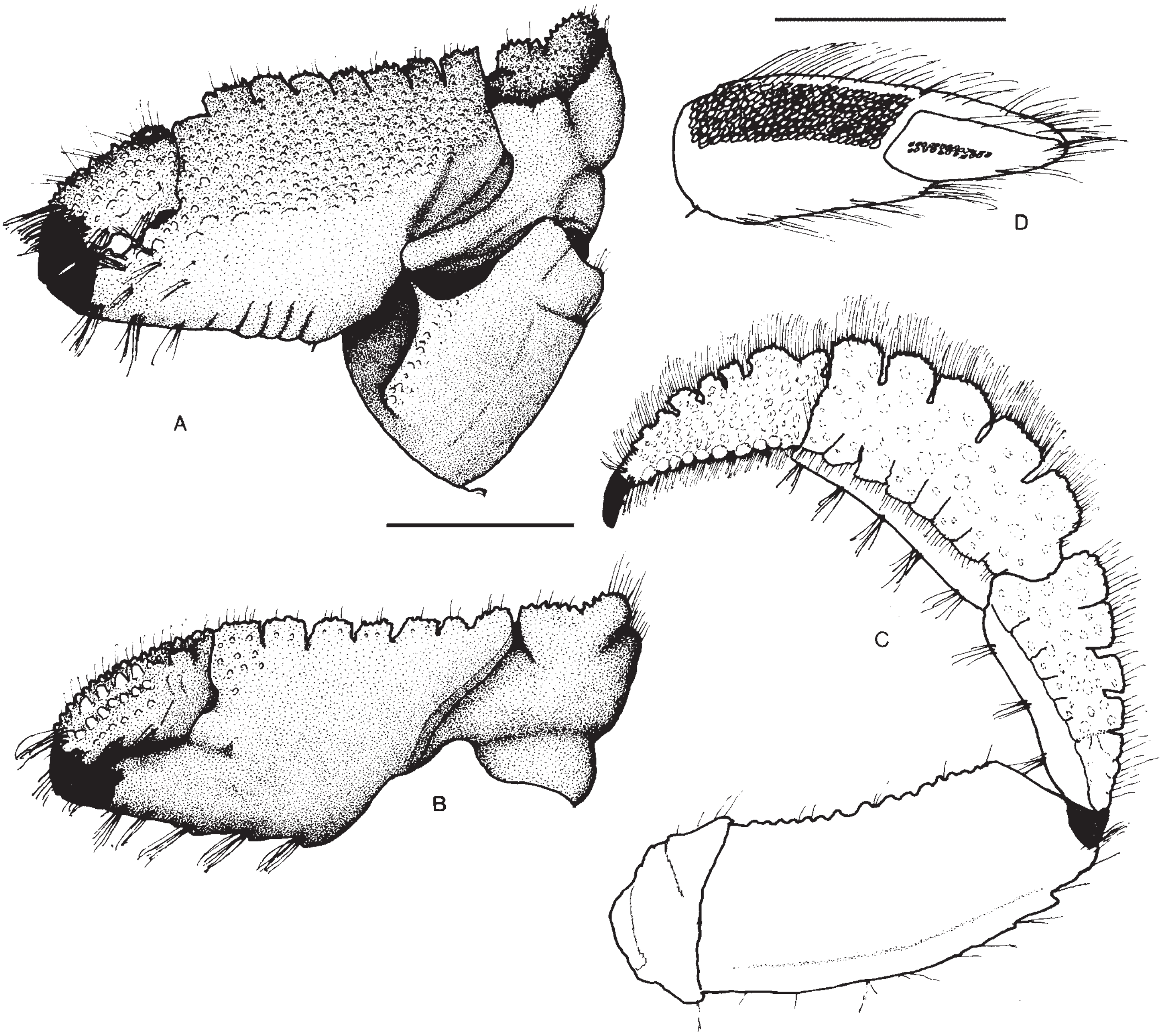

Fig. 4. *Cancellus panglaoensis*, new species, female paratype, Panglao, no specific locality (11.6, NMCR): A, chela and carpus of left cheliped (external surface); B, chela and carpus of right cheliped (internal view); C, right second pereopod (internal view); D, propodus and dactyl of right fifth pereopod (setation not precise). Scale bars: D = 3.0 mm; A–C = 5.0 mm.

may have a few marginal spines or tubercles on both anterior and posterior portions; and the telsons are comparable in shape. *Cancellus mayoae* is known only from the female holotype (7.8 mm) and a smaller male paratype, so the variation seen in *C. panglaoensis*, new species, can not be assessed in the former species. However, it is probable that the spination of the ocular peduncles and sixth pleonal tergite in *C. mayoae* are similarly growth related. Two characters that do not appear variable in *C. panglaoensis*, new species, will serve to distinguish between the two taxa. The first is the number of smooth or granular transverse striae on the lower inner surface of each chela. There are nine striae in *C. mayoae*, but only five or six in *C. panglaoensis*, new species. More importantly, the coxae of the male fifth pereopods are markedly different in the two species: globular and distally widely separated in small males of *C. panglaoensis* (Fig. 3J) changing to ovate and deeply concave in large males (Fig. 3I); the gonopores are centrally placed on or near the anterior margins. In *C. mayoae*, the male fifth coxae (Fig. 3K) are subrectangular and proximally somewhat bell-shaped with inner margins nearly approximate and large gonopores opening on anterior midlines.

Cancellus frontalis was described from two females, the holotype and paratype, plus two damaged specimens, one male and one female; the holotype has been re-examined. There are discrepancies and errors in the listing of material examined and the figure legend in the original publication. The material examined identifies the holotype as a female with a shield length of 10 mm; the figure legend lists the holotype as a male with a carapace length of 10 mm. The holotype is a female; the shield length is 6.8 mm and the

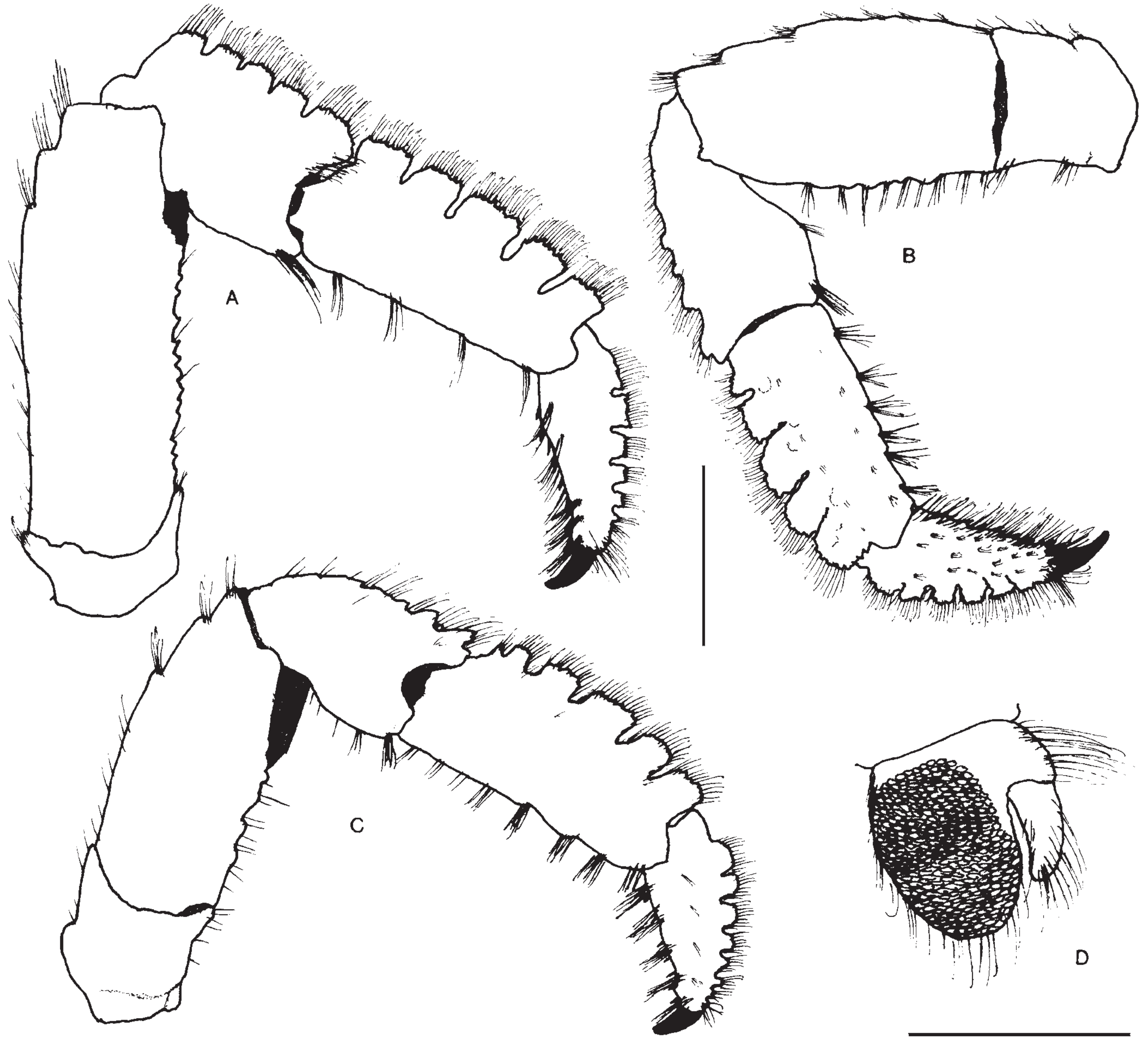

Fig. 5. *Cancellus panglaoensis*, new species, female paratype, Panglao, no specific locality (11.6, NMCR): A, right second pereopod (external view); B, right third pereopod (mesial view); C, right third pereopod (lateral view); D, propodus and dactyl of right fourth pereopod (lateral view, setation not precise). Scale bars: D = 3.0 mm; A–C = 5.0 mm.

carapace length (cl) is 10 mm. Although the illustrated shield and cephalic appendages (Forest & McLaughlin, 2000: Fig. 32a) correspond well with the holotype, the coxa of the right fifth pereopod (Fig. 32b) and the sixth pleonal tergite and telson (Fig. 32c) do not. It would appear that figure of the right coxa was drawn of the male (cl = 9.5 mm, NMNZ Cr 9595) as there is an indication of a possible gonopore on the anterior margin of the coxa. It is unclear to which specimen the pleonal tergite and telson belong, although they appear to simply represent minor variations from the holotype.

Based on the holotype, the ratios of ocular peduncle length to shield length, as well as the antennular and antennal lengths are comparable in *C. frontalis* and *C. panglaoensis*, new species, as are the spinations of the antennal acicles. The lower inner surfaces of the chelae in both species are marked by 5 or 6 smooth or weakly granular, transverse striae. The illustrated coxa of the male fifth right pereopod of *C. frontalis* and the described male right coxa bear considerable resemblance to that of *C. panglaoensis*, new species, and the sixth pleonal tergites are similarly armed in specimens of approximately the same size. However, the species are readily distinguished by the ocular peduncles and acicles, and the frontal rims of the shields. In *C. panglaoensis*, new species, the ocular peduncles are armed with two or three proximal spines in specimens with shield lengths of 8 mm and less while the ocular acicles are each have 2–4 terminal spinules; the frontal rim of the shield is narrow. In contrast, the ocular peduncles of *C. frontalis* lack proximal spines; the ocular acicles each terminate in a simple acute spine; and the frontal rim is quite broad.

Remarks. **–** Although most early investigators noticed the occasional occurrences of female pleopods on the right side of the pleon in species of *Cancellus*, these were considered anomalies. It was not until Mayo (1973) had a sufficient number of female specimens of a single species, *C. spongicola* Benedict, 1901, that she was able to suggest that female pleopod development was not restricted to the left side of the pleon as it was in most paguroids. However, she, as A. Milne-Edwards & Bouvier (1891), Boas (1926) and other early carcinologists had, considered the symmetry exhibited by *Cancellus* species secondarily acquired as a result of habitat adaptation.

DISCUSSION

The presumed superficial resemblance of *Cancellus* to the Pylochelidae has been noted by several authors (e.g., A. Milne-Edwards & Bouvier, 1891, 1893; Boas, 1926; Mayo, 1973); however, the phylogenetic position of the genus has never been addressed critically. In the only two investigations to consider the genus directly, McLaughlin & Lemaitre (1997) ranked it a sister clade to the pagurid genus *Xylopagurus* A. Milne-Edwards, 1880, whereas Tudge (1997) placed it between the galatheids and porcellanids in the Galatheoidea. Mayo (1973) and Forest & McLaughlin (2000) informally suggested that two morphological groupings existed within the genus: those species in which the frontal margin was continuous and those in which fissures resulted in a tripartite rim. Until all currently recognized species and the undescribed taxa alluded to by Forest & McLaughlin (2000) are examined in detail, any phylogenetic hypothesis would be premature. However, with the current detailed examination of several specimens of *C. panglaoensis*, new species, attention can be called to certain morphological attributes that are shared with the pylochelids and others that set at least this *Cancellus* species apart from the remainder of the Diogenidae.

A. Milne-Edwards & Bouvier (1891) gave the branchial formula for *Cancellus* as paired arthrobranchs on the third maxillipeds and pereopods 1–4; single pleurobranchs on pereopods 2–5, but noted that the arthrobranchs of the third maxillipeds were represented only by a rudiment and a small bud. Following the criterion used by McLaughlin et al. (2007), nonfunctional gill structures are not considered as representative of true gills. Therefore, gills are considered absent on the third maxillipeds in *Cancellus*.

Alcock (1905) reported that with the exception of the external endopodal lobe (his “palp”) of the maxillule, which was well developed and recurved in *Paguristes* Dana, 1851, but obsolete in *Cancellus*, the mouthparts in the two genera were identical. Mouthparts other than the third maxillipeds have not been described for most *Cancellus* species; however, two characters in *C. panglaoensis*, new species, differ considerably from those found in species of *Paguristes*. The first is seen in the mandibular palp. In *C. panglaoensis*, new species, the second segment has a dorsal protuberance similar to those seen in genera of the Pylochelidae; no such protuberance is found in palp of *Paguristes* species. A second difference is found in the first maxillipeds of the two genera: In *Paguristes* and all pylochelids an epipod is present on the first maxilliped; no epipod is present in *C. panglaoensis*, new species. With the exception of the pylochelid genus *Mixtopagurus* A. Milne-Edwards, 1880, the uropods and telsons of pylochelids and *Cancellus* are symmetrical, whereas uropod symmetry when present in species of *Paguristes* is unquestionably habitat induced. The chelipeds of species in certain genera of the Pylochelidae, like species of *Cancellus*, are operculate; species of *Paguristes* are not. However, only in *Cancellus* species and the monotypic pylochelid genus *Cancellocheles* are the second pereopods modified to compliment the opercular closure. Although the second pereopods are functionally homologous in the two taxa, they most probably represent convergent development.

Two additional characters shared by *C. panglaoensis*, new species, and the pylochelid *Parapylocheles scorpio* Alcock, 1894, are the presence of spines on the ocular peduncles and on the epistome. Similar spines are also seen on the ocular peduncles of *C. mayoae*. This spination has been found to disappear with increased animal size in *C. panglaoensis*, new species, but not in *P. scorpio*. *Cancellus mayoae* is known only from two moderate to small specimens, so the fate of ocular spination is unknown in this species. Nonetheless, is probable that ocular spination has arisen independently in the two genera. Spines on the epistome are also not common in paguroids, but do occur in some parapagurids as well as in *Cancellus panglaoensis*, new species, and *P. scorpio*, thus it is improbable that this represents a synapomorphy linking these taxa.

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