

Neogene and Quaternary Ghost Shrimps and Crabs (Crustacea: Decapoda) from the Philippines

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Abstract Twenty species in 17 genera of decapod crustaceans are reported from the Upper Miocene Mapulo Formation in Taysan, Batangas, southern Luzon and the Lower Pleistocene Mandog Formation in Davao City, southeastern Mindanao, Philippines. Of these, *Leucosia martini*, *Nursia bilobata*, *Pseudophilypira granulimarginata*, *Cryptolutea warreni*, *Demania pilipinas*, and *Hexapus granuliformis* are described as new. *Neocallichirus dijki* (Martin, 1883), new combination is also included. In addition, three new combinations are proposed: *Philypira shihchenii* for *Leucosia shihchenii* Hu and Tao, 1979, from the Pliocene of Taiwan, *Paranursia acharyai* for *Nursia acharyai* Bachmayer and Mohanti, 1973, from the Miocene of India, and *Cryptolutea litoralis* for *Galene litoralis* Collins, Lee, and Noad, 2003, from the Pleistocene of Sarawak.

Key words: Neogene, Crustacea, Decapoda, Thalassinidea, Brachyura, Philippines.

Introduction

Decapod fossils are hitherto poorly known from the Philippines. So far, the only reported occurrence is the single ghost shrimp, *Callianassa dijki* Martin, 1883, identified by Martin (1895) and Smith (1913) from the Neogene of central Cebu. In 2003, the National Museum of Nature and Science, Tokyo (NMNS), and the Mines and Geosciences Bureau, Philippines (MGB), launched a joint research project on fossil collection building and natural history research in the Philippines. This project aims to establish standard fossil reference materials in the Philippines,

revive paleontological researches in the MGB, and understand the origin of marine biodiversity in the tropical Indo-Western Pacific (see Aguilar and Kase, 2004). Since its initiation, T. Kase, Y. M. Aguilar and Y. Kurihara undertook fossil collection surveys in many islands in the Philippines, and discovered a number of unexplored younger Cenozoic fossil localities. During the course of paleontological surveys conducted by NMNS and MGB, a number of decapod fossils were collected in Taysan, Batangas and Davao City in Mindanao. A total of 20 species are represented in the collections, six of which are new (Table 1). The purpose of this paper is to system-

Table 1. List of species from the Mapulo and Mandog Formation

Species	Collecting site, age and formation	
	TYS-1 Late Miocene Mapulo Formation	DVO-11 Pleistocene Mandog Formation
<i>Callianassa</i> (s. l.) sp.	+	
<i>Neocallichirus djiki</i> (Martin, 1883), new combination	+	
<i>Neocallichirus</i> sp.	+	+
<i>Raninoides</i> sp.		+
<i>Calappa pustulosa</i> Alcock, 1896		+
<i>Calappa</i> sp.		+
<i>Leucosia martini</i> Karasawa & Kato, new species		+
<i>Nursia bilobata</i> Karasawa & Kato, new species	+	
<i>Philyra</i> sp. cfr. <i>P. actidens</i> Chen, 1987	+	
<i>Pseudophilyra granulimarginata</i> Karasawa & Kato, new species	+	
<i>Galene bispinosa</i> (Herbst, 1783)	+	
<i>Cryptolutea warreni</i> Karasawa & Kato, new species		+
<i>Liagore rubromaculata</i> (de Haan, 1835)		+
<i>Demania pilipinas</i> Karasawa & Kato, new species		+
<i>Demania</i> sp.		+
<i>Eucrate</i> sp.		+
<i>Carcinoplax purpurea</i> Rathbun, 1914		+
<i>Hexapus granuliformis</i> Karasawa & Kato, new species		+
<i>Podophthalmus vigil</i> (Fabricius, 1798)		+
<i>Pinnixa</i> sp.		+

atically document these decapod species.

The first and second authors are responsible for the taxonomy of the crabs, while the others are for the description of geology and collecting sites. The specimens described in this paper are stored in the MGB and NMNS with prefix MGB and NMNS, respectively.

Description of Fossil Localities

By T. Kase, Y. M. Aguilar, Y. Kurihara, H. Hayashi and K. Hagino

The fossil decapods described in this paper were collected from two sites: Locality TYS-1 (Mapulo Formation) and locality DVO-11 (Mandog Formation). Details of the localities are described below.

Locality TYS-1

Location: Limestone quarry at Fortune Cement Co. Ltd., Barangay Mapulo, Taysan municipality in Batangas Province, southern Luzon (13°44.472'N, 121°11.240'E) (Fig. 1).

Stratigraphy: Locality TYS-1 is from the limestone quarry located in Mapulo Hill, Taysan that forms a small topographic high within the Pleistocene volcanic sediments. The sedimentary beds exposed in this quarry consist of an upper ca. 30-m-thick coralline limestone and a lower ca. 50-m-thick, slightly consolidated dark-gray muddy sandstone. The upper limestone facies was assigned to the Mapulo Limestone by Avila (1980) and was accordingly adopted by the Philippine Bureau of Mines and Geosciences (1985). Kase and Aguilar (2004) elevated the Mapulo to formational level to include the upper limestone and lower sandstone beds. Fossil mollusks are quite common in the upper part of the lower muddy sandstone beds. In a preliminary examination, Kase and Aguilar (2004) identified a total of 55 molluscan species, 36 of which are identical to modern species that are mostly dwellers in subtidal to bottoms of about 50 m in depth. Fossil crabs are rather sporadic and found in floated calcareous concretions.

Age: Philippine Bureau of Mines and Geosciences (1985) assigned the Mapulo Limestone

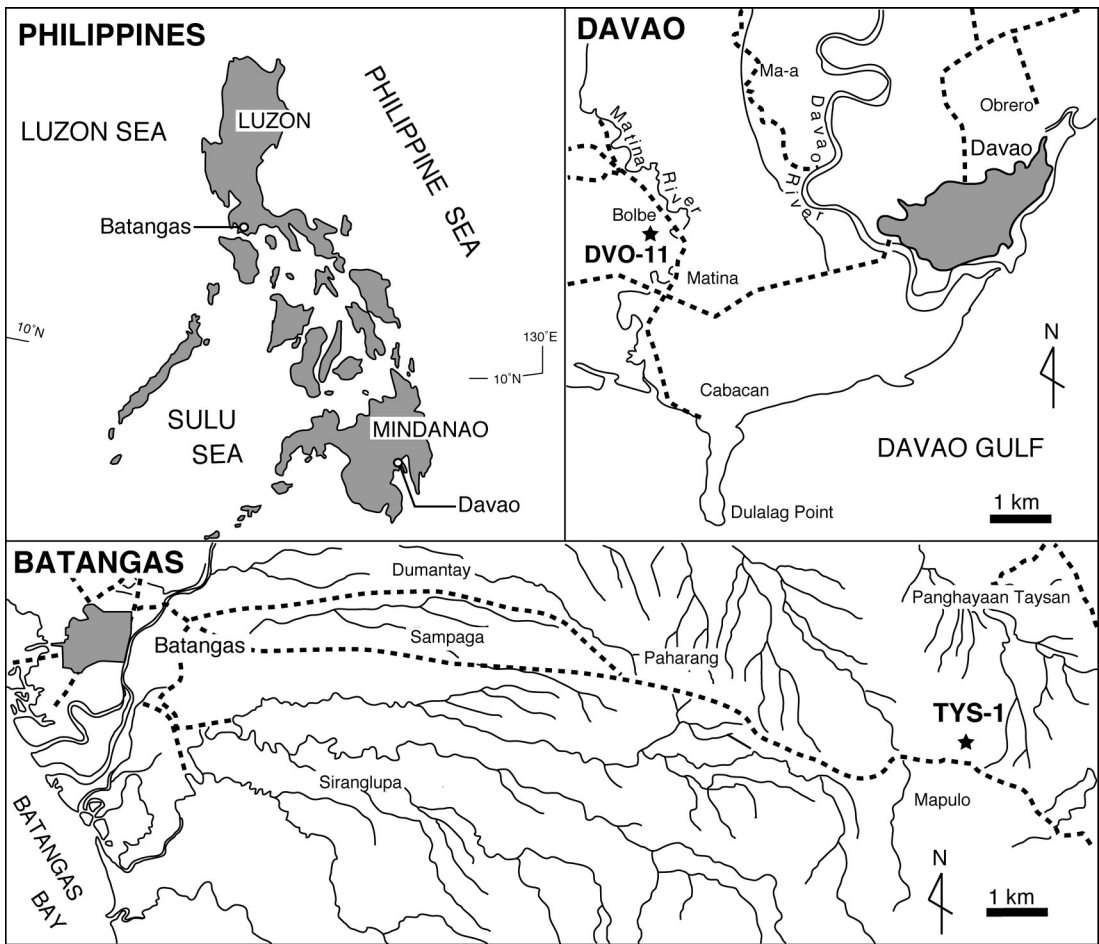


Fig. 1. Maps showing detailed locations of DVO-11 in Davao Province (upper right) and TYS-1 in Batangas Province (lower left).

a late Miocene to Pliocene age. This was substantiated by nannofossil analysis made by H. Kameo of Chiba University on the sandstone sample that can be assigned to nannofossil zone CN9 (8.36 to 5.56 Ma), equivalent to a late Late Miocene age.

Locality DVO-11

Location: Abandoned sand quarry at Bolbe, Davao City, southeastern Mindanao ($7^{\circ}04'01''\text{N}$, $125^{\circ}34'05''\text{E}$) (Fig. 1).

Stratigraphy: Younger Cenozoic, fluvio-deltatic to shallow marine sedimentary sequences in the area around Davao City, southeastern Mindanao consist of lower Masuhi and upper Mandog for-

mations which are overlain unconformably by the younger Pleistocene Apo Volcanics and the Samal Limestone. According to the geological map published by Mines and Geosciences Bureau, Philippines (Philippine Bureau of Mines and Geoscience, 1984), DVO-11 is within the Mandog Formation that is referred vaguely to early Pleistocene in age. The Masuhi Formation in this area is represented by deltaic conglomerate of more than 100 m thick, while the overlying Mandog Formation represents a transgressive facies succession that consists of sandstone, marl and coralline limestone. The sandstone beds at DVO-11 is the lowermost part of the Mandog Formation, remarkably fossiliferous, and contain

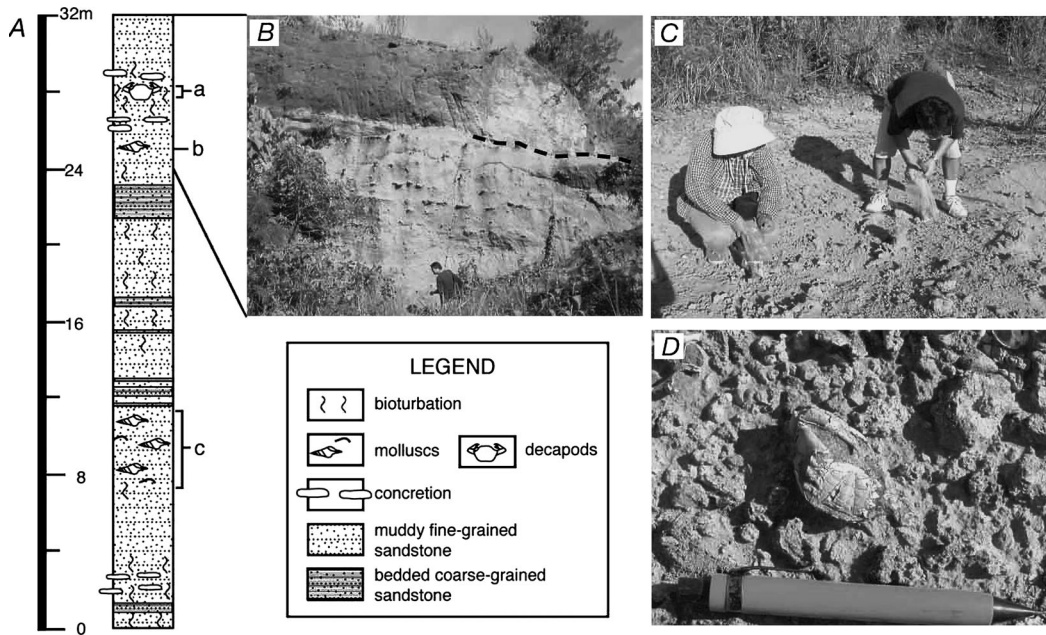


Fig. 2. Mandog Formation at DVO-11, abandoned sand quarry in Bolbe, Davao City. A. Columnar section of lowermost part of Mandog Formation exposed at DVO-11. B. Outcrop of upper part of section, showing muddy fine-grained sandstone with concretions. Fossil crabs described in this paper were collected from bedding surface on terrace (ca. 100 m²) above dotted line. C. Photograph showing weathered surface of crab-bearing bed. D. Photograph showing articulated specimen in crab-bearing bed.

diverse mollusks that are mostly identical to modern species found today in bottoms of open marine, around 50 m in depth (Bed c in Fig. 2A). The fossil crabs described here are from an upper horizon of the beds exposed in this quarry (Bed a in Fig. 2A). The crab-bearing beds are composed of fine-grained sandstone with abundant calcareous concretions that may have originated by burrows of benthic animals (Fig. 2B–D). The crabs are abundant in a weathering bedding surface (Fig. 2B), and often articulated in good condition (Fig. 2D).

Age: We analyzed planktonic foraminifers and nannofossils from Bed b just below the crab-bearing bed (Fig. 2A). Bed b yielded beautifully preserved planktonic foraminifer abundantly. Species identified include *Globigerina bulloides*, *G. decoraperta*, *Globoturborotalita cf. rubescens*, *Globigerinella* sp., *Globigerinina glutinata*, *Globigerinoides bulloideus*, *G. ruber*, *G. sacculifer*, *Globorotalia cf. crassaformis*, *G.*

menardii, *Neogloboquadrina humerosa* s.l., *Pulleniatina obliquiloculata* (dextrally coiled form), *P. obliquiloculata* (sinistrally coiled form), *Orbulina* spp. and some others. These species are not diagnostic in determining detailed age, except that the abundance occurrence of dextral form of *Pulleniatia obliquiloculata* suggests an age younger than 3.95 Ma (Berggren *et al.*, 1995). Bed b yielded moderate to well-preserved Pleistocene calcareous nannofossils as well as reworked specimens from older Pliocene sedimentary rocks. The calcareous nannofossil species identified from this sample are; *Calcidiscus leptoporus*, *Gephyrocapsa caribbeanica*, medium-sized *Gephyrocapsa oceanica* (3.5–5.0 μm in length of placolith), *Discoaster broweri*, *Sphenolithus* sp., and *Reticulofenestra minutula*. The occurrence of medium-sized *G. oceanica* indicates that the sample is younger than 1.7 Ma (Raffi *et al.*, 2006). Therefore, these micropaleontological data demonstrate that Bed b is broadly assigned

to the Pleistocene. Taking the stratigraphic position into consideration, however, the age of the crab-bearing beds in the lowest part of the Mandog Formation is estimated to be early Pleistocene.

Systematics

By H. Karasawa and H. Kato

Infraorder Thalassinidea Latreille, 1831

Superfamily Callianassoidea Dana, 1852

Family Callianassidae Dana, 1852

Subfamily Callianassinae Dana, 1852

Genus *Callianassa* (s. l.) Leach, 1814

Type species: Cancer (Astacus) subterraneus Montagu, 1808, by monotypy.

Callianassa (s. l.) sp.

(Fig. 3A)

Material examined: MGB-CF0001 and NMNS PA16389 from TYS-1.

Remarks: The present specimens are the poorly preserved propodi of the major chelipeds. Therefore, the generic placement of the species awaits the discovery of more well-preserved material and it is considered best to place the species in *Callianassa* (s. l.). The smooth lateral surface and dorsal and ventral margins easily distinguish it from the following two callichirhines, *Neocallichirus dijki* (Martin, 1883) and *Neocallichirus* sp.

Subfamily Callichirinae Manning and Felder,
1991

Genus *Neocallichirus* Sakai, 1988

Type species: Neocallichirus horneri Sakai, 1988, by original designation.

Included fossil species: see Schweitzer *et al.* (2008).

Remarks: Most recently, Schweitzer *et al.* (2006b, 2008) reviewed the fossil species within

Neocallichirus and included 16 species in the genus. Among these, *Neocallichirus grandis* Karasawa and Goda, 1996, has been transferred to *Grynaminna* Poore, 2000, based upon the characters of the chelipeds (Obata and Hayashi, 2000). After that, Sakai (2005) synonymised *Grynaminna* with *Podocallichirus* Sakai, 1999; therefore, Karasawa *et al.* (2006) removed *Grynaminna grandis* to *Podocallichirus*. Additionally, *Callianassa dijki* Martin, 1883, is herein moved to the present genus.

Neocallichirus dijki (Martin, 1883),

new combination

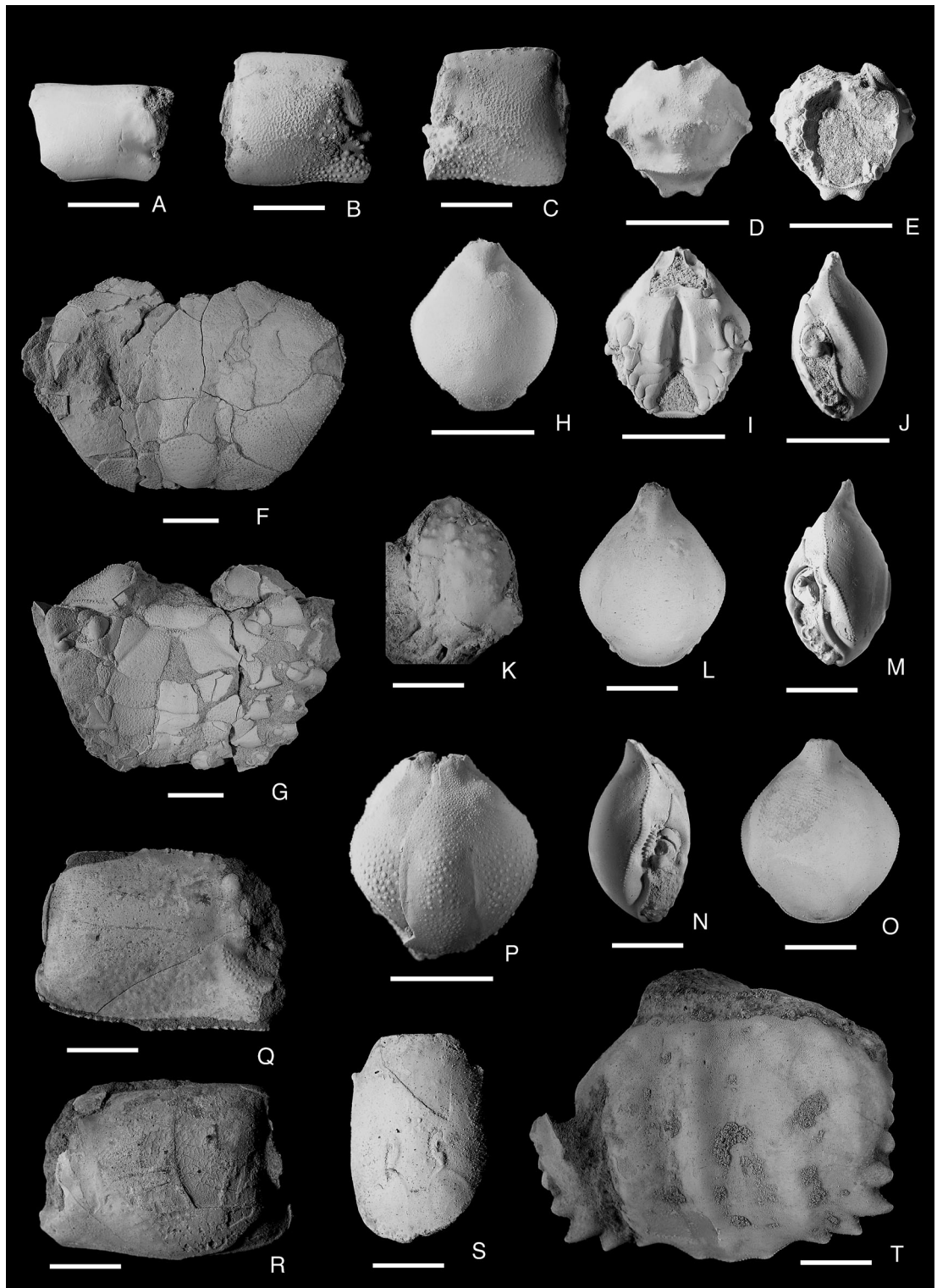
(Fig. 3B, C)

Callianassa dijki Martin, 1883, 36, pl. 3, figs. 31–33.

Material examined: MGB-CF0002 and NMNS PA16390 from TYS-1.

Emended diagnosis: Large-sized major cheliped. Palm about as long as high; lateral and mesial surfaces coarsely granulate distally; ventral margin denticulate; dorsal margin finely denticulate; distal margin granulated. Fixed finger slightly shorter than palm, gently curved dorsally, occlusal margin finely serrated. Dactylus coarsely granulated proximally; ventrolateral surface pitted; tip acutely pointed, hooking ventrally; occlusal margin bearing large denticles varying in size.

Remarks: Martin (1883) described *Callianassa dijki* from the Miocene of Java. After that, Martin (1895) and Smith (1913) recorded this species from the Miocene deposits of Philippines. *Callianassa dijki* possesses characters of the propodus of the major cheliped most like those of the extant *Neocallichirus karumba* (Poore and Griffin, 1979), a senior synonym of *Neocallichirus kempfi* Sakai, 1999 (see Dworschak, 2008), from East Asia, Australia, and India, previously assigned to *Callianassa maxima* A. Milne Edwards, 1870; therefore, this species is moved to *Neocallichirus*.



Neocallichirus sp.

(Fig. 3Q, R)

Material examined: MGB-CF0003 from DVO-11; NMNS PA16391 from TYS-1.

Remarks: This species is represented by a broken propodus of the larger cheliped. A large-sized propodus with serrated dorsal, ventral, and distal margins and a granulated dorso-mesial surface of the fixed finger characterize it. A smooth lateral surface readily distinguishes this species from *Neocallichirus dijki*. This species is similar to *Neocallichirus* sp. from the Pliocene Shimajiri Group, reported by Karasawa (1997), but differs in having a serrated dorsal margin and a granulated dorso-lateral surface of the fixed finger.

Infraorder Brachyura Latreille, 1802

Section Raninoidea de Haan, 1841

Superfamily Raninoidea de Haan, 1841

Family Raninidae de Haan, 1841

Subfamily Raninoidinae Lőrenthey in Lőrenthey and Beurlen, 1929

Genus *Raninoides* H. Milne Edwards, 1837

Type species: *Raninoides laevis* Latreille, 1825, by monotypy.

Included fossil species: see Schweitzer *et al.* (2006a).

Remarks: Although Schweitzer *et al.* (2006a) made a list of the known extant and fossil species within the genus, there is an additional species,

Raninoides fulungensis Hu and Tao, 2000, from the Oligocene–Miocene of Taiwan.

Raninoides sp.

(Fig. 3S)

Material examined: MGB-CF0004 and NMNS PA16392 from DVO-11.

Remarks: In the present specimen, detailed characters of the fronto-orbital region is wanting. The specific identification of this species awaits the discovery of more well-preserved specimens.

Section Eubrachyura de Saint Laurent, 1980

Superfamily Calappoidea de Haan, 1833

Family Calappidae de Haan, 1833

Genus *Calappa* Weber, 1795

Type species: *Cancer granulatus* Linnaeus, 1758, by subsequent designation of Latreille (1810).

Included fossil species: see Schweitzer *et al.* (2006b).

Remarks: Schweitzer *et al.* (2006b) reviewed the fossil species of *Calappa* and recognized 19 species in the fossil record. In their review, three species lack: two extinct, *Calappa chungii* Hu and Tao, 1984, and *Calappa oboui* Hu and Tao, 1996, from the Pliocene of Taiwan; and one extant *Calappa pustulosa* Alcock, 1896, from the Pliocene of Taiwan (Hu and Tao, 2000; 2004).

Fig. 3. **A.** *Callianassa* (s. l.) sp., MGB-CF0001, loc. TYS-1, propodus of major cheliped, lateral view. **B, C.** *Neocallichirus dijki* (Martin, 1883), new combination, MGB-CF0002, loc. TYS-1, propodus of major cheliped, B, lateral; C, mesial view. **D, E.** *Nursia bilobata* Karasawa and Kato, new species, MGB-CF0009 (holotype), loc. TYS-1, carapace, D, dorsal; E, ventral view. **F, G.** *Galene bispinosa* (Herbst, 1783), MGB-CF0012, loc. TYS-1, carapace, F, dorsal; G, ventral view. **H–J.** *Pseudophilyra granulimarginata* Karasawa and Kato, new species, MGB-CF0011 (holotype), loc. TYS-1, carapace, H, dorsal; I, ventral; J, lateral view. **K.** *Calappa* sp., MGB-CF0006, loc. DVO-11, carapace, dorsal view. **L, M.** *Leucosia martini* Karasawa and Kato, new species, MGB-CF0008 (paratype), loc. DVO-11, carapace, L, dorsal; M, lateral view. **N, O.** *Leucosia martini* Karasawa and Kato, new species, MGB-CF0007 (holotype), loc. DVO-11, carapace, N, lateral; O, dorsal view. **P.** *Philyra* sp. cfr. *P. actidens* Chen, 1987, MGB-CF0010, loc. TYS-1, carapace, dorsal view. **Q, R.** *Neocallichirus* sp., MGB-CF0003, loc. DVO-11, propodus of major cheliped, Q, mesial; R, lateral view. **S.** *Raninoides* sp., MGB-CF0004, loc. DVO-11, carapace, dorsal view. **T.** *Calappa pustulosa* Alcock, 1896, MGB-CF0005, loc. DVO-11, carapace, dorsal view. Scale bars=1 cm.

Table 2. List of know fossil species of *Leucosia*. Asterisk indicates extant species.

Original status	Current status	Age and locality	References
<i>L. anatum</i> (Herbst, 1783)*	<i>Leucosia</i> s. l.	M. Pleistocene, Japan	Karasawa & Tanaka (1994); Kato & Karasawa (1997)
<i>L. calcarata</i> Collins <i>et al.</i> , 2003	<i>Leucosia</i> s. l.	E. Miocene, Sarawak	Collins <i>et al.</i> (2003)
<i>L. craniolaris</i> (Linnaeus, 1758)*	<i>Leucosia</i> s. s.	Pliocene, Taiwan	Hu & Tao (1996)
<i>L. formosensis</i> Sakai, 1937	<i>Philyra</i>	Pleistocene, Taiwan	Hu & Tao (1996)
<i>L. haematsticta</i> Adams & White, 1848*	<i>Urnalana parahaematsticta</i> Galil, 2005	M. Pleistocene, Japan	Karasawa & Goda (1996); Kato & Karasawa (1998); Kobayashi <i>et al.</i> (2008)
<i>L. longiangulata</i> Morris & Collins, 1991	<i>Leucosia</i> s. l.	Pliocene, Brunei	Morris & Collins (1991)
<i>L. martini</i> Karasawa & Kato, new species	<i>Leucosia</i> s. l.	Pleistocene, Philippines	This paper
<i>L. obtusifrons</i> de Haan, 1841	<i>Euclosia</i>	Pliocene, Taiwan Neogene, Java	Hu & Tao (1996) Martin (1879)
<i>L. ovalata</i> Hu & Tao, 1996	<i>Leucosia</i> s. l.	L. Miocene, Taiwan	Hu & Tao (1996)
<i>L. rhomboidalis</i> de Haan, 1841*	<i>Seulocia</i>	L. Pliocene–Pleistocene	Hu & Tao (1996)
<i>L. serenei</i> Morris & Collins, 1991	<i>Leucosia</i> s. l.	Pliocene, Brunei	Morris & Collins (1991)
<i>L. shihcheni</i> Hu & Tao, 1979	<i>Philyra</i>	Pliocene, Taiwan	Hu & Tao, 1979; This work
<i>L. subrhomboidalis</i> Desmarest, 1822	<i>Leucosia</i> s. l.	Pleistocene, Indo-W. Pacific	Glaessner (1929)
<i>L. subrhomboidea</i> Hu & Tao, 1996	<i>Leucosia</i> s. l.	L. Miocene, Taiwan	Hu & Tao (1996)
<i>L. taiwanica</i> Hu & Tao, 1996	<i>Leucosia</i> s. l.	E. Pleistocene, Taiwan	Hu & Tao (1996)
<i>L. takamii</i> Karasawa, 1993	<i>Leucosia</i> s. l.	Pleistocene, Japan	Karasawa (1993)
<i>L. tricarinata</i> Martin, 1880	<i>Leucosia</i> s. l.	Miocene, Java	Martin (1880)
<i>L. tutongensis</i> Morris & Collins, 1991	<i>Leucosia</i> s. l.	Pliocene, Brunei	Morris & Collins (1991)
<i>L. unidentata</i> de Haan, 1841*	<i>Euclosia</i>	Pliocene, Taiwan Pleistocene, Japan Miocene, Java	Hu & Tao (1996) Karasawa (2000) Martin (1879)

Calappa pustulosa Alcock, 1896

(Fig. 3T)

Material examined: MGB-CF0005 from DVO-11.

Remarks: The dorsal surface of the present specimen is rather smooth because of erosion. This species is also recorded from the Pliocene Shimajiri Group of the Miyako island, Ryukyus, Japan (Karasawa and Nobuhara, 2008). More complete material will be necessary to confirm identification of this species.

Calappa sp.

(Fig. 3K)

Material examined: MGB-CF0006 and NMNS PA16393 from DVO-11.

Remarks: The specimens are a poorly preserved carapace and cheliped. However, the remaining carapace characters may be similar to the extant *Calappa clyeata* (Borradaile, 1903).

Superfamily Leucosioidea Samouelle, 1819

Family Leucosiidae Samouelle, 1819

Genus *Leucosia* Weber, 1795

Type species: *Cancer craniolaris* Linnaeus, 1758, by subsequent designation of Holthuis (1959).

Included fossil species: Table 2.

Remarks: Most recently, Galil (2003a, b, 2005a, b, 2006) reviewed *Leucosia* and erected five new genera, *Euclosia* Galil, 2003b, *Urnalana* Galil, 2005a, *Seulocia* Galil, 2005b, *Coleusia* Galil, 2006a, and *Soceulia* Galil, 2006b, all which were previously assigned to the species of *Leucosia*. In her revision, *Leucosia* was restricted to four species, *L. craniolaris* (Linnaeus, 1758), *L. moresbiensis* Haswell, 1880, *L. punctata* Bell, 1855, and *L. rubripalma* Galil, 2003a, and most species were transferred to her new genera. Her work is continuous and the remaining species have not yet been assigned to any genus.

Eighteen species of *Leucosia* sensu lato have

been known in the fossil record. However, it is very difficult to adapt Galil's classification for the extinct species because of lacking detailed characters of the gonopod 1 of males within the fossils. Therefore, it is considered best to place the extinct species within *Leucosia* sensu lato for the time being. Among these fossils, *Leucosia shichenii* Hu and Tao, 1979, from the Pliocene of Taiwan, has a granulated dorsal carapace, a well-developed subhepatic facet, and well-defined cardiac and intestinal regions; therefore, this species should be assigned to *Philyra* Leach, 1817. *Leucosia formosensis* Sakai, 1937, described from the Pleistocene of Taiwan by Hu and Tao (1996), has deep cervical and branchiocardiac grooves and a well-defined intestinal region. These specimens are identical with the carapace of *Philyra*, but its species-level identification awaits the discovery of more well-preserved specimens.

Leucosia martini Karasawa and Kato,
new species
(Fig. 3L–O)

Material examined: MGB-CF0007 (holotype), MGB-CF0008 (paratype), and NMNS PA16394 from DVO-11.

Diagnosis: Carapace elongate rhomboidal, widest a little posterior to mid-length. Front narrow, strongly projected anteriorly, upturned dorsally. Anterolateral margin slightly sinuous, granulate, rimmed. Epibranchial angle not pronounced. Posterolateral margin granulate, rimmed. Posterior margin gently convex, granulated, rimmed. Epimeral edge invisible dorsally, finely granulate. Thoracic sinus deep; anterior edge not investigated, defined by nearly straight, obtusely granulated edge of pterygostomian region; three rows of granules present above coxa of cheliped.

Etymology: After K. Martin, who first reported fossil decapods from the Philippines.

Description: Carapace elongate rhomboidal in outline, width about 85% carapace length, widest a little posterior to mid-length. Fronto-orbital margin narrow, about 15% carapace width. Dor-

sal surface glabrous, smooth, regions not defined. Front strongly projected anteriorly, upturned dorsally. Frontal margin weakly trilobed. Orbit small. Anterolateral margin slightly sinuous, granulate, rimmed. Epibranchial angle not pronounced. Posterolateral margin also granulate, rimmed. Posterior margin gently convex, granulated, rimmed, about 25% carapace width. Epimeral edge invisible dorsally, finely granulate, joining posterior margin. Thoracic sinus deep; anterior edge not investigated, defined by nearly straight, obtusely granulated edge of pterygostomian region; three rows of granules present above coxa of cheliped; granules on upper row largest, nearly close to granules on middle row; lower row consisting of fine granules.

Remarks: The present new species possesses characters of the thoracic sinus of the carapace most like those of *Leucosia tricarinata* Martin, 1880, but differs in having three granulated rows above the coxa of cheliped in the thoracic sinus (vs. two granulated rows in *L. tricarinata*).

Genus *Nursia* Leach, 1817

Type species: *Nursia hardwickii* Leach, 1817, by monotypy.

Included fossil species: *Nursia bilobata*, new species; *N. sp. aff. N. japonica* Sakai, 1935 (Kato and Karasawa, 1998) (extant?).

Remarks: The genus *Nursia* is recognized as a heterogeneous group (Ihele, 1918; Serène and Soh, 1976; Komatsu and Takeda, 2003); therefore, Serène and Soh (1976) erected a new genus *Paranursia* for *N. abbreviata* Bell, 1855, and Komatsu and Takeda (2003) proposed a new genus *Nobiliella* for *N. jousseamei* Nobili, 1905 and *N. jousseamei* var. *cornigera* Nobili, 1905. However, a generic level reconsideration of remaining species of *Nursia* is needed (Serène and Soh, 1976; Komatsu and Takeda, 2003). *Nursia acharyai* Bachmayer and Mohanti, 1973, is known from the Miocene of India. This species is represented by a single specimen of an eroded carapace. In *Nursia acharyai* the dorsal carapace has a median longitudinal ridge and oblique

ridges running from the mesogastric region across the epibranchial regions and lacks hepatic ridges, and the posterior margin bears no lobe. Those are definitive characters of *Paranursia* (Serène and Soh, 1976; Poore, 2004); therefore, *N. acharyai* is moved to *Paranursia*. *Paranursia acharyai* differs from *P. abbreviata* by having dentate anterolateral margins and concave posterolateral margins.

Nursia bilobata Karasawa and Kato,
new species
(Fig. 3D, E)

Material examined: MGB-CF0009 (holotype) from TYS-1.

Diagnosis: Carapace rhomboidal, widest about at mid-length. Pterygostomian margin well developed, prominent medially. Anterolateral margin bearing 3 teeth; anterior two teeth low; last one projected, directed posterolaterally. Posterolateral margin with broadly triangular tooth at posterior third. Posterior margin with 2 triangular lobes. Dorsal surface strongly convex; elevated regions covered with fine granules and tubercles. Weak median ridge present on anterior mesogastric process. Mesogastric region bearing pair of large tubercles, with weak, oblique ridge extending from anterolateral margin across hepatic region. Arcuate ridge running from anterior part of inverted-triangle cardiac elevation to epibranchial ridge, extending from hepatic ridge to last anterolateral tooth. Strong transverse ridge present on intestinal and metabranchial regions.

Etymology: The trivial name refers to the bilobate posterior margin.

Description: Carapace rhomboidal in outline, appears to be slightly longer than wide, widest about at mid-length. Fronto-orbital margin about 28% carapace width, detailed characters wanting. Pterygostomian margin well developed, elevated medially. Anterolateral margin bearing 3 teeth; anterior tooth low, broad, directed anterolaterally, behind posterior end of pterygostomian margin; second one low, broadly triangular, directed later-

ally; last one projected, directed posterolaterally. Posterolateral margin bearing posterolaterally directed, broadly triangular tooth at posterior third. Posterior margin bilobate, slightly shorter than fronto-orbital margin; lobes triangular with rounded tip. Dorsal surface strongly convex longitudinally and transversely; elevated regions covered with fine granules and tubercles. Weak median ridge present on anterior mesogastric process. Mesogastric region bearing pair of large tubercles, with low, oblique ridge extending from anterolateral margin across hepatic region. Cardiac region most convex; arcuate ridge well defined, running from anterior part of inverted-triangle cardiac elevation to epibranchial ridge. Epibranchial ridge strong, extending from hepatic ridge to last anterolateral tooth. Strong transverse ridge extending from tooth on posterolateral margin across intestinal and metabranchial regions.

Remarks: The present new species is most similar to the extant *Nursia nasuta* Alcock, 1896, because the carapace is relatively narrow with a weak hepatic ridge on the dorsal region, and the posterior margin consists of two lobes. However, the present species differs from *N. nasuta* in that a well defined arcuate ridge extends from the anterior part of the cardiac region to the epibranchial ridge, the intestinal and mesobranchial regions are much longer than those of *N. nasuta*, and two posterior lobes are well developed and are more strongly protruded posteriorly than in *N. nasuta*.

Genus *Philyra* Leach, 1817

Type species: *Leucosia globus* Fabricius, 1775, by subsequent designation of H. Milne Edwards (1837).

Included fossil species: *Philyra alveola* Hu and Tao, 2000; *P. cranium* (Desmarest, 1822); *P. ferrica* Hu and Tao, 1996; *P. granulosa* Morris and Collins, 1991; *P. hayasakai* Karasawa and Inoue, 1992; *P. heterograna* Ortmann, 1892 (also extant); *P. miyamotoi* Karasawa and Kishimoto, 1996; *P. nishimotoi* Karasawa, 1989; *P. pisum* de

Table 3 List of fossil species of *Philyra*. Asterisk indicates extant species

Species	Age and locality	References
<i>P. alveola</i> Hu & Tao, 2000	Pliocene, Taiwan	Hu & Tao (2000)
<i>P. cranium</i> (Desmarest, 1822)	Pleistocene?, Indo-Pacific	Glaessner (1929)
<i>P. ferrica</i> Hu & Tao, 1996	U. Miocene, Taiwan	Hu & Tao (1996)
<i>P. granulosa</i> Morris & Collins, 1991	M. Miocene, Sarawak	Morris & Collins (1991)
<i>P. hayasakai</i> Karasawa & Inoue, 1992	M. Miocene, Japan	Karasawa & Inoue (1992)
<i>P. heterograna</i> Ortmann, 1892*	Pleistocene, Japan	Kato & Koizumi (1992)
<i>P. miyamotoi</i> Karasawa & Kishimoto, 1996	M. Miocene, Japan	Karasawa & Kishimoto (1996)
<i>P. nishimotoi</i> Karasawa, 1989	E. Miocene, Japan	Karasawa (1989)
<i>P. pisum</i> de Haan, 1841*	Pleistocene, Japan	Kato & Koizumi (1992)
<i>P. plana</i> Karasawa, 1989	M. Miocene	Karasawa (1989)
<i>P. platycheir</i> de Haan, 1841*	Pliocene, Taiwan	Hu & Tao (2000)
	Pliocene–Pleistocene, Japan	Karasawa (1993), Karasawa & Tanaka (1994)
<i>P. scabriuscula</i> (Fabricius, 1793)*	Pliocene, Java, Sumatra	Van Straelen (1938)
<i>P. shihcheni</i> (Hu & Tao, 1979)	M. Miocene, Taiwan	Hu & Tao (1979)
<i>P. syndactyla</i> Ortmann, 1892*	Pleistocene, Japan	Kato & Koizumi (1992), Kato & Karasawa (1998), Kobayashi <i>et al.</i> (2008)
<i>P. tanakai</i> Karasawa, 1993	Pliocene, Japan	Karasawa (1993)
<i>P. tridentata</i> Karasawa, 1993	Pliocene, Japan	Karasawa (1993)

Haan, 1841 (also extant); *P. plana* Karasawa, 1989; *P. platycheir* de Haan, 1841 (also extant); *P. scabriuscula* (Fabricius, 1793) (also extant); *P. shihcheni* (Hu and Tao, 1979), new combination; *P. syndactyla* Ortmann, 1892 (also extant); *P. tanakai* Karasawa, 1993; *P. tridentata* Karasawa, 1993; *P. trusanensis* Collins *et al.*, 2003; *Philyra* sp. cfr. *P. actidens* Chen, 1987.

Remarks: The systematic status of *Philyra shihcheni* (Hu and Tao, 1979) was discussed above. The stratigraphic and geographic distribution of the known fossils of *Philyra* is summarized in Table 3.

Philyra sp. cfr. *P. actidens* Chen, 1987
(Fig. 3P)

Material examined: MGB-CF0010 from TYS-1.

Remarks: The present specimen is incomplete but bears similarity to the extant *P. actidens* from the East China Sea, including the dorsal carapace densely covered with tubercles. We refer the specimen to the species provisionally because it lacks the maxilliped 3 and male gonopod 1,

which are considered very important for the identification of the genus.

Genus *Pseudophilyra* Miers, 1879

Type species: *Pseudophilyra tridentata* Miers, 1879, by subsequent designation of Rathbun (1922).

Included fossil species: *Pseudophilyra elongatella* Hu and Tao, 1996.

Pseudophilyra granulimarginata Karasawa
and Kato, new species
(Fig. 3H–J)

Material examined: MGB-CF0011 (holotype) from TYS-1.

Diagnosis: Carapace elongate rhomboidal, widest at mid-length. Fronto-orbital margin narrow, about 15% carapace width. Dorsal surface smooth; regions not defined. Anterolateral margin slightly sinuous, granulate, rimmed. Epibranchial angle not pronounced. Posterolateral margin convex, granulate, rimmed. Posterior margin nearly straight, granulated, rimmed.

Etymology: The trivial name refers to the gran-

ulated anterolateral, posterolateral, and posterior margins.

Description: Carapace elongate rhomboidal in outline, width about 87% carapace length, widest at mid-length. Fronto-orbital margin narrow, about 15% carapace width. Dorsal surface glabrous, smooth, regions not defined. Front projected anteriorly, upturned dorsally. Frontal margin weakly trilobed. Orbit small. Anterolateral margin slightly sinuous, granulate, rimmed. Epi-branchial angle not pronounced. Posterolateral margin convex, granulate, rimmed. Posterior margin nearly straight, granulated, rimmed, about 23% carapace width. Epimeral edge invisible dorsally, finely granulate, joining posterior margin. Thoracic sternites 1–3 completely fused, much wider than long; sternite 4 longest of all sternites, lateral margin deeply notched behind coxa of cheliped; sulcus between sternites 3 and 4 medially interrupted by narrow, triangular sterno-abdominal cavity; sulci between sternites 4/5, 5/6, and 6/7 incomplete medially. Episternites 4–7 narrow, granulated ventrally, protruded posteriorly, separated from each sternite by rather deep grooves; episternite 8 small, granulate. Sterno-abdominal cavity deep; anterior end reaching sternites 2 and 3.

Remarks: The present new species is most similar to *Pseudophilypira* sp., an unnamed species described from the Recent Philippines by Tan (1996), but differs in having a narrow fronto-orbital margin and a convex posterolateral margin. This species is easily distinguished from the extinct *P. elongatella* from the upper Miocene of Taiwan by having a narrow fronto-orbital margin and granulated anterolateral, posterolateral, and posterior margins. In the carapace characters, *P. granulimarginata* may be similar to *Leucosia martini*, but differs in lacking the thoracic sinus.

Superfamily Xanthoidea MacLeay, 1838, *sensu*
Karasawa and Schweitzer, 2006

Family Pilmunidae Samouelle, 1819, *sensu*
Karasawa and Schweitzer, 2006

Subfamily Galeninae Alcock, 1898

Genus *Galene* de Haan, 1833

Type species: *Cancer bispinosus* Herbst, 1783, by monotypy.

Included fossil species: *G. bispinosa* (Herbst, 1783) (= *G. hainanensis* Hu and Tao, 1979) (also extant); *G. granulifera* Lin, 1947; *G. obscura* A. Milne Edwards, 1865; *G. stipata* Morris and Collins, 1991.

Remarks: Hu and Tao (1979) described a new species, *Galene hainanensis*, based upon nine specimens collected from the Hainan island, China (Hu and Tao, 1979; p. 148). These specimens appear to be brought from drugstores of Taipei, Taiwan, and they showed that they occurred in the Pleistocene deposits (Hu and Tao, 1979; p. 148). Comparison of the descriptions and illustrations of *G. hainanensis* and *G. bispinosa* indicates that they are very similar in carapace and pereopod morphology. Therefore, *Galene hainanensis* should be synonymised with *G. bispinosa*. Additionally, examination of the illustrated specimen (Hu and Tao, 1979, pl. 1, figs. 3, 4; registered number, MTNU2002, deposited in the Museum of Taiwan Normal University) of *G. hainanensis* suggests that it is not referable to that species. Hu and Tao (1979, p. 148) stated, “This small sized skeleton is possibly an immature individual”. However, in the specimen, the dorsal surface is smooth, the anterolateral margin is entire without anterolateral teeth, the thoracic sternum is very wide without deep lateral grooves on sternite 4, the telson of male abdomen is triangular and not elongate, and the lateral surface of the cheliped is smooth with a keeled ventro-lateral margin. These characters lack in *Galene* and are observed in the rhizopine genus *Arges* de Haan, 1835. However, detailed examination of the material will be necessary to confirm the taxonomic status of it. Two other fossil species were previously assigned to the genus, but *G. proavita* Glaessner, 1960, was moved to *Carcinoplax* H. Milne Edwards, 1852 (Karasawa and Kato, 2003) and *G. litoralis* Collins, Lee, and Noad, 2003, is transferred to the rhizopine genus *Cryptolutea* Ward, 1936, discussed below.

The genus *Galene* has been recorded from the

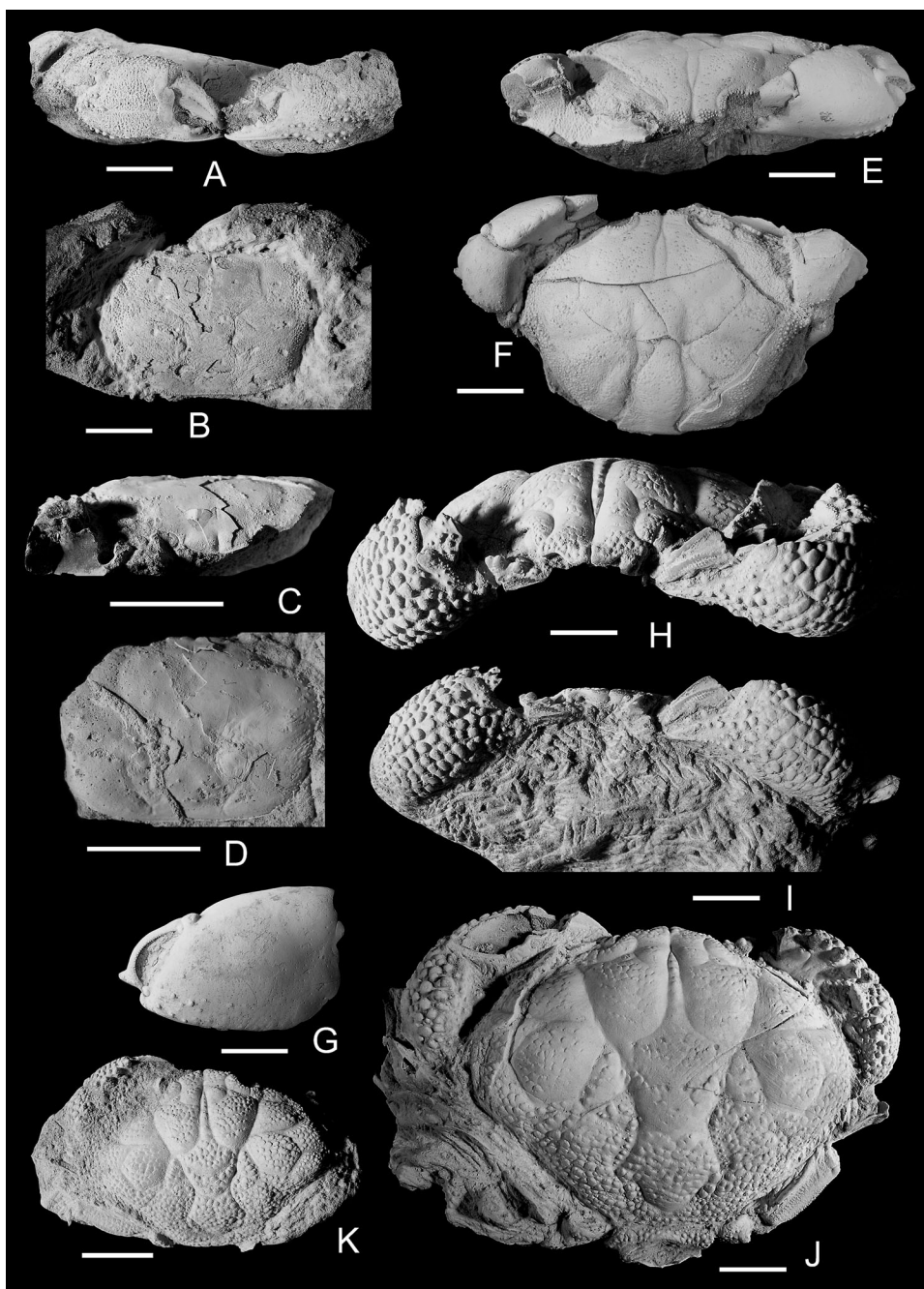


Fig. 4. **A, B.** *Cryptoplutea warreni* Karasawa and Kato, new species, MGB-CF0015 (holotype), loc. DVO-11, carapace and chelipeds, A, frontal; B, dorsal view. **C, D.** *Cryptoplutea warreni* Karasawa and Kato, new species, MGB-CF0016 (paratype), loc. DVO-11, carapace, C, frontal; D, dorsal view. **E, F.** *Galene bispinosa* (Herbst, 1783), MGB-CF0012, loc. TYS-1, carapace and cheliped, E, frontal; F, dorsal view. **G.** *Galene bispinosa* (Herbst, 1783), MGB-CF0014, loc. TYS-1, propodus of right cheliped, lateral view. **H-J.** *Demania pilipinas* Karasawa and Kato, new species, MGB-CF0021 (holotype), loc. DVO-11, carapace, chelipeds, and pereopods, H, frontal; I, ventral; J, dorsal view. **K.** *Demania pilipinas* Karasawa and Kato, new species, MGB-CF0022 (paratype), loc. DVO-11, carapace, chelipeds, and pereopods, dorsal view. Scale bars=1 cm.

fossil record from the Miocene of Taiwan (Lin, 1947; Hu and Tao, 1979; Hu and Tao, 1996); the Pliocene of Taiwan (Hu and Tao, 1996), Philippines (this work), and Brunei (Morris and Collins, 1991); the Pleistocene of Java (Böhm, 1922), and the Holocene of Australia (Etheridge and McCulloch, 1916).

Galene bispinosa (Herbst, 1783)

(Figs. 3F, G; 4E–G)

Material examined: MGB-CF0012, MGB-CF0013, MGB-CF0014, and NMNS PA16395 from TYS-1.

Remarks: The fossil occurrence of this species has previously been reported from the Pleistocene of Taiwan (Hu and Tao, 1996) and the Holocene of Australia (Etheridge and McCulloch, 1916).

Subfamily Rhizopinae Stimpson, 1858

Genus *Cryptolutea* Ward, 1936

Type species: *Cryptolutea lindemanensis* Ward, 1936, by monotypy.

Included fossil species: *Cryptolutea litoralis* (Collins, Lee, and Noad, 2003), new combination; *C. warreni*, new species.

Remarks: Collins *et al.* (2003) described the new galenine species, *Galene litoralis* Collins *et al.*, 2003, from the Pleistocene of Sarawak. However, *G. litoralis* is moved to *Cryptolutea* because the carapace is rounded rectangular in outline and the anterolateral margins consist of three lobes. *Galene*, in contrast with *Cryptolutea*, has a transversely hexagonal carapace with three anterolateral spines. Additionally, *Galene* bears more or less defined metabranchial regions, which *Cryptolutea* lack. *Cryptolutea litoralis* resembles the extant *Cryptolutea sagamiensis* (Sakai, 1935), but differs in having well defined mesogastric and cardiac regions and well developed anterolateral lobes.

The Rhizopinae comprises 22 genera within the present oceans (Ng *et al.*, 2008); however, it

is poorly known in the fossil record, and only *Arges de Haan*, 1835, *Cryptolutea*, and *Typhlocarcinus* Stimpson, 1858 are recognized as fossils (de Haan, 1835; Karasawa, 1993; Hu and Tao, 1996).

Cryptolutea warreni Karasawa and Kato,

new species

(Fig. 4A–D)

Material examined: MGB-CF0015 (holotype), MGB-CF0016 (paratype), and NMNS PA16394 from DVO-11.

Diagnosis: Moderate-sized *Cryptolutea*. Carapace rounded rectangular. Front protruded anteriorly, downturned, with shallow, narrow median groove; frontal margin rimmed with 2 rounded lobes. Upper orbital margin granular, rimmed, separated from frontal margin by weak notch. Anterolateral margin strongly convex, granular, divided into 4 lobes by very shallow notches; short, oblique groove extending from last two anterolateral notches on epibranchial region. Junction between anterolateral and posterolateral margins rounded. Posterolateral margin about equal to anterolateral margin, slightly convex. Posterior margin nearly straight, granular, rimmed. Dorsal surface moderately arched transversely, nearly flat longitudinally; surface densely covered with fine granules and fine granular lines irregularly arranged. Regions poorly defined. Branchial regions undifferentiated. Chelipeds unequal, dissimilar; right cheliped slightly larger than left. Carpus finely tuberculated on lateral surface. Palm short; lateral surface with rows of tubercles; dorsal surface finely tuberculate; ventral margin fringed with scattered tubercles. Both fingers short.

Etymology: In honor of the late Warren Blow, a specialist on fossil crabs who was our friend.

Description: Moderate-sized carapace for *Cryptolutea*. Carapace rounded rectangular in outline, length about 75% carapace width, widest at mid-length. Fronto-orbital margin about 54% carapace width. Front protruded anteriorly,

downturned, with shallow, narrow median depression; frontal margin rimmed with 2 rounded lobes. Upper orbital margin granular, rimmed, separated from frontal margin by weak notch. Anterolateral margin strongly convex, granular, divided into 4 lobes by very shallow notches; 1st lobe (=outer orbital angle) broadly triangular; 2nd lobe broadest of all lobes; short, oblique groove extending from last two anterolateral notches on epibranchial region. Junction between anterolateral and posterolateral margins rounded. Posterolateral margin about equal to anterolateral margin, slightly convex. Posterior margin nearly straight, granular, rimmed, about 65% carapace width. Dorsal surface moderately arched transversely, nearly flat longitudinally; surface densely covered with fine granules and fine granular lines irregularly arranged, but in small specimen surface smoother. Regions poorly defined. Protogastric regions separated from surrounding regions by shallow, broad grooves. Mesogastric region separated from cardiac region by narrow groove and from branchial regions by rather deep grooves. Hepatic regions separated from branchial regions by obtuse groove. Branchial regions undifferentiated. Branchiocardiac groove shallow. Intestinal region narrow.

Chelipeds unequal, dissimilar; right cheliped slightly larger than left one. Carpus of right cheliped poorly preserved; lateral surface finely tuberculate. Palm of right cheliped about 1.25 times longer than high; lateral surface slightly convex, with 2 rows of tubercles proximally; dorsal surface gently convex, finely tuberculate; ventral margin sinuous, fringed with scattered tubercles. Fixed finger of right cheliped about half palm length, with acutely pointed tip; occlusal margin bearing 3 broadly triangular teeth, middle one largest; ventral margin gently convex; ventro-lateral margin keeled. Dactylus of right cheliped slightly longer than palm, gently curved downward; lateral surface with a row of pits medially; occlusal margin with 3 broad teeth. Palm of left cheliped about 1.32 times longer than high; 4 rows of irregular tubercles present on lateral surface, diminishing in length toward dorsal

margin, upper 3 rows running from proximal margin to median part; dorsal margin gently convex, finely tuberculate; ventral margin sinuous, armed with irregular tubercles. Fixed finger about 60% palm length, with acutely pointed tip; occlusal margin with irregular, triangular teeth, proximal one highest, middle one broadest; ventral margin nearly straight; ventro-lateral margin keeled, crenulated. Dactylus broken.

Remarks: The present new species is readily distinguished from *Cryptolutea litoralis* by having the carapace densely covered with fine granules and irregularly arranged granulated lines. In *C. litoralis* the carapace is punctate. The anterolateral teeth in *C. litoralis* are well separated, but *C. warreni* has anterolateral lobes divided by weak notches. Additionally, the carapace regions of *C. litoralis* are well defined whereas in *C. warreni* they are poorly defined.

Family Xanthidae MacLeay, 1838, *sensu*
Karasawa and Schweitzer, 2006

Subfamily Xanthinae MacLeay, 1838

Genus *Liagore* de Haan, 1833

Type species: Cancer (Liagore) rubromaculata de Haan, 1835, by monotypy.

Included fossil species: Liagore rubromaculata (de Haan, 1835) (also extant).

Remarks: Most recently, Ng and Naruse (2007) described the third extant species, *Liagore pulchella* Ng and Naruse, 2007, from Vanuatu. Among these, *L. rubromaculata* is the only known as fossil species.

Liagore rubromaculata (de Haan, 1835)

(Fig. 5G–L)

Material examined: MGB-CF0017?0020 and NMNS PA16396 from DVO-11.

Remarks: This species is abundant in sandstone exposed at DVO-11. *Liagore rubromaculata* is also found in the Pliocene–Pleistocene deposits of Taiwan (Hu and Tao, 1996).

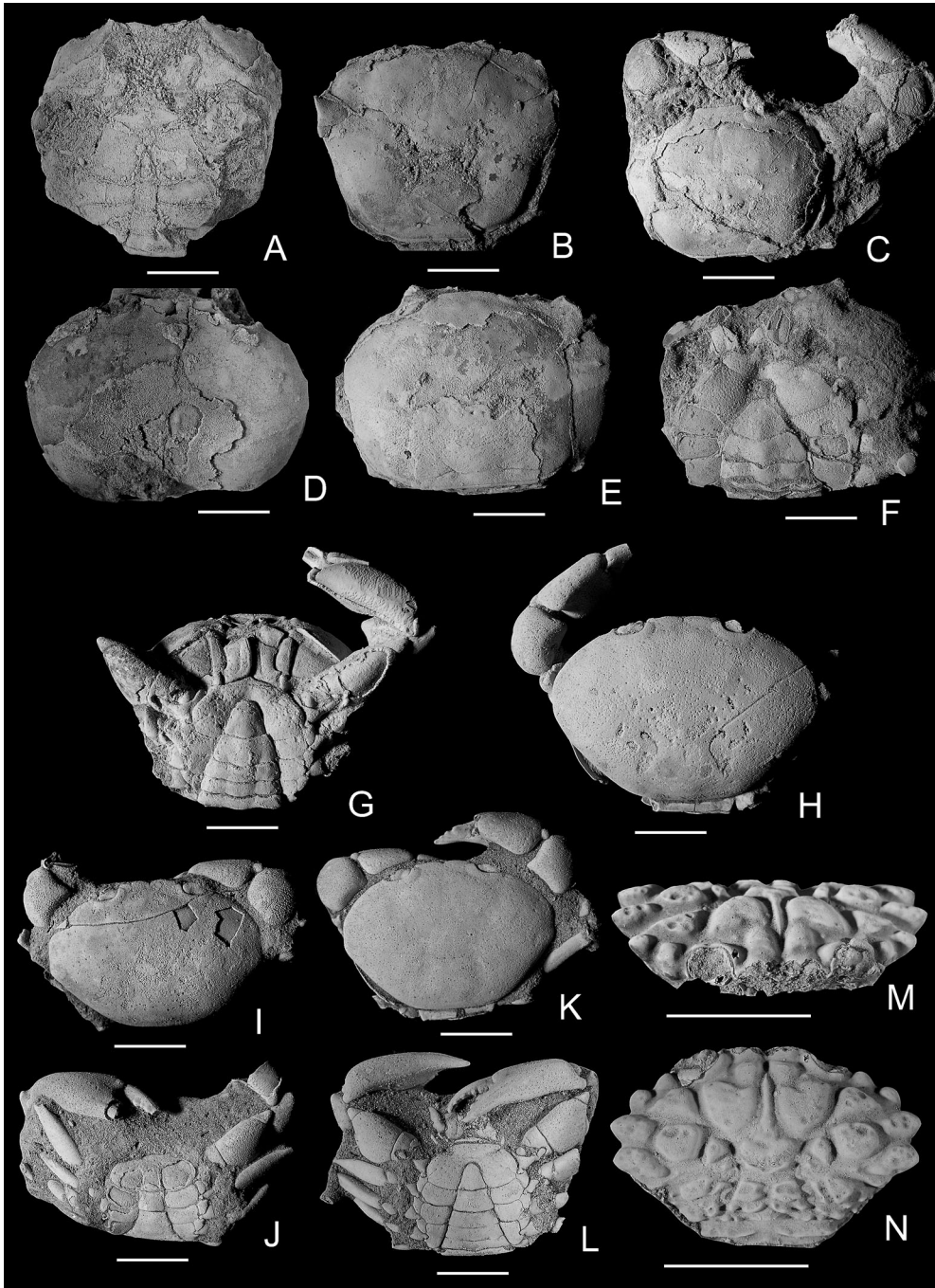


Fig. 5. **A, B.** *Eucrate* sp., MGB-CF0024, loc. DVO-11, A, ventral; B, dorsal view. **C.** *Carcinoplax purpurea* Rathbun, 1914, MGB-CF0025, loc. DVO-11, carapace, dorsal view. **D.** *Carcinoplax purpurea* Rathbun, 1914, MGB-CF0026, loc. DVO-11, carapace, dorsal view. **E, F.** *Carcinoplax purpurea* Rathbun, 1914, MGB-CF0026, loc. DVO-11, E, dorsal; F, ventral view. **G, H.** *Liagore rubromaculata* (de Haan, 1835), MGB-CF0017, loc. DVO-11, female, G, ventral; H, dorsal view. **I, J.** *Liagore rubromaculata* (de Haan, 1835), MGB-CF0018, loc. DVO-11, male, I, dorsal; J, ventral view. **K, L.** *Liagore rubromaculata* (de Haan, 1835), MGB-CF0019, loc. DVO-11, female, K, dorsal; L, ventral view. **M, N.** *Demania* sp., MGB-CF0023, loc. DVO-11, carapace, M, frontal; N, dorsal view. Scale bars = 1 cm.

Genus *Demania* Laurie, 1906

Type species: Demania splendida Laurie, 1906, by original designation.

Included fossil species: Demania caltripes (Alcock, 1898) (as *D. reynaudi caltripes* (Alcock, 1898) in Hu and Tao (1996)) (also extant); *D. chayiensis* (Hu, 1981); *D. pilipinas* Karasawa and Kato, new species; *D. reynaudi* (H. Milne Edwards, 1834) (also extant); *D. scamberrima* (Walker, 1887) (also extant); *D. wardi* Garth and Ng, 1985 (also extant); *D. sp.* in this paper.

Remarks: Demania chayiensis (Hu, 1981), a previously known extinct species was recorded from the upper Miocene–lower Pliocene of Taiwan (Hu, 1981; Hu and Tao, 1996). Four extant species, *D. caltripes* and *D. reynaudi* from the Pliocene–Pleistocene of Taiwan (Hu and Tao, 1996), *D. wardi* from the Pleistocene of New Hebrides (Garth and Ng, 1985), and *D. scamberrima* from the Pliocene of Java (Van Straelen, 1938), are recognized as fossils.

Demania pilipinas Karasawa and Kato,
new species
(Fig. 4H–K)

Material examined: MGB-CF0021 (holotype), MGB-CF0022 (paratype), and NMNS PA16397 from DVO-11.

Diagnosis: Carapace pentagonal, length about 80% carapace width, widest at mid-length. Fronto-orbital margin about 40% carapace width. Front strongly protruded anteriorly, bilobed, with deep V-shaped notch; frontal margin of each lobe sinuous, outer angle angular. Anterolateral margin strongly convex without teeth or lobes. Junction at anterolateral and posterolateral margins rounded. Posterolateral margin about as long as anterolateral margin. Posterior margin nearly straight. Dorsal regions well defined; elevated regions covered with flattened, rounded tubercles. Carpus and palm of cheliped densely covered with large, flattened, rounded tubercles on lateral surface; carpus with large, erect tubercles on dorsal margin; palm with 4–5 tuberculate spines on

dorsal margin. Lateral surface of meri of pereopods finely granulate; dorsal and ventral margins crested, finely serrated.

Etymology: The specific name is derived from the word, “Pilipinas”, meaning Philippines in the Pilipinse Language.

Description: Carapace pentagonal in outline, length about 80% carapace width, widest at mid-length. Fronto-orbital margin about 40% carapace width. Front protruded anteriorly, bilobed, medially projected anteriorly, with deep V-shaped axial notch; frontal margin of each lobe sinuous, outer angle angular, sloping towards inner orbital angle. Upper orbital margin narrow, concave, finely dentate, without orbital fissures. Anterolateral margin strongly convex, without teeth or lobes. Junction at anterolateral and posterolateral margins rounded. Posterolateral margin about as long as anterolateral margin. Posterior margin nearly straight, slightly shorter than fronto-orbital margin. Dorsal surface gently convex longitudinally and transversely; regions well defined, elevated regions covered with flattened, rounded tubercles which vary in size; 1F, 2F, and 1M regions divided into two by median deep groove; 1F regions extremely narrow, smooth; 2F region separated from 1M by shallow groove; 2L- and 3L regions, and 1R and 2R regions united.

Chelipeds symmetrical. Carpus densely covered with large, flattened, rounded tubercles on lateral surface; dorsal margin with large, erect tubercles; mesiodistal spine large, finely tuberculate. Palm much longer than high; lateral surface densely covered with large, flattened, rounded tubercles; dorsal margin with 4–5 tuberculate spines. Fixed finger about half palm length, ornamented with 2 longitudinal rows of rounded tubercles on lateral surface; occlusal margin with 4 blunt teeth. Dactylus about as long as fixed finger; occlusal margin with 4 blunt teeth; lateral surface and dorsal margin smooth except for finely tuberculate proximal part.

Meri of pereopods flattened, much longer than high; lateral surface finely granulate; dorsal and ventral margins crested, finely serrated.

Remarks: The above-mentioned terminology

used the dorsal carapace regions followed Dana (1852). The present new species resembles the extant *Demania japonica* Guinot, 1997, from the South China Sea, East China Sea, and Japan, but differs in that the tubercles on the dorsal carapace surface are rather large, flattened and not spinose, and the carpi and propodi of the both chelipeds are ornamented with large, flattened, rounded tubercles. The smooth anterolateral margins of the carapace readily distinguish this species from the extinct *Demania chayiensis*.

Demania sp.

(Fig. 5M, N)

Material examined: MGB-CF0023 from DVO-11.

Remarks: The specimen is represented by an internal mould of the carapace; therefore, detailed carapace ornamentations are unknown. Additionally, the frontal region is broken. The well developed anterolateral teeth and a wider carapace readily distinguish this species from *Demania chayiensis* and *D. pilipinas*. Ornamentation of a posterior carapace region of the present species resembles that of two extant species, *D. raynaudi* and *D. scaberrima*. More complete material will be necessary to confirm identification of this species.

Superfamily Goneplacoidea MacLeay, 1838,
sensu Karasawa and Schweitzer, 2006
 Family Euryplacidae Stimpson, 1871,
sensu Karasawa and Schweitzer, 2006

Genus *Eucrate* de Haan, 1835

Type species: *Cancer (Eucrate) crenatus* de Haan, 1835, by monotypy.

Included fossil species: see Karasawa and Kato (2003).

Eucrate sp.

(Fig. 5A, B)

Material examined: MGB-CF0024 from DVO-11.

Remarks: The present specimen is a broken carapace associated with the thoracic sternum and male abdomen. The detailed characters of the fronto-orbital and anterolateral margins are obscure. The specific identification of this species awaits the discovery of well-preserved carapaces.

Family Goneplacidae MacLeay, 1838, *sensu*
 Karasawa and Schweitzer, 2006

Genus *Carcinoplax* H. Milne Edwards, 1852

Type species: *Cancer (Crutonotus) longimanus* de Haan, 1833, by subsequent designation of Glaessner (1929).

Included fossil species: see Karasawa and Kato (2003).

Remarks: Karasawa and Kato (2003) made the list of previously known fossil species of *Carcinoplax*. However, two species are lacking in their list: *Carcinoplax wuhsini* Hu and Tao, 1999, from the Oligocene–Miocene of Taiwan; and *Carcinoplax prepurpurea* Hu and Tao, 2000, from the Pliocene of Taiwan. Most recently, Castro (2007) redefined *Carcinoplax* and transferred several members previously assigned to the genus to his new genera, *Entricoplax*, *Menoplax*, *Pycnoplax*, and *Thyraplax*. The recognition of these five genera is mainly based upon characters of sternal sutures 6/7, eyes, vulva, and gonopod 1 (Castro, 2007). However, it is very difficult to adapt his classification for the extinct species because these characters are not usually preserved within the fossils. Therefore, it is considered best to place the extinct species within *Carcinoplax sensu lato* for the time being.

Carcinoplax purpurea Rathbun, 1914
(Fig. 5C–F)

onymised with *C. purpurea* by Karasawa and Kato (1993)).

Material examined: MGB-CF0025-0028, NMNS PA16398 from DVO-11.

Remarks: This species is also recorded from the upper Pliocene of Taiwan (Hu and Tao, 1996; as *Carcinoplax liniae* Hu and Tao, 1996, syn-

Family Hexapodidae Miers, 1886

Genus *Hexapus* de Haan, 1835

Type species: *Cancer sexpes* Fabricius, 1798, by designation in ICZN Opinion 85.

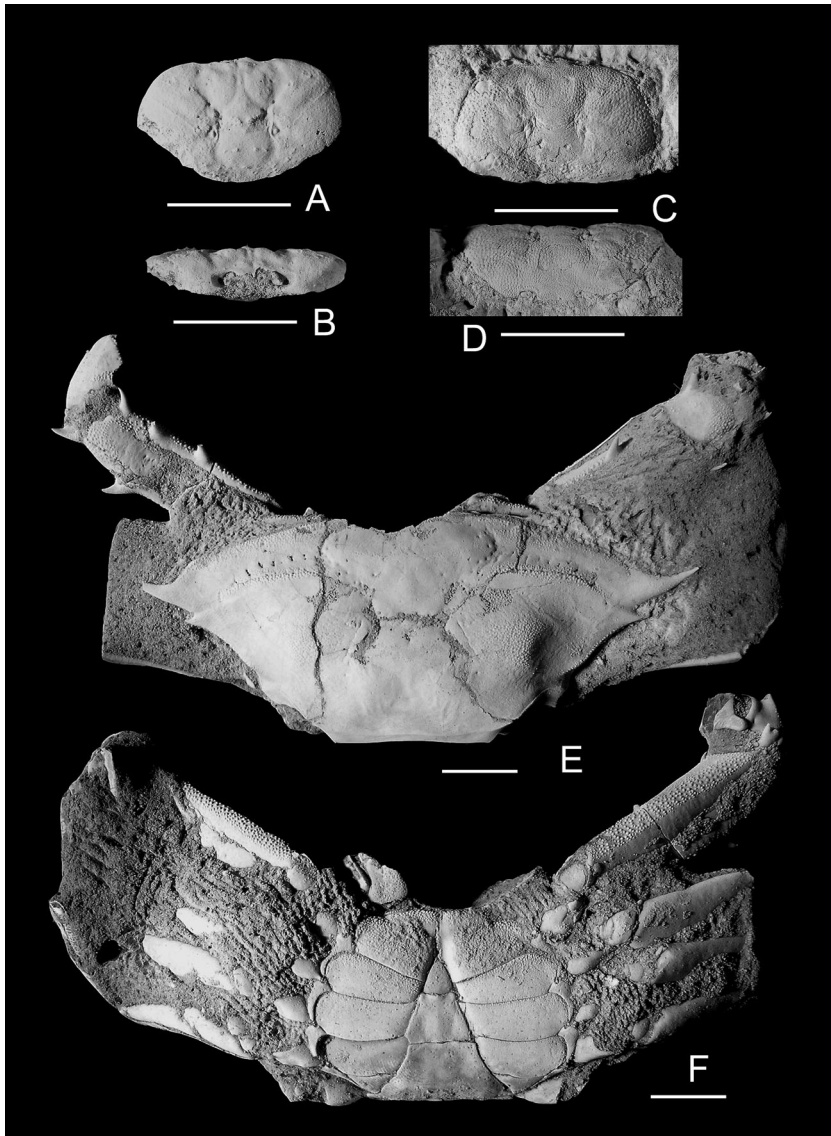


Fig. 6. A, B. *Pinnixa* sp., MGB-CF0032, carapace, loc. DVO-11, A, dorsal; B, frontal view. C, D. *Hexapus granuliformis* Karasawa and Kato, new species, MGB-CF0029 (holotype), loc. DVO-11, C, dorsal; D, frontal view. E, F. *Podophthalmus vigil* (Fabricius, 1798), MGB-CF0030, loc. DVO-11, E, dorsal; F, ventral view. Scale bars = 1 cm.

Included fossil species: *Hexapus anfractus* (Rathbun, 1909) (also extant); *H. decapodus* (Morris and Collins, 1991); *H. granuliformis* Karasawa and Kato, new species; *H. nakajimai* Imaizumi, 1959; *H. pinfoldi* Collins and Morris, 1978.

Hexapus granuliformis Karasawa and Kato,
new species
(Fig. 6C, D)

Material examined: MGB-CF0029 (holotype) from DVO-11.

Diagnosis: Moderate-sized *Hexapus*. Carapace trapezoidal, much wider than long, length about 60% carapace width. Fronto-orbital margin about 30% carapace width. Posterior margin slightly convex, about 90% carapace width. Dorsal surface covered with fine granules, moderately convex longitudinally, slightly convex transversely. Regions poorly defined. Cervical and branchiocardiac grooves moderately defined.

Etymology: The trivial name refers to the finely granulated dorsal surface of the carapace.

Description: Moderate-sized carapace. Carapace trapezoidal in outline, wider than long, length about 60% carapace width, widest at posterolateral angle. Fronto-orbital margin about 30% carapace width. Front narrow, about 15% carapace width, weakly protruded anteriorly, strongly downturned, slightly widening distally, with weak median depression; frontal margin straight, rimmed. Orbit small, weakly rimmed. Anterolateral margin gently convex, granular, rimmed, not clearly demarcated from posterolateral margin. Posterolateral margin nearly straight, granular, rimmed, divergent posteriorly. Posterolateral re-entrant well developed with low, broad lobe. Posterior margin slightly convex, about 90% carapace width. Dorsal surface covered with fine granules, moderately convex longitudinally, slightly convex transversely. Regions poorly defined. Cervical groove weakly developed anteriorly, moderately developed posteriorly. Branchiocardiac groove moderately defined. Hepatic re-

gion weakly defined by shallow grooves. Epi-branchial region slightly vaulted and meso- and metabranchial regions differentiated. Intestinal region narrow, flattened.

Remarks: The new species may be similar to the extant *Hexapus sexpes*, but differs in having the finely granulated dorsal surface. The cervical and branchiocardiac grooves in the newspecies are deeper than those in *H. sexpes*. The finely granulated carapace readily distinguishes this species from two Miocene species, *Hexapus decapodus* (Morris and Collins, 1991) from Sarawak and Sabah and *H. nakajimai* Imaizumi, 1959, from Japan. The carapace in *H. granuliformis* is much narrower than that of *H. decapodus* and *H. nakajimai*.

Superfamily Portunoidea Rafinesque, 1815

Family Portunidae Rafinesque, 1815,
sensu Karasawa *et al.*, 2008

Subfamily Podophthalminae Dana, 1851

Genus *Podophthalmus* Lamarck, 1801

Type species: *Podophthalmus* [sic] *spinosus* Lamarck, 1801 (= *Portunus vigil* Fabricius, 1798), by monotypy.

Included fossil species: *Podophthalmus fusiformis* Morris and Collins, 1991; *P. taiwanicus* Hu and Tao, 1985; *P. vigil* (Fabricius, 1798) (also extant).

Podophthalmus vigil (Fabricius, 1798)

(Fig. 6E, F)

Material examined: MGB-CF0030, MGB-CF0031, NMNS PA16399 from DVO-11.

Remarks: The fossil occurrence of this species has previously been reported from the Pliocene of Java (Martin, 1883), the Pleistocene of Sarawak (Collins *et al.*, 2003), the Pleistocene of Guam (Kesling, 1958; Schweitzer *et al.*, 2002), the Pleistocene of Taiwan (Hu and Tao, 1996), the Pleistocene of Japan (Karasawa *et al.*, 1995), and the Holocene of Australia (Etheridge and McCulloch, 1916).

Superfamily Pinnotheroidea de Haan, 1833

Family Pinnotheridae de Haan, 1833

Subfamily Pinnotherelinae Alcock, 1990

Genus *Pinnixa* White, 1846

Type species: Pinnotheres cylindricum Say, 1818, by monotypy (ICZN Opinion 85).

Included fossil species: see Feldmann *et al.* (2005).

Remarks: Feldmann *et al.* (2005) recognized six species of *Pinnixa* in the fossil record and excluded three fossil species, *Pinnixa aequipunctata* Morris and Collins, 1991, *P. omega* Morris and Collins, 1991, and *P. microgranulosa* Collins *et al.*, 2003, from the Neogene of Brunei, Sabah and Sarawak. They suggested that these three species might be referred to *Tetrias* Rathbun, 1898. However, the paratype specimen (BM IC 274) of *P. microgranulosa* figured by Collins *et al.* (2003, pl. 7, fig. 6) has great similarities with an immature female specimen (Morris and Collins, 1991, fig. 57) of *Orthakrolophos bittneri* (Morris and Collins, 1991) (see Schweitzer and Feldmann, 2001, p. 335). The generic status of only *Pinnixa omega* is retained in that the carapace is much wider than long and the dorsal surface is not punctuated.

Pinnixa sp.

(Fig. 6A, B)

Material examined: MGB-CF0032 from DVO-11.

Remarks: A poorly preserved carapace represents the present species. This species resembles *Pinnixa omega*, but differs in that the large-sized carapace is more flattened with strongly inflated anterolateral margins. More complete material will be necessary to confirm identification of this species. The carapace of this species may be similar to that of the hexapodid *Hexapus granuliformis*. However, the more flattened carapace, the well defined gastric regions, and the strongly inflated anterolateral margins are readily distinguished this species from *H. granuliformis*.

Acknowledgments

We thank C. E. Schweitzer (Kent State University, U.S.A.) for reading carefully the systematic part of this paper and T. Naruse (National University of Singapore) for providing useful comments on some fossil crabs. We also thank E. Mula (MGB), R. Ancog (MGB), W. Mago (MGB), E. Azurin (MGB), C. Neis (Fortune Cement Co. Ltd.) and R. Guinto (Fortune Cement Co. Ltd.) for their assistance in field work, S. Laserna who introduced us to the fossil locality in Batangas, and H. Komatsu (NMNS) for review of the manuscript. H. C. Ramos, the director of MGB, is also acknowledged for permitting us to conduct this research. This study was financially supported by the National Museum of Nature and Science and by a Grant-In-Aid for the Scientific Research from the Japan Society for the Promotion of Science (no. 18253007).

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