

Palaeogene decapod Crustacea from the Kishima and Okinoshima Groups, Kyushu, Japan

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Received 20 May, 2000, Revised manuscript accepted 14 August, 2000

Abstract. Twelve species in 11 genera of decapod crustaceans are recorded from Palaeogene rocks of Nagasaki and Saga Prefectures, Kyushu, Japan. *Carinocarcinoides* gen. nov. (Goneplacidae) is proposed to accommodate *Carinocarcinoides carinatus* sp. nov. and *Varuna angustifrons* Karasawa from the lower Oligocene Kishima Group. A new monotypic genus, *Cicarnus* (Portunidae), is erected with *Cicarnus fumiae* sp. nov. from the middle Eocene Okinoshima Group. *Neocallichirus sakiae* sp. nov. (Callianassidae) is described from the lower Oligocene Kishima Group. *Axius* (s. l.) sp. and *Euphyllax* ? sp. from the Kishima Group represent the first records for both genera from the Oligocene of Japan. The occurrence of *Minohellenus macrocheilus* Kato and Karasawa extends the known geologic range of this species back to the lower Oligocene. A new description is given for *Collinsius simplex* Karasawa.

Key words: Crustacea, Decapoda, Japan, Kyushu, Palaeogene

Introduction

Previous contributions describing and illustrating decapod species from Palaeogene rocks of Kyushu are rather limited. Yokoyama (1911) was the first to describe two new species, *Xanthilites pentagonalis* and *Homolopsis japonicus*, from the Palaeogene of the Miike Coalfield. Nagao (1941) recorded and illustrated an unnamed *Callianassa* sp. indet. from the Palaeogene of the Asakura Coalfield. Five species in five genera were described from the lower Oligocene Kishima Group in Saga and Nagasaki Prefectures by Imaizumi (1958) and Karasawa (1993, 1997). Inoue (1972) introduced an abundant occurrence of unnamed crabs from the lower Oligocene Kishima Group distributed in the Karatsu Coalfield. Karasawa (1992) described five species from the middle Eocene Manda Group, moved *Xanthilites pentagonalis* to *Branchioplax* Rathbun, 1916 and erected a new monotypic genus *Prohomola* for *Homolopsis japonicus*. Kato and Karasawa (1994) described a new portunid, *Minohellenus macrocheilus* from the upper Oligocene Ashiya Group and additional material of the species was recorded (Kato and Karasawa, 1996).

The purpose of this paper is to describe 12 species in 11 genera, including two new genera and three new species, of decapods from the middle Eocene-lower Oligocene rocks in Saga and Nagasaki Prefectures, Kyushu. New descriptions are given for *Carinocarcinoides angustifrons* (Karasawa, 1993) comb. nov. and *Collinsius simplex* Karasawa, 1993.

The specimens described in the paper are housed in the Mizunami Fossil Museum (MFM).

Localities

Kosasa area (Figure 1A)

Imaizumila sexdentata Karasawa, 1993 occurred in sandstone of the Nagashima Sandstone Member, Haiki Formation, Kishima Group exposed at Takasakiyama (Loc. KSM-1), Usunoura, Kosasa-cho, Kitamatsura-gun, Nagasaki Prefecture. The Haiki Formation was correlated with the Hatatsu Sandstone Member and Yukiaino Sandstone Member of the Kishima Group distributed in the Karatsu-Taku areas (Matsui *et al.*, 1989). According to Okada (1992), the Hatatsu Sandstone Member and Yukiaino Sandstone Member are assigned to Zone CP17 (early Oligocene) of Okada and Bukry's (1980) scale of nannofossils.

Karatsu-Taku areas (Figure 1B)

Eight species in seven genera of decapods (Figure 2) were collected from the Kishima Formation and Yukiaino Sandstone Member of the Kishima Group from 15 localities distributed in the eastern part of Saga Prefecture. Okada (1992) assigned the Kishima Formation to Zone CP16a of Okada and Bukry's nannozones and the Yukiaino Sandstone to Zone CP17. Details of localities are shown in Table 1.

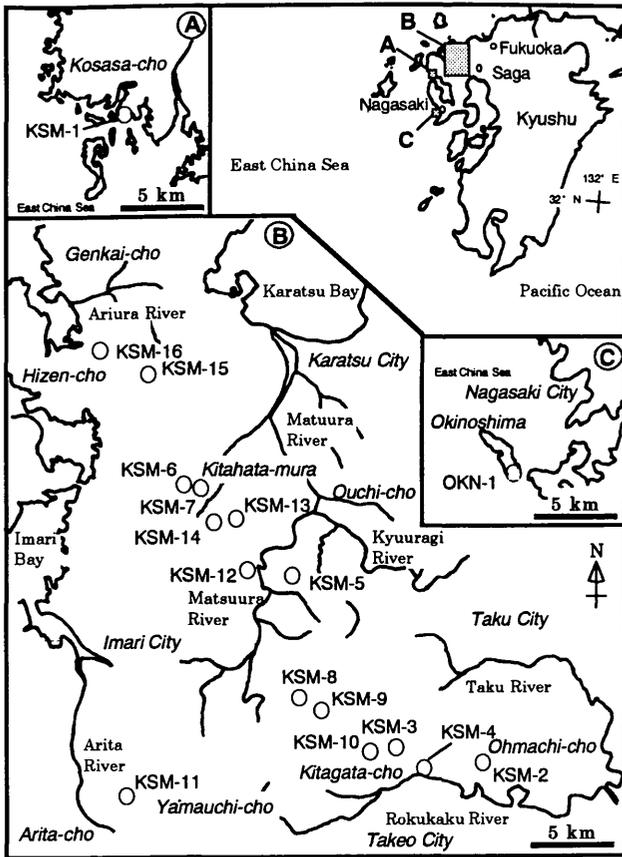


Figure 1. Map showing decapod localities of the studied areas.

Okinoshima area (Figure 1C)

Three species in three genera of decapods (Figure 2) were collected from sandstone of the Okinoshima Formation of the Okinoshima Group exposed at Aze, Iojima-cho, Nagasaki City. The Okinoshima Formation is correlated with the lower part of the Sakasegawa Group in the Amakusa Coalfield and the Nougata Group in the Chikuho Coalfield (Ozaki and Hamasaki, 1991). According to Ozaki and Hamasaki, the formation seems to be assigned to Zones CP13-14 (middle Eocene) by Okada and Bukry's (1980) nannozone.

Summary of the Palaeogene decapod fauna of Kyushu

The decapod fauna from the Okinoshima Group comprises three species, *Callianassa* (s. l.) sp., *Raninoides nodai* Karasawa, 1992 and *Cicarnus fumiae* gen. et sp. nov. (Figure 2). Previously known decapods from the middle Eocene rocks are recorded from the Dosi and Kawamagari Formations (Nagao, 1941) and the Manda Group (Yokoyama, 1911; Karasawa, 1992). *Callianassa* (s. l.) sp. is known from the Dosi and Kawamagari Formations and *R. nodai* from the Manda Group. *Cicarnus* is only known from the Okinoshima Group. The middle Eocene decapod fauna has close affinities with those of the western-central Tethys region, based on the occurrences of *Prohomola*, *Portunites* and *Branchioplax* from the Manda Group (Karasawa, 1992, 1999).

The early Oligocene decapod fauna from the Kishima Group is represented by nine species in eight genera (Figure 2). The fauna from the Kishima Formation is characterized by the abundant occurrence of *Collinsius simplex* Karasawa, 1993, whilst from the Yukiaino Sandstone Member it is char-

Species	Age	Middle Eocene	Early Oligocene																	
			Nanno Zone by Okada & Bukry (1980)	CP16a																CP17
				Formation	Kishima Group															
					Locality	Kishima Formation														Yukiaino Sandstone M.
	OKN-1	2	3	4		5	6	7	8	9	10	11	12	13	14	15	16	1		
<i>Axius</i> (s.l.) sp.						X														
<i>Ctenocheles sujakui</i> Imaizumi, 1958			X	X	X		X													
<i>Callianassa</i> (s.l.) sp.		X																		
<i>Neocallichirus sakiae</i> sp. nov.												X	X	X	X	X				
<i>Raninoides nodai</i> Karasawa, 1992		X																		
<i>Imaizumila sexdentata</i> Karasawa, 1993																		X		
<i>Cicarnus fumiae</i> gen. et sp. nov.		X																		
<i>Minohellenus macrocheilus</i> Kato and Karasawa, 1994						X											X			
<i>Euphyllax</i> ? sp.				X																
<i>Carinocarcinoides angustifrons</i> (Karasawa, 1993) comb. nov.			X																	
<i>Carinocarcinoides carinatus</i> gen. et sp. nov.										X										
<i>Collinsius simplex</i> Karasawa, 1993			X	X	X	X	X	X	X	X	X	X								

Figure 2. List of fossil decapods from the studied areas. Locality numbers are shown in Figure 1.

Table 1. List of decapod-bearing localities of the Karatsu-Taku areas.

Loc. no.	Locality	Formation
KSM-2	Hatada, Ohmachi, Ohmachi-cho, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-3	Magami, Osaki, Kitagata-cho, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-4	SE of Magami, Osaki, Kitagata-cho, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-5	Tatsugawa, Okawa-cho, Imari City, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-6	Shimohirano, Kitahata-mura, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-7	Shimohiranotoge, Kitahata-mura, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-8	Sarajuku, Takeo City, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-9	Wakagi, Takeo City, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-10	Takatori, Kitagata-cho, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-11	Oubounotoge, Arita-cho, Saga Prefecture	Sandy mudstone of the Kishima Formation, Kishima Group
KSM-12	Komanaki, Okawa-cho, Imari City, Saga Prefecture	Sandstone of the Yukiaino Sandstone Member, Kishima Group
KSM-13	Shige, Kitahata-mura, Saga Prefecture	Sandstone of the Yukiaino Sandstone Member, Kishima Group
KSM-14	Tuzumi, Minamihata-cho, Imari City, Saga Prefecture	Sandstone of the Yukiaino Sandstone Member, Kishima Group
KSM-15	Kirigo, Hizen-cho, Saga Prefecture	Sandstone of the Yukiaino Sandstone Member, Kishima Group
KSM-16	Sosorogawachi, Genkai-cho, Saga Prefecture	Sandstone of the Yukiaino Sandstone Member, Kishima Group

acterized by the frequent occurrence of *Neocallichirus sakiæ* sp. nov. Among the known genera from the Kishima Group, *Carinocarcinoides* and *Collinsius* are Japanese early Oligocene endemic genera; *Imaizumila* is only known from the Oligocene of Japan and the Eocene-Miocene of Chile (Schweitzer and Feldmann, 2000); *Minohellenus* occurs outside of Japan in Oligocene-Miocene rocks of Washington and Oregon (Schweitzer and Feldmann, 2000). *Axius* (s. l.), *Ctenocheles*, *Callianassa* (s. l.) and *Neocallichirus* are cosmopolitan. *Euphyllax* occurs in the Caribbean and East Pacific Ocean at the present day, but the fossil record seems to extend to the lower Oligocene of Japan. Karasawa (1999) suggested that the Tethyan genera *Prohomola*, *Portunites* and *Branchioplax* disappeared by the Oligocene and that the decapod fauna of southwest Japan appears to become endemic in the early Oligocene.

Systematic paleontology

Infraorder Thalassinidea Latreille, 1831
 Superfamily Axioidea Huxley, 1879
 Family Axiidae Huxley, 1879
 Genus *Axius* Leach, 1814

Type species.—*Axius stirhynchus* Leach, 1814 by monotypy.

Geologic range.—Oligocene to Recent.

Axius (s. l.) sp.

Figure 3.1a–c

Description.—Anterior half of carapace preserved but lacks rostrum. Anterolateral margin unarmed. Gastric region convex; median carina smooth, well marked, extending from anterior margin to posterior fourth of gastric region; lat-

eral carinae weak, extending from anterior margin to anterior third of gastric region. Cervical groove well developed, reaching anteroventrally to hepatic region. Postcervical region of carapace glabrous. Pereiopods 1–3 preserved. Meri of both pereiopods 1 flattened laterally, lateral surface smooth, dorsal and ventral margins pitted, without spines. Palm and carpus of pereiopod 2 compressed laterally; lateral surface, dorsal and ventral margins smooth. Carpus and merus of pereiopod 3 cylindrical in cross section, without marginal spines.

Discussion.—Poore (1994) recognized four families and 32 genera for taxa previously assigned to the extant Axiidae. The definition of the extant axiids includes detailed characters of eyes, antennae, pleopods, and uropods, which are not available for study in fossil specimens. The present species is assigned to *Axius* (s. l.) by having a carapace with a well defined cervical groove and without *linea thalassinicae*. The single incomplete specimen renders generic placement obscure and it is considered best to place the specimen in *Axius* (s. l.).

Previously known fossil members of *Axius* (s. l.) are recorded from the Oligocene of Panama and the Pliocene of France (Glaessner, 1969).

Material examined.—MFM218633 from KSM-6.

Superfamily Callianassoidea Dana, 1852
 Family Ctenochelidae Manning and Felder, 1991
 Subfamily Ctenochelinae Manning and Felder, 1991
 Genus *Ctenocheles* Kishinoue, 1926

Type species.—*Ctenocheles balssi* Kishinoue, 1926 by monotypy.

Geologic range.—Late Cretaceous to Recent.

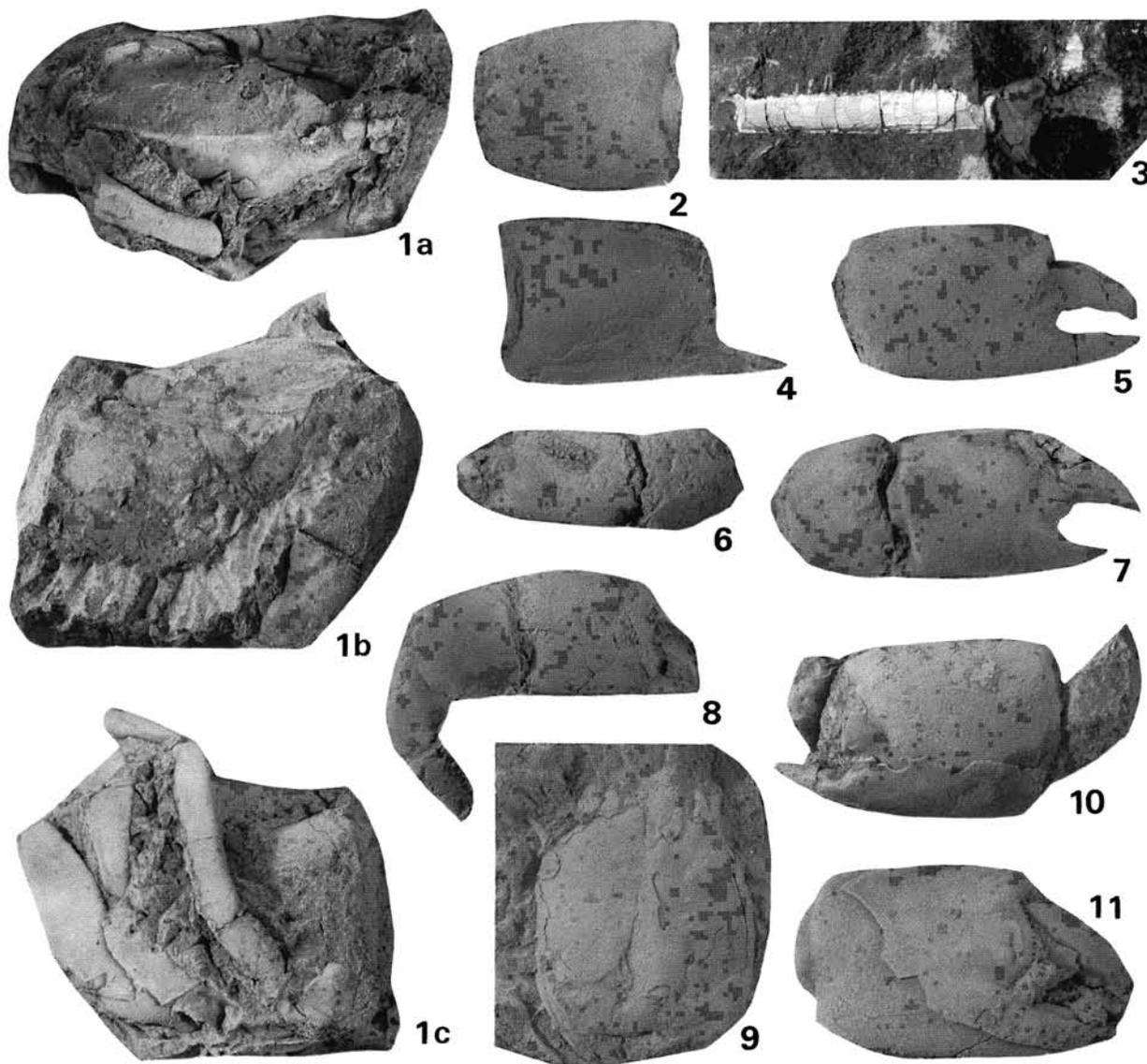


Figure 3. 1a-c. *Axius* (s. l.) sp., MFM218633, $\times 1.8$; 1a: carapace, dorsal view; 1b: carapace and pereopod 1, lateral view; 1c: carapace and pereopods 1-3, lateral view. 2, 4. *Callianassa* (s. l.) sp., $\times 1.2$; 2: carpus of major cheliped, lateral view; 4: propodus of major cheliped, mesial view. 3. *Ctenocheles sujakui* Imaizumi, 1958, MFM218631, fixed finger of major cheliped, $\times 1.8$, lateral view. 5-8, 10, 11. *Neocallichirus sakiæ* sp. nov.; 5: MFM218516 (paratype), major cheliped, $\times 1.5$, lateral view; 6: MFM218515 (holotype), minor cheliped, $\times 2.5$, lateral view; 7: MFM218519 (paratype), major cheliped, $\times 1.5$, lateral view; 8: MFM218515 (holotype), major cheliped, $\times 1.5$, lateral view; 10: MFM218518 (paratype), major cheliped, $\times 1.5$, lateral view; 11: MFM218517 (paratype), major cheliped, $\times 1.5$, lateral view. 9: *Raninoides nodai* Karasawa, 1992, MFM218636, carapace, $\times 1.5$, dorsal view.

***Ctenocheles sujakui* Imaizumi, 1958**

Figure 3.3

Ctenocheles sujakui Imaizumi, 1958, p. 301, pl. 44, figs. 2-5;
Karasawa, 1997, p. 31, pl. 3, figs. 5, 7.

Remarks.—Imaizumi (1958) originally described the species from the lower Oligocene Kishima Formation of Nagao, Taku City, Saga Prefecture.

Material examined.—MFM218631 and 218632 from KSM-3; referred specimens from KSM-2, 4, 7.

Family Callianassidae Dana, 1852
Subfamily Callianassinae Dana, 1852

Remarks.—Manning and Felder (1991) recognized two families, seven subfamilies and 21 genera for taxa previously assigned to the extant Callianassidae. According to Manning and Felder's (1991) classification, Poore (1994) gave keys to 20 genera in the extant Callianassidae. Since then, four genera, *Grynaminna* Poore, 2000, *Necallianassa* Heard and Manning, 1998, *Nihonotrypaea* Manning and Tamaki, 1998, and *Pseudobiffarius* Heard and Manning, 2000, have been described. Fossil taxa have traditionally been assigned to *Callianassa* (s. l.); however, recent studies have employed the classification of Manning and Felder (Karasawa, 1992, 1993, 1997; Karasawa and Goda, 1996; Kato, 1996; Schweitzer Hopkins and Feldmann, 1997; Stilwell *et al.*, 1997; Vega *et al.*, 1995). Sakai (1999) reexamined all known extant members in the family Callianassidae and recognized four subfamilies and 10 genera in the family. The classification of Callianassidae by Sakai is quite different from Manning and Felder's (1991) system. After that, Sakai and Türkay (1999) erected a new subfamily Bathycalliinae with a new genus *Bathycalliax*. Therefore, the fossil species referred to the Callianassidae are in need of reexamination.

Genus *Callianassa* Leach, 1814

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

Geologic range.—Cretaceous to Recent.

Callianassa (s. l.) sp.

Figure 3.2, 3.4

Callianassa sp. indet.; Nagao, 1941, p. 85, pl. 26, figs. 8, 9.

Description.—Propodus and carpus of major cheliped preserved. Fixed finger short, about 0.3 propodus length, with acutely pointed tip. Palm subrectangular in lateral view, longer than high, with distally convergent dorsal and ventral margins. Carpus subrectangular in lateral view, equal to palm length; dorsal and ventral margins divergent distally.

Discussion.—The generic placement of the present species awaits the discovery of better material and it is considered best to place the species in *Callianassa* (s. l.). The known Japanese Palaeogene species formerly placed in the genus *Callianassa* comprise five species, *Callianassa elongatodigitata* Nagao, 1941, *Callianassa isikariensis* Nagao and Ôtatumé, 1938, *Callianassa kushiroensis* Nagao, 1941 and *Callianassa muratai* Nagao, 1932 of Hokkaido, and *Callianassa* sp. indet. (Nagao, 1941) of Kyushu. Among these, *C. muratai* and *C. elongatodigitata* were moved to the genus *Callianopsis* De Saint Laurent, 1973 in the family Ctenochelidae by Kato and Karasawa (1994). The present species differs from *C. isikariensis* and *C. kushiroensis* in that the major cheliped has a short fixed finger and a palm with distally convergent dorsal and ventral margins. The species is identical with *Callianassa* sp. indet. described from the middle Eocene Dosi and

Kawamagari Formations of Fukuoka Prefecture by Nagao (1941).

Material examined.—MFM218634 and 218635 from OKN-1.

Subfamily Callichirinae Manning and Felder, 1991
Genus *Neocallichirus* Sakai, 1988

Type species.—*Neocallichirus horneri* Sakai, 1988 by original designation.

Geologic range.—Oligocene to Recent.

Neocallichirus sakiae sp. nov.

Figure 3.5–3.8, 3.10, 3.11

Etymology.—The specific name is in honor of Miss Saki Fudouji.

Diagnosis.—Chelipeds large, unequal, dissimilar. Dorsal margin of dactylus of major cheliped smooth; occlusal margin with broad tooth on midlength. Fixed finger shorter than dactylus; occlusal margin with broad tooth on proximal half. Palm rectangular, about 1.3 times longer than high, 1.3 propodus length, with serrated distal margin. Carpus subrectangular, about 0.6 palm length, slightly higher than long. Merus equal to palm length, about 0.6 times higher than long; ventral margin strongly convex without ventral hook. Ischium with dentate ventral margin.

Description.—Chelipeds large in size, unequal, dissimilar. Dactylus of major cheliped curved ventrally with acutely pointed tip; dorsal margin smooth with 4 setal pits; occlusal margin bearing broad tooth at midlength; lateral surface inflated with 4 setal pits parallel to occlusal margin. Fixed finger about 0.75 dactylus length with acutely pointed tip; occlusal margin bearing broad tooth on proximal half; ventral margin smooth; lateral surface slightly convex with row of setal pits parallel occlusal and ventral margins. Palm rectangular in lateral view, about 1.3 times longer than high, 1.3 propodus length; dorsal margin slightly convex; ventral margin nearly straight; distal margin gently convex, serrate; lateral surface longitudinally inflated with row of setal pits parallel to ventral margin. Carpus subrectangular in lateral view, about 0.6 palm length, slightly higher than long, tapering proximally, with convex lateral surface. Merus equal to palm length, about 0.6 times higher than long; dorsal margin gently convex; ventral margin strongly convex without ventral hook; lateral surface with longitudinal ridge. Ischium poorly preserved, about as long as merus, ventral margin dentate.

Fingers of minor cheliped poorly preserved. Palm rectangular in lateral view, occupying about half palm length of major cheliped, slightly longer than high, with convex lateral surface; dorsal margin smooth, ventral margin pitted. Carpus rectangular, about 0.75 palm length, with convex lateral surface, its length equal to height.

Discussion.—The Japanese fossil *Neocallichirus* is represented by three species, *Neocallichirus bona* (Imaizumi, 1959) from the Miocene Moniwa Formation and Mizunami Group (Karasawa, 1993, 1997), *Neocallichirus grandis* Karasawa and Goda, 1996, from the middle Pleistocene Atsumi Group (Karasawa and Goda, 1996) and the middle-

upper Pleistocene Shimosa Group (Kato and Karasawa, 1998), and *Neocallichirus okamotoi* (Karasawa, 1993) from the upper Oligocene Hioki Group (Karasawa, 1993, 1997). Among these, the new species most resembles *N. okamotoi* but differs in that the major cheliped has broad teeth on the occlusal margin of both fingers, a longer palm with a serrated, convex distal margin and a shorter carpus. The merus on the major cheliped without marginal denticules and a short merus readily distinguish *N. sakiæ* from *N. bona* and *N. grandis*.

Material examined.—MFM218515 (holotype) and 218516 (paratype) from KSM-12; MFM218517 (paratype) and 218518 (paratype) from KSM-16; MFM218519 (paratype) from KSM-14; referred specimens from KSM-13, 14, 15.

Infraorder Brachyura Latreille, 1802
Section Podotremata Guinot, 1977
Superfamily Raninoidea De Haan, 1841
Family Raninidae De Haan, 1841
Subfamily Raninoidinae Lörenthey in Lörenthey
and Beurlen, 1929
Genus *Raninoides* H. Milne Edwards, 1837

Type species.—*Ranina loevis* Latreille, 1825 by monotypy.

Geologic range.—Palaeocene to Eocene.

Raninoides nodai Karasawa, 1992

Figure 3.9

Raninoides nodai Karasawa, 1992, p. 1252, figs. 4.2–4.8;
Karasawa, 1997, p. 39, pl. 7, figs. 7, 9, 11.
Laeviranina nodai (Karasawa); Tucker, 1998, p. 351.

Remarks.—Tucker (1998) provisionally placed *Raninoides nodai* in *Laeviranina* Lörenthey in Lörenthey and Beurlen, 1929. However, this species should be assigned to *Raninoides* based upon the absence of the postfrontal ridge on the carapace.

Material examined.—MFM218636 from OKN-1.

Section Heterotremata Guinot, 1977
Superfamily Portunoidea Rafinesque, 1815
Family Portunidae Rafinesque, 1815
Subfamily Carcininae MacLeay, 1838
Genus *Cicarnus* gen. nov.

Type species.—*Cicarnus fumiae* sp. nov. by monotypy.

Etymology.—*Cicarnus* is an anagram of *Carcinus* Leach, 1814; masculine gender.

Diagnosis.—Carapace transversely hexagonal in outline, length about 0.8 its width. Orbitofrontal margin wide. Front with 3 rounded lobes, separated from small, bluntly triangular supraorbital angle by shallow V-shaped notch. Upper orbital margin with 2 open fissures. Anterolateral margin convex, bearing 4 well developed teeth. Dorsal surface smooth, moderately convex. Regions well defined. Epigastric region transversely raised anteriorly. Proto-gastric region inflated with transverse ridge on each side. Mesogastric region bearing anterior transverse ridge.

Cervical groove well defined. Epibranchial region more inflated. Branchiocardiac grooves poorly defined.

Discussion.—The subfamily Carcininae is defined by the following characters: The carapace is not broad with four or five anterolateral teeth; chelae are short; pereopods 2–5 are similar and rather stout, and the pereopod 5 has a lanceolate dactylus [modified from Glaessner (1969)]. Although carapace characters of Carcininae overlap those of the subfamily Polybiinae Ortmann, 1893, Polybiinae are distinguished from Carcininae by having a paddle-like pereopod 5 (Glaessner, 1969; Schweitzer and Feldmann, 2000).

The Recent Carcininae comprises six genera, *Benthochascon* Alcock and Anderson, 1899, *Brusinia* Števíć, 1991, *Carcinus* Leach, 1814, *Nectocarcinus* A. Milne Edwards, 1860, *Portumnus* Leach, 1814 and *Xaiva* MacLeay, 1838 (Moosa, 1996). Three extinct genera, *Portunites* Bell, 1858, *Pleolobites* Remy, 1960 and *Mioxaiva* Müller, 1979, were previously assigned to the subfamily (Glaessner, 1969; Müller, 1979). Schweitzer and Feldmann (2000) and Schweitzer *et al.* (2000) removed *Portunites* to Polybiinae based upon the presence of a paddle-like pereopod 5. The position of *Pleolobites* and *Mioxaiva* within Carcininae is doubtful (Glaessner, 1969; Müller, 1984).

The present new genus and species are represented by a single carapace specimen, and chelipeds and pereopods are not preserved. However, *Cicarnus* possesses carapace characters most like those of *Benthochascon*, *Carcinus* and *Nectocarcinus*, and may be assigned to Carcininae. *Cicarnus* is most similar to *Nectocarcinus*, but differs in having well developed anterolateral teeth, the frontal margin composed of three rounded lobes, and a smooth dorsal carapace. The mesogastric region in *Cicarnus* has a transverse ridge interrupted by a shallow median groove. With respect to the front which is composed of three rounded lobes, the new genus resembles *Benthochascon* and *Carcinus*. *Cicarnus* differs from *Carcinus* in having four anterolateral teeth and well defined dorsal regions. Although *Cicarnus* together with *Benthochascon* bears four anterolateral teeth, in *Cicarnus* the dorsal regions are well defined and a wide anterolateral margin bears well separated teeth.

Cicarnus fumiae sp. nov.

Figure 4.2a–c

Etymology.—The specific name is in honor of Mrs. Fumie Karasawa.

Diagnosis.—As for the genus.

Description.—Carapace hexagonal in outline, length about 0.8 its width. Orbitofrontal margin wide, occupying 0.6 carapace width. Front composed of 3 rounded lobes, occupying about 0.3 carapace width, separated from small, bluntly triangular supraorbital angle by shallow V-shaped notch; median frontal lobe small and laterals broad. Upper orbital margin concave, bearing shallow fissure at about midwidth of orbit and shallower fissure anterior to outer orbital tooth. Anterolateral margin convex, occupying about 0.45 carapace width, bearing 4 well separated teeth including outer orbital tooth; outer orbital tooth acutely triangular,

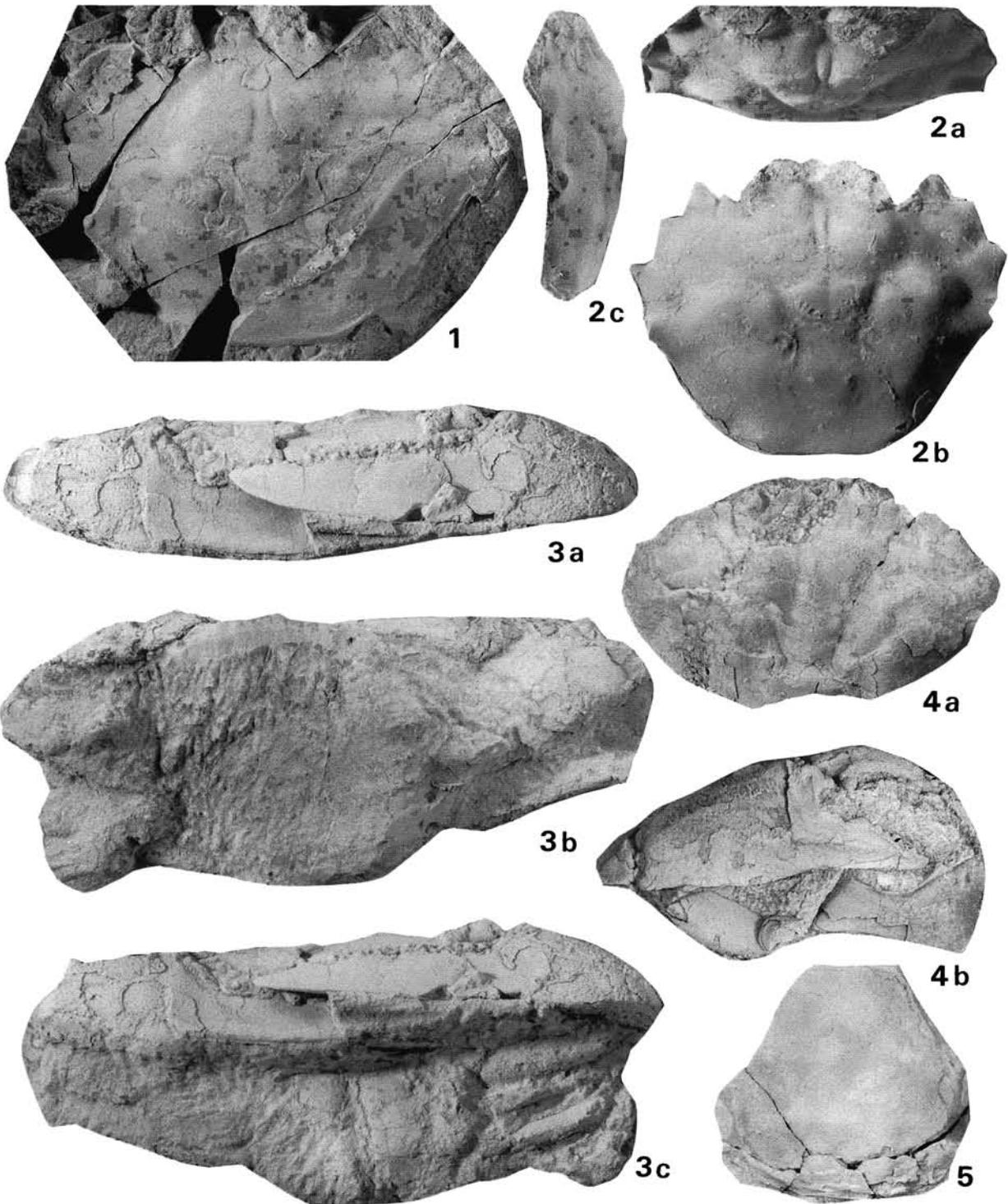


Figure 4. 1. *Imaizumila sexdentata* Karasawa, 1993, MFM218507 (holotype), carapace, $\times 1.2$, dorsal view. 2a–c. *Cicarnus fumiae* gen. et sp. nov., MFM218512 (holotype), $\times 1.5$, 2a: frontal view; 2b: dorsal view; 2c: lateral view. 3a–c. *Euphylax* ? sp., MFM218639, $\times 1.0$; 3a: both chelipeds, lateral view; 3b: carapace, cheliped and pereopods, dorsal view; 3c: thoracic sternum, chelipeds and pereopods, ventral view. 4a, b, 5. *Minohellenus macrocheilus* Kato and Karasawa, 1994, $\times 1.2$; 4a: MFM218637, carapace, dorsal view; 4b: MFM218637, right cheliped, lateral view; 5: MFM218638, carapace, dorsal view.

directed anteriorly; second broadly triangular, slightly directed anterolaterally and dorsally; third acutely triangular, directed anterolaterally and dorsally; last lacking tip, but directed laterally and dorsally. Posterolateral margin sinuous, slightly longer than anterolateral margin. Posterior margin nearly straight, slightly longer than posterolateral margin.

Dorsal surface smooth, moderately convex, with well defined regions. Epigastric region transversely raised anteriorly. Protogastric region inflated, well separated from narrow anterior mesogastric process, with transverse ridge on each side. Mesogastric region convex, pentagonal in outline, bearing anterior transverse ridge divided into two by shallow median depression. Urogastric region narrow, depressed. Cervical groove well defined. Cardiac region slightly convex, hexagonal in outline, bearing two nodes transversely arranged. Intestinal region depressed. Hepatic region slightly convex. Epibranchial region more inflated, shallowly separated from mesobranchial region. Meso- and metabranchial regions also inflated. Branchio-cardiac grooves poorly defined.

Discussion.—As for the genus.

Material examined.—MFM218512 (holotype) from OKN-1.

Subfamily Polybiinae Ortmann, 1893
Genus *Imaizumila* Karasawa, 1993

Type species.—*Imaizumila sexdentata* Karasawa, 1993 by monotypy.

Geologic range.—Eocene to Middle Miocene.

Imaizumila sexdentata Karasawa, 1993

Figure 4.1

Imaizumila sexdentata Karasawa, 1993, p. 52, pl. 11, figs. 1–3; Karasawa, 1997, p. 48, pl. 11, figs. 8, 12.

Remarks.—Previously specimens were recorded only from the lower Oligocene Haiki Formation of the Kishima Group (Karasawa, 1993). Schweitzer and Feldmann (2000) described an additional species, *Imaizumila araucana* (Philippi, 1887) from the Eocene-Miocene of Chile.

Material examined.—MFM218507 (holotype) and 218508 (paratype) from KSM-1.

Genus *Minohellenus* Karasawa, 1990

Type species.—*Charybdis (Minohellenus) quinquedentata* Karasawa, 1990 by monotypy.

Geologic range.—Early Oligocene to Middle Miocene.

Minohellenus macrocheilus Kato and Karasawa, 1994

Figure 4.4a, b, 4.5

Minohellenus macrocheilus Kato and Karasawa, 1994, p. 55, fig. 2; pl. 4, figs. 1–4; Kato and Karasawa, 1996, p. 31, pl. 10, figs. a–c; Karasawa, 1997, p. 49, pl. 14, figs. 2–7.

Remarks.—Previously known specimens were recorded from the upper Oligocene Ashiya Group (Kato and

Karasawa, 1994, 1996). The discovery of *M. macrocheilus* from the Kishima Group extends the geologic range for the species back to the early Oligocene.

Material examined.—MFM218637 from KSM-16; MFM 218638 from KSM-6.

Subfamily Podophthalminae Miers, 1886
Genus *Euphylax* Stimpson, 1860

Type species.—*Euphylax dovii* Stimpson, 1860 by monotypy.

Geologic range.—Oligocene to Recent.

Euphylax ? sp.

Figure 4.3a–c

Description.—Right half of carapace poorly preserved; upper orbital margin wide, gently convex; anterolateral margin narrow with laterally directed stout spine; posterolateral margin sinuous. Thoracic sternum wide, sternites 4–7 preserved.

Chelipeds similar. Dactylus slender, elongate, with smooth dorsal margin and irregularly dentate opposing margin. Fixed finger elongate, about 0.3 times higher than long proximally, with acutely pointed tip; occlusal margin straight, irregularly dentate; ventral margin convex, smooth. Palm short, about 0.75 fixed finger length, about 0.6 times longer than high, converging proximally; dorsal surface tuberculated; ventral margin smooth.

Meri of pereopods 2 and 3 ovate in cross section.

Discussion.—There is, in the general outline of chelipeds, similarity between the species and *Euphylax domingensis* (Rathbun, 1919) from the lower Miocene? of Haiti, but this species has a slender dactylus and a short palm without carinae on the lateral margin. However, a well preserved carapace of this species is needed to qualify the systematic position.

Material examined.—MFM218639 from KSM-3.

Superfamily Xanthoidea MacLeay, 1838

Family Goneplacidae MacLeay, 1838

Subfamily Carcinoplacinae H. Milne Edwards, 1852

Carinocarcinoides gen. nov.

Type species.—*Carinocarcinoides carinatus* sp. nov. by present designation.

Etymology.—The genus is named in allusion to its close resemblance to *Carinocarcinus* Lörentz, 1898; masculine gender.

Diagnosis.—Carapace transversely hexagonal to roundly quadrate in outline, widest at anterolateral angle. Orbitofrontal margin wide. Front nearly straight with sharply squared corners. Upper orbital margin concave with triangular, forwardly directed outer orbital spine and without fissures. Inner suborbital tooth sharp, projecting anteriorly. Anterolateral margin strongly convex with 2 small, anterolaterally directed spines exclusive of outer orbital spine. Dorsal surface smooth, moderately vaulted transversely and weakly vaulted longitudinally. Regions distinct. Protogastric, cardiac and epigastric ridges present.

Anterior mesogastric process poorly defined. Cervical and branchiocardiac grooves well defined. Thoracic sternum narrow, longer than wide, tapering anteriorly and posteriorly. Chelipeds large; dactylus, palm and carpus finely granulate on dorsal and lateral surfaces.

Discussion.—*Carinocarcinoides* possesses characters most like those of the extant genera *Carcinoplax* H. Milne Edwards, 1852 and *Homoioplax* Rathbun, 1914. However, *Carinocarcinoides* has a dorsal carapace with well defined regions and several ridges. The thoracic sternum of the new genus is much narrower than that of *Carcinoplax*. Of the extinct genera within Carcinoplacinae, *Carinocarcinoides* is most similar to *Carinocarcinus* Lörenthey, 1898, a monotypic genus from the middle Eocene of Hungary, but differs in having a straight front with sharp lateral corners, three anterolateral teeth including the outer orbital spine, and a protogastric ridge.

The new genus is represented by two species, *Carinocarcinoides angustifrons* (Karasawa, 1993) comb. nov. and *Carinocarcinoides carinatus* sp. nov., from the lower Oligocene Kishima Group.

Carinocarcinoides angustifrons
(Karasawa, 1993) comb. nov.

Figure 5.3

Varuna angustifrons Karasawa, 1993, p. 81, pl. 23, fig. 13;
Karasawa, 1997, p. 69, pl. 27, fig. 8.

Revised diagnosis.—*Carinocarcinoides* with rounded-quadrate carapace and with epigastric, protogastric, cardiac and epibranchial ridges.

Revised description.—Carapace roundly quadrate in outline, about as long as wide, widest at midlength. Orbitofrontal margin 0.75 carapace width. Front straight, occupying about 0.3 carapace width, with sharp lateral corners. Upper orbital margin wide, concave, rimmed, with small, forwardly directed outer orbital spine. Anterolateral margin gently convex, about 0.4 carapace width, with two small spines excluding outer orbital spine. Posterolateral margin also strongly convex, about 1.4 times as long as anterolateral margin. Posterior margin straight, about 0.4 carapace width.

Dorsal surface smooth, moderately vaulted transversely and weakly vaulted longitudinally. Regions somewhat distinct. Epigastric region with weak, transverse ridge on each side. Protogastric regions inflated with broad, transverse ridge interrupted by narrow anterior mesogastric process. Anterior mesogastric process poorly defined. Mesogastric region slightly convex. Cervical groove distinct, sinuous. Cardiac region gently inflated transversely, hexagonal in outline, bearing two nodes transversely arranged, with anterior transverse ridge. Intestinal region poorly defined. Hepatic region depressed. Branchiocardiac grooves shallow. Branchial regions convex; each epibranchial region inflated with broad ridge extending in convex-forward arc from mesogastric region to last anterolateral spine.

Discussion.—The present species was originally placed in *Varuna* H. Milne Edwards, 1852 in the family Grapsidae. However, the species is moved here from *Varuna* to

Carinocarcinoides on the basis of its inflated dorsal carapace with several ridges and three anterolateral spines. Members of *Varuna* have a flattened dorsal surface with a wider frontal margin and three broadly triangular anterolateral teeth.

Material examined.—MFM218501 (holotype) from KSM-2.

***Carinocarcinoides carinatus* sp. nov.**

Figure 5.1a-d, 5.2, 5.4

Diagnosis.—*Carinocarcinoides* with transversely hexagonal carapace and with anterior frontal, protogastric, urogastric, cardiac and epigastric ridges dorsally.

Etymology.—From Latin *carina* (= keel), in reference to dorsal ridges on the carapace.

Description.—Carapace transversely hexagonal in outline, length 0.8 its width, widest at anterolateral angle. Orbitofrontal margin occupying about 0.75 carapace width. Front nearly straight, about 0.4 carapace width, weakly protruded medially, with well developed ridge parallel to anterior margin and with sharply squared corners. Upper orbital margin concave, rimmed, with weak, central projection and broadly triangular, forwardly directed outer orbital spine. Inner suborbital spine sharp, projecting anteriorly, visible in dorsal view. Anterolateral margin strongly convex, about 0.35 carapace width, with two small, anterolaterally directed spines exclusive of outer orbital spine. Posterolateral margin also strongly convex, about 1.8 times as long as anterolateral margin. Posterior margin short, about 0.3 carapace width.

Dorsal surface smooth, moderately vaulted transversely and weakly vaulted longitudinally. Regions distinct. Protogastric region inflated with broad, arcuate ridge on each side. Anterior mesogastric process poorly defined. Mesogastric region slightly convex. Urogastric region with transverse ridge. Cervical groove well defined, sinuous. Cardiac region gently vaulted transversely, hexagonal in outline, bearing two nodes transversely arranged, with transverse ridge anteriorly. Intestinal region small, poorly defined. Hepatic region flattened. Branchiocardiac grooves fairly deep. Branchial regions convex; each epibranchial region most strongly inflated with broad ridge extending in convex-forward arc from mesogastric region to last anterolateral spine. Infraorbital region with weak, granulated ridge parallel to lower orbital margin. Pterygostomian region bearing finely granulated ridge below and parallel to pleural suture. Maxilliped 3 poorly preserved.

Thoracic sternum longer than wide, tapering anteriorly and posteriorly, occupying about 0.4 carapace width, widest at sternite 6. Sternites 1 and 2 fused, triangular. Sternite 3 twice as wide as long with shallow median depression; anterior margin weakly concave, posterior margin broadly V-shaped, lateral margin straight, converging anteriorly. Sternites 4-7 with blunt episternal projections. Sternite 4 about 1.5 times wider than long, narrower anteriorly, wider posteriorly; anterior and posterior margins broadly V-shaped, lateral margins convex. Sternite 5 wider than long, becoming narrower anteriorly; anterior margin broadly V-

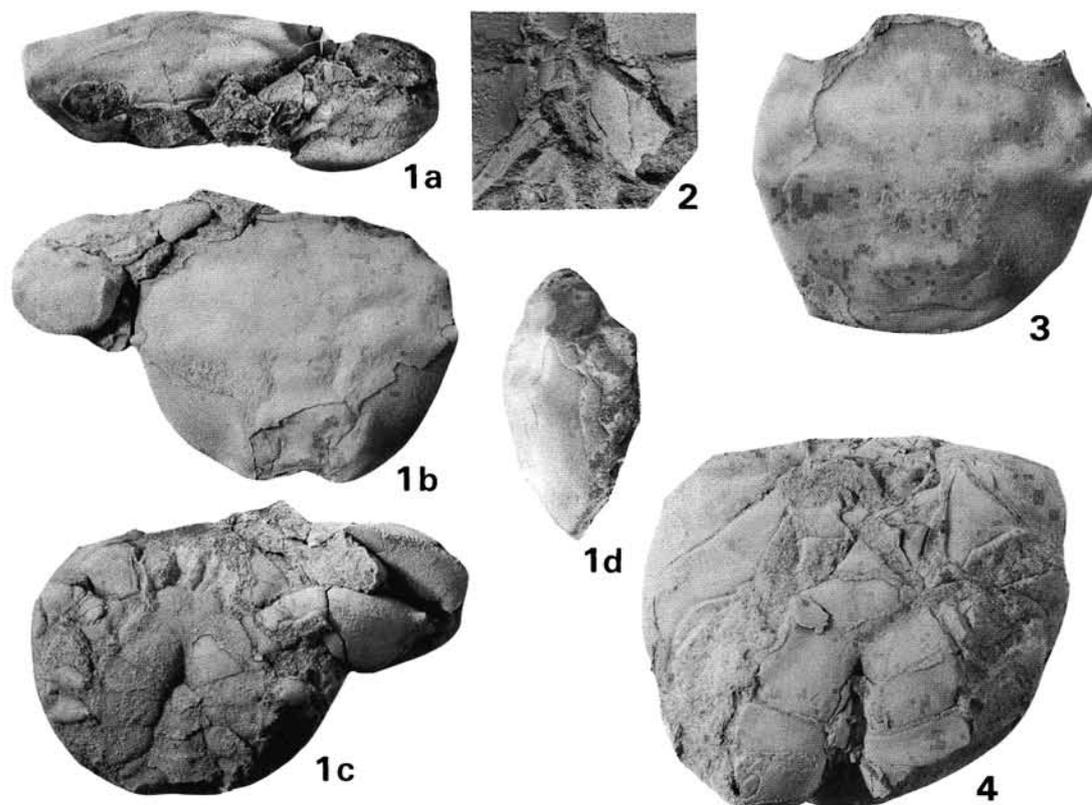


Figure 5. 1a-d. *Carinocarcinoides carinatus* gen. et sp. nov., MFM218513 (holotype), $\times 2.0$; 1a: carapace and left cheliped, frontal view; 1b: carapace and left cheliped, dorsal view; 1c: carapace, thoracic sternum, abdomen of male, and left cheliped, ventral view; 1d: carapace, lateral view. 3. *Carinocarcinoides angustifrons* (Karasawa, 1993) comb. nov., MFM218501 (holotype), carapace, $\times 2.5$, dorsal view. 2, 4. *Carinocarcinoides carinatus* gen. et sp. nov., MFM218514 (paratype), 2: pleopods, $\times 3.0$, ventral view; 4: carapace and thoracic sternum, $\times 1.5$, ventral view.

shaped, posterior margin sinuous, lateral margin convex. Sternites 6 and 7 wider than long, narrowing posteriorly; anterior and posterior margins sinuous, lateral margin convex. Sternite 8 directed strongly posterolaterally with weak lateral projections. Pleopods poorly preserved.

Abdomen of male narrow. Telson triangular, as long as wide at base. Somites 4-6 preserved, widest at posterior part of somite 4, with straight, anteriorly convergent lateral margins; somite 6 about as long as wide; somites 4 and 5 wider than long.

Left cheliped large, poorly preserved. Dorsal surface of dactylus and lateral surface of palm finely granulate. Lateral surface of carpus also finely granulate with finely granulated ridge parallel to proximal margin; dorsal margin with forwardly directed spine.

Discussion.—A transversely hexagonal carapace with transverse frontal and urogastric ridges readily distinguishes *C. carinatus* from *C. angustifrons*. In *C. carinatus* the carapace length occupies about 80% of the width, while in *C. angustifrons* a roundly quadrate carapace is about as long

as wide.

Material examined.—MFM218513 (holotype) and 218514 (paratype) from KSM-9.

Subfamily Chasmocarcininae Serène, 1964
Genus *Collinsius* Karasawa, 1993

Type species.—*Collinsius simplex* Karasawa, 1993 by monotypy.

Geologic range.—Early Oligocene.

Revised diagnosis.—Carapace slightly wider than long, widest at posterolateral angle. Orbitofrontal margin occupying about half carapace width. Front narrow, bilobed, projecting anteriorly, with squared lateral corner. Upper orbital margin narrow, concave, rimmed, with broadly triangular outer orbital angle. Lateral margin rounded, divergent posteriorly. Posterior margin short, straight. Dorsal surface smooth, gently convex longitudinally and transversely. Epigastric region poorly defined. Cervical groove becoming obsolete in advance of hepatic region. Urogastric region

narrow, depressed. Cardiac region transversely convex. Intestinal region narrow. Branchiocardiac grooves well defined. Branchial regions inflated. Thoracic sternum wide, wider than long, widest at sternite 6. Sternite 8 of male with supplementary sternal plate. Abdomen of male narrow; somites 3–5 fused. Chelipeds unequal.

Discussion.—Karasawa (1993) originally placed the genus in the family Goneplacidae, but did not assign it to any known subfamily. Later, Karasawa (1997) assigned *Collinsius* to the subfamily Chasmocarcininae by recognising the presence of supplementary sternal plates of the thoracic sternite 8 in the male. The subfamily Chasmocarcininae comprises five extant genera, *Chasmocarcinus* Rathbun, 1898, *Camatopsis* Alcock and Anderson, 1899, *Chasmocarcinops* Alcock, 1900, *Hepthopelta* Alcock, 1899 and *Scalopidia* Stimpson, 1858, and the Eocene *Falconoplax* Van Straelen, 1933 (Davie and Guinot, 1996). Among these genera, *Collinsius* resembles *Chasmocarcinus*, *Hepthopelta* and *Falconoplax* in that abdominal somite 3 of the male fuses to somites 4 and 5. However, the genus differs from *Chasmocarcinus* by having a narrow front and lacking the posterolateral expansion of the carapace; *Hepthopelta* has a wider front and a strongly inflated dorsal carapace; the carapace of *Falconoplax* has well defined epibranchial regions, protogastric tubercles, deep branchiocardiac grooves and epibranchial ridges.

Collinsius is only known from the lower Oligocene Kishima Formation of Kyushu, Japan.

***Collinsius simplex* Karasawa, 1993**

Figure 6.1–6.9

Collinsius simplex Karasawa, 1993, p. 73, pl. 21, figs. 3–8; Karasawa, 1997, p. 61, pl. 23, figs. 4–6, 8–10.

Revised description.—Carapace slightly wider than long, widest at posterolateral angle. Orbitofrontal margin occupying about half of carapace width. Front narrow, projecting anteriorly with shallow median depression dorsally; anterior margin nearly straight, interrupted by weak median notch with sharply squared lateral corner; lateral margin rimmed. Upper orbital margin concave, rimmed, occupying about 0.2 carapace width, with weak, central projection and broadly triangular outer orbital angle. Lateral margin rounded, divergent posteriorly. Posterior margin short, straight. Dorsal surface smooth, gently convex longitudinally and transversely. Epigastric region poorly defined, but visible. Protogastric region separated from anterior mesogastric process by shallow groove. Cervical groove becoming obsolete in advance of hepatic region. Urogastric region narrow, depressed. Cardiac region transversely hexagonal in outline, transversely convex. Intestinal region narrow. Branchiocardiac grooves well defined. Branchial regions inflated.

Thoracic sternum wide, wider than long, widest at sternite 6. Sternites 1 and 2 fused, narrow, broadly triangular in outline, with deep median depression. Sternite 3 about 0.3 as long as wide with median depression; anterior margin nearly straight, posterior margin broadly V-shaped, lateral margin straight, strongly converging anteriorly. Sternites 4–7 with

blunt episternal projections. Sternite 4 about 0.4 times longer than wide, narrower anteriorly, wider posteriorly; anterior and posterior margins broadly V-shaped; lateral margins convex. Sternite 5 wider than long, narrower anteriorly, wider posteriorly; anterior margin broadly V-shaped, posterior margin sinuous, lateral margin convex. Sternite 6 wider than long; anterior and posterior margins sinuous, lateral margin convex. Sternite 7 wider than long, wider anteriorly, narrower posteriorly; anterior and posterior margins sinuous, lateral margin convex. Sternite 8 wider than long, wider anteriorly, narrower posteriorly, directed posterolaterally; supplementary sternal plate developed in male; shallow, transverse groove in female surface.

Abdomen of male narrow. Telson triangular, slightly longer than wide at base. Somite 6 wider than long with straight, anteriorly convergent lateral margins. Somites 3–5 fused, wider than long, widest at base, with slightly concave, anteriorly convergent lateral margins; posterior lateral expansions covering mesial ends of supplementary plates. Somite 2 narrow. Somite 1 unknown. Telson of female abdomen rounded, wider than long at base. Somites 1–6 narrow, much wider than long, widest at somite 3, longest at somite 6.

Chelipeds unequal. Fixed finger short on major cheliped; palm with smooth, inflated lateral surface. Dactylus elongate on minor cheliped, curving ventrally, with acutely pointed tip; fixed finger also elongate, about as long as dactylus, occupying about half of propodus length, slightly deflexed ventrally, with acutely pointed tip; palm longer than high, distal margin much wider than proximal margin, with smooth, inflated lateral surface.

Pereiopods 1–4 of female poorly preserved. Propodi of pereiopods 2–4 elongate, cylindrical in cross section. Coxa and ischium fused to basis short.

Discussion.—As for the genus.

Material examined.—MFM218502 (holotype), 218503 (paratype), and 218601–218610 from KSM–2; MFM218505 (paratype), 218506 (paratype), and 218613–218620 from KSM–4; MFM218504 (paratype), 218621–218630, 218640, 218641 from KSM–5; MFM218612 from KSM–3; MFM 218642, 218643 and 218644 from KSM–6; referred specimens from KSM–7, 8, 9, 10, 11.

Acknowledgements

We thank J. S. H. Collins (London) for reading our manuscript, Y. Okumura (MFM) for assisting in the senior author's field work in 1995 and 1999 and Mr. T. Yamada (Kyoto University) for offering fossil crab specimens for study. This work was partly supported by the Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture (no. 1663) for Karasawa.

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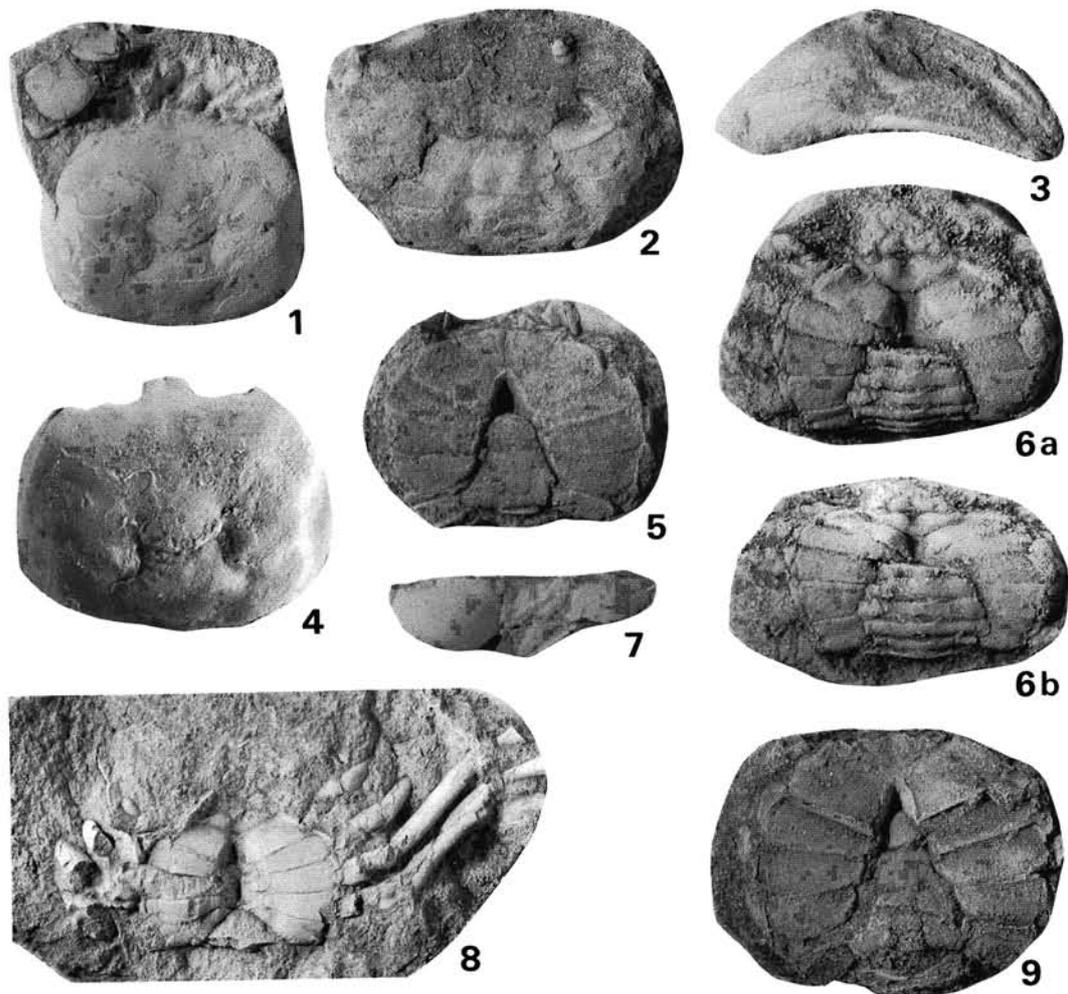


Figure 6. 1–9. *Collinsius simplex* Karasawa, 1993; 1: MFM218502 (holotype), carapace and left cheliped, $\times 3.0$, dorsal view; 2: MFM218642, thoracic sternum and abdomen of female, $\times 3.0$, ventral view; 3: MFM218640, right cheliped, $\times 3.0$, lateral view; 4: MFM218504 (paratype), carapace, $\times 4.0$, dorsal view; 5: MFM218505 (paratype), thoracic sternum and abdomen of male, $\times 3.0$, ventral view; 6a, b: MFM218643, thoracic sternum and abdomen of female, $\times 3.0$, ventral view; 7: MFM218503 (paratype), both chelipeds, $\times 2.5$, lateral view; 8: MFM218641, thoracic sternum and pereopods of female, $\times 3.0$, ventral view; 9: MFM218644, thoracic sternum and abdomen of male, $\times 3.0$, ventral view.

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