

Pleistocene Fossil Decapod Crustacea from the Boso Peninsula, Japan

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Abstract Sixty four species-level forms of decapods belonging to at least 32 genera in 18 families are recorded from the middle and upper Pleistocene Shimosa Group in Chiba Prefecture, Japan. The decapod fauna from the Shimosa Group, which includes the first fossil record of many extant species, is one of the most diverse decapod faunas known from the Japanese Pleistocene. Four assemblage types, based on the dominant families in selected localities, are recognized.

Key words: Decapoda, Crustacea, fossils, Shimosa Group, Pleistocene, Japan.

Fossil decapod crustaceans from the Pleistocene deposits distributed in the southern Kanto region have been reported by many authors. These decapod fossils were found in the lower and middle Pleistocene Kazusa Group (Takeda and Masubuchi, 1984, 1985; Masubuchi and Takeda, 1988), middle Pleistocene Ninomiya Group (Takeda and Masubuchi, 1989), upper Pleistocene Shimosueyoshi Formation (Imaizumi, 1959; Kato and Koizumi, 1992) and the middle and upper Pleistocene Shimosa Group (Fukuda, 1971; Fukuda and Fukuda, 1969a, 1969b, 1973, 1976; O'hara *et al.*, 1976; Aiba *et al.*, 1997).

The Shimosa Group distributed in Chiba and Ibaraki Prefectures yields fragmentary decapod crustacean remains in association with other various marine fossils. Fukuda (1971) and Fukuda and Fukuda (1969a, 1969b, 1973) discussed the paleoecology and taphonomy of decapods with regards to the "peeling"-damaged gastropods presumably caused by predatory crab *Calappa lophos* (Herbst, 1785), and crabs exhibiting the parasitism attributable to a bopyrid isopod, from the Kioroshi Formation, Shimosa Group in Chiba City. Aiba *et al.* (1997) reported a cluster of *Cancer gibbosulus* (de Haan) from the Higashiyatsu Formation of the Shimosa Group and considered it to have been an ovigerous female community buried in the sand layer

of turbidite.

Despite these various fossil records, very few attempts except for O'hara *et al.* (1976) have so far been made concerning a taxonomic study of the decapod fauna from the Shimosa Group. The reason for this disregard is that almost all of the decapod remains obtained from the Shimosa Group are isolated fingers of chelae and/or fragmented chelipeds and carapaces making precise taxonomic study extremely difficult.

However, we consider that the large amount of material now available may provide a more reliable classification and that it will show the general aspects of the decapod assemblages in the each locality or stratigraphic horizon. The material must exhibit not only the paleoecological and taphonomic information concerning the decapods, but implies the geological and paleoenvironmental signification in the study of the Shimosa Group.

The purpose of this paper is to describe the decapod species obtained from 15 localities of the middle and upper Pleistocene Shimosa Group, thus providing basic data for future studies of the paleoecology and taphonomy of the Pleistocene decapods of the Paleo-Tokyo Bay.

With the exception of a large number of descriptions on the fossil '*Callianassa*' spe-

cies, previous works on the fossil decapods relying mainly on description of fingers or chelae are relatively few (Collins *et al.*, 1996; Collins and Portell, 1998; Förster, 1979a, 1979b; Holthuis, 1949; Karasawa and Tanaka, 1994).

Material

About 2000 specimens, mostly limb fragments, were collected by Mr. Tadashi Asada during the late 1970's and 1980's, from 15 localities of the Shimosa Group (Fig. 1, 2). Most of them were sieved from shelly, medium- to fine-grained sands. Unfortunately the collecting was, in general, arbitrary and quantitative studies were impossible. All the specimens are deposited in the Natural History Museum and Institute, Chiba (CBM-PI 00255-00434) or the Mizunami Fossil Museum (MFM 142200-142301).

We compared these fossil remains with the recent decapod species mainly inhabiting the waters around the Boso Peninsula, which are deposited in the Natural History Museum

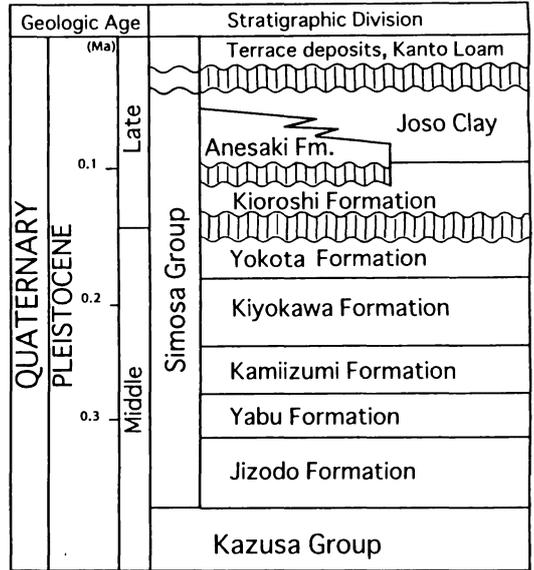


Fig. 2. Stratigraphic divisions of the Shimosa Group in the study area. Modified after Tokuhashi and Kondo (1989).

and Institute, Chiba (CBM-ZC collection).

In many cases there are almost complete

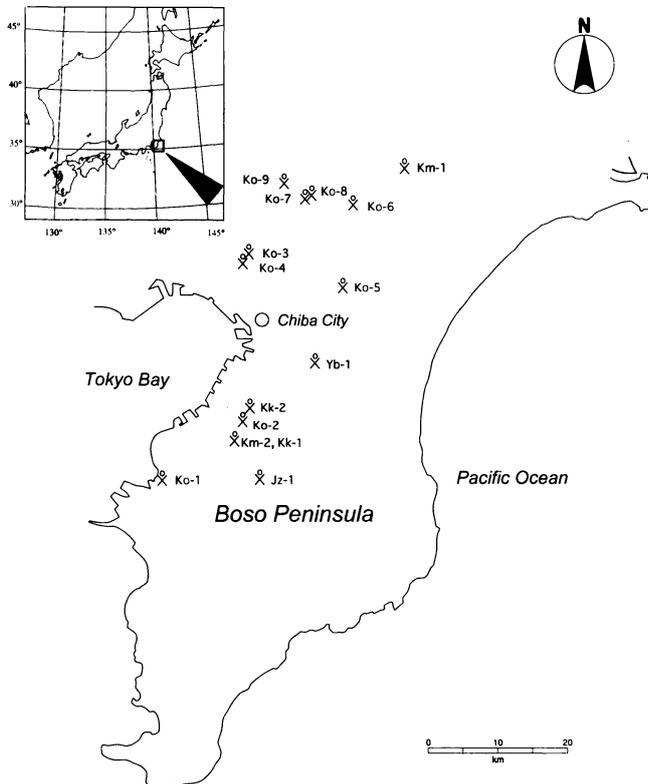


Fig. 1. The study area and the fossil localities.

coincidences between the fossil and Recent material in detailed features such as the arrangement of granules, tubercles, spines, setal pits and teeth of the occurrent margins of the fingers. However, sufficient diagnostic characters are not always found based solely on the fingers or chelae for identification at the species level. In addition, the plasticity of chelae has been pointed out by many authors (e.g. Smith and Palmer, 1994; Rebach and Wowor, 1997). Therefore, we deferred the determination of the species in the most of present collection; if we were not able to identify them at the species and/or genus level, we tried to determine the family of almost all the material on the basis of the general features.

Localities and Horizons

- Jz-1: Left cliff of Izumigawa River, Atebi, Mariyatsu, Kisarazu City, Chiba Pref. 35°21'24"N, 140°5'28"E (Jizodo Formation). The same as 'Atebi' in Itoigawa *et al.* (1978).
- Yb-1: Cliff at Sematanoseki, Ochishinden, Ichihara City, Chiba Pref. 35°31'32"N, 140°13'47"E (Yabu Formation).
- Km-1: Sand quarry at Maebayashi, Taiemachi, Katori-gun, Chiba Pref. 35°47'40"N, 140°26'4"E (Kamiizumi Formation).
- Km-2: Sand quarry at Nagayoshi, Sodegaura City, Chiba Pref. 35°25'11"N, 140°3'32"E (Kamiizumi Formation). The same as 'Kamiizumi I' in Itoigawa *et al.* (1978) and as 'Bed No. A' in Sato and Shimoyama (1992).
- Kk-1: Ditto. 7.5 m above the Kk-2 (Kiyokawa Formation). The same as 'Kamiizumi V' in Itoigawa *et al.* (1978) and as 'Bed No. F' in Sato and Shimoyama (1992).
- Kk-2: Sand quarry at Hikita, Ichihara City, Chiba Pref. 35°27'N, 140°6'E (Kiyokawa Formation).
- Ko-1: Cliff at Sakurai, Kisarazu City, Chiba Pref. 35°21'30"N, 139°55'21"E (Kioroshi Formation). The same as 'Loc. 2' in O'hara *et al.* (1976).
- Ko-2: Cliff at Toyonari, Ichihara City, Chiba Pref. 35°26'40"N, 140°4'43"E (Kioroshi Formation). The same as 'Toyonari' in Itoigawa *et al.* (1978).

- Ko-3: Right cliff of the Hanamigawa River, Shimoyokodo, Yokodo-cho, Hanamigawa-ku, Chiba City, Chiba Pref. 35°41'51"N, 140°6'53"E (Kioroshi Formation).
- Ko-4: Left side of the Hanamigawa River, near the Kashiwai-bashi Bridge, Kashiwai-cho, Hanamigawa-ku, Chiba City, Chiba Pref. 35°41'15"N, 140°6'35"E (Kioroshi Formation).
- Ko-5: Cliff at Yatou-cho, Wakaba-ku, Chiba City, Chiba Pref. 35°38'24"N, 140°13'13"E (Kioroshi Formation).
- Ko-6: Hiyoshikura, Tomisato-machi, Inba-gun, Chiba Pref. 35°45'13"N, 140°19'41"E (Kioroshi Formation).
- Ko-7: Cliff at Otake, Inba-mura, Inba-gun, Chiba Pref. 35°47'17"N, 140°13'35"E (Kioroshi Formation).
- Ko-8: Cliff at Yoshitaka, Inba-mura, Inba-gun, Chiba Pref. 35°47'5"N, 140°14'12"E (Kioroshi Formation).
- Ko-9: Cliff at Wadayatsu, Inba-mura, Inba-gun, Chiba Pref. 35°47'50"N, 140°12'33"E (Kioroshi Formation).

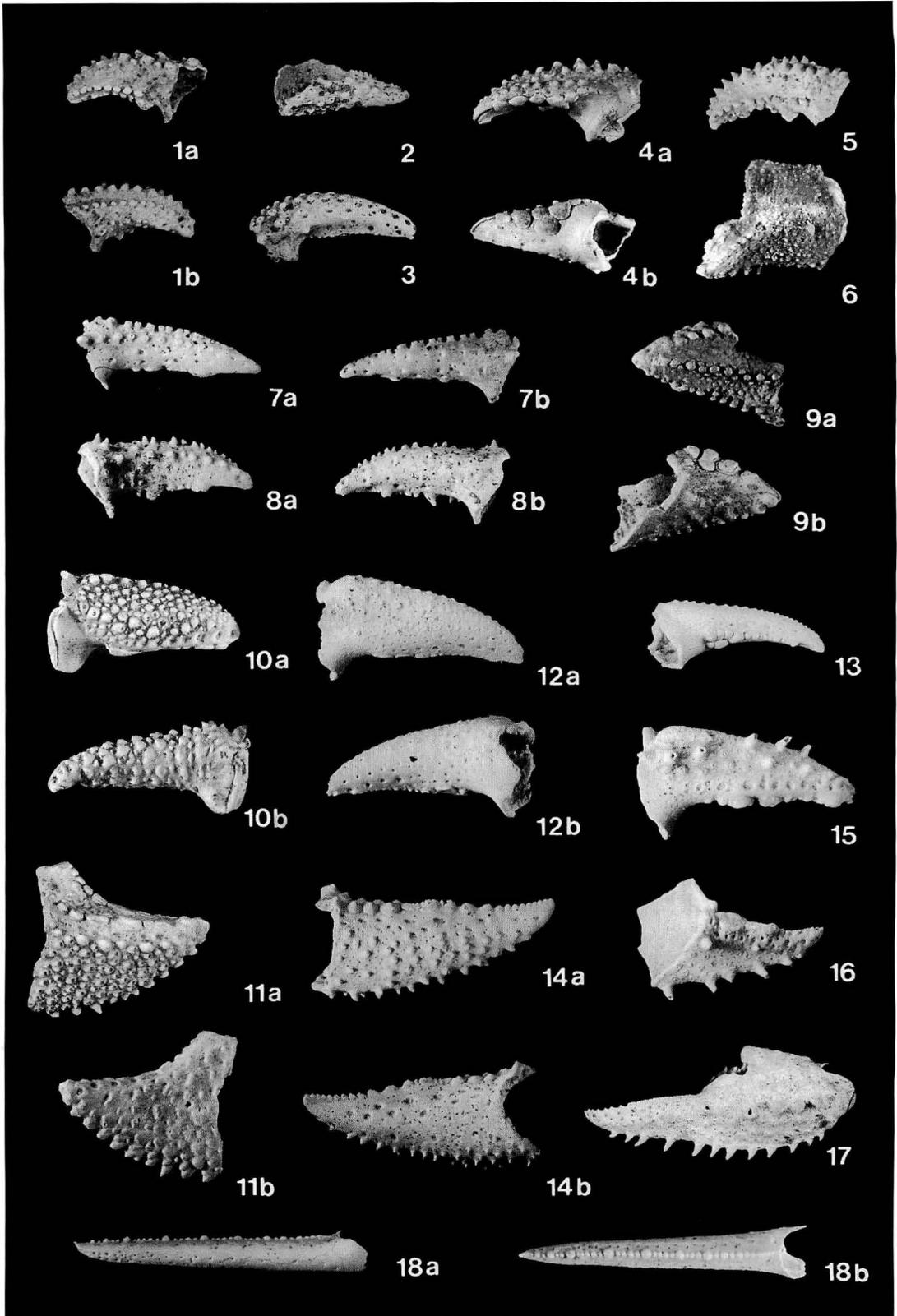
Systematic Descriptions

The fossil record is based mainly on the specimens from the Holocene Nanyo Formation (Tokai Fossil Society, 1977), the upper Pleistocene Kioroshi Formation, Shimosa Group (O'hara *et al.*, 1976), the upper Pleistocene Shimosueyoshi Formation (Kato and Koizumi, 1992), and the middle Pleistocene Toyohashi Formation, Atsumi Group (Karasawa and Tanaka, 1994; Karasawa and Goda, 1996). Only the literature other than these papers is cited for the fossil record under each taxon.

Infraorder THALASSINIDEA Superfamily Thalassinoidae Family Ctenochelidae? Genus *Ctenocheles*?

Ctenocheles? sp. (Pl. 1. 18)

A fixed finger of the minor cheliped which is assignable to this genus is transversely oblong in the cross section and almost straight except for the slightly upwardly directed tip. The beads-like teeth, the every



three to five of which are larger than others, are evenly arranged on the occudent margin.

Material. CBM-PI 00287.

Locality. Ko-1.

Family Callianassidae
Genus *Neocallichirus*

Neocallichirus grandis

Karasawa and Goda, 1996

(Pl. 2. 7–16)

Fingers of the major and minor chelipeds and meri of the major cheliped are the most dominant elements among many localities.

Material. CBM-PI 00274, 00277, 00288, 00340, 00347, 00369, 00379, 00399, 00409; MFM 142215, 142259, 142262, 142279, 142285.

Localities. Km-2; Kk-1; Ko-1, Ko-2, Ko-3, Ko-4, Ko-5, Ko-7, Ko-8.

Fossil record. Toyohashi Formation (middle Pleistocene), Shimosueyoshi Formation (upper Pleistocene), Nanyo Formation (Holocene).

Genus *Callianassa*

'*Callianassa*' sp.

(Pl. 2. 1–4)

A few small fingers which are comparable with those of the genus *Callianassa*, were obtained among several localities. Considering Manning and Felder's (1991) remarks concerning the restriction of *Callianassa* (*sensu stricto*), it may as well avoid the use of the name of this taxon here.

Material. CBM-PI 00268, 00289, 00344, 00416; MFM 142206, 142216.

Localities. Kk-2; Ko-1, Ko-2, Ko-9.

Infraorder ANOMURA
Superfamily Paguroidea
Family Diogenidae
Genus *Diogenes*

Diogenes* sp. cf. *D. edwardsii

(de Haan, 1849)

(Pl. 1. 1–3, 5–6)

Fingers and chelae referable to the present species occurred in many localities. The chelae of the present species closely resemble those of *D. spinifrons* (de Haan, 1849). However the major chela of *D. edwardsii* is distinguished from that of *D. spinifrons* in having rows of more strong tubercles on the upper part of the dactylus and a smooth outer surface of the manus to which part the anemones adhere.

Material. CBM-PI 00267, 00345, 00368, 00378, 00384, 00415; MFM 142260, 142273, 142278.

Localities. Kk-2; Ko-3, Ko-4, Ko-5, Ko-6, Ko-9.

Fossil record for the species. Nanyo Formation (Holocene: Umemoto and Tanaka, 1993).

Genus *Dardanus*

Dardanus* sp. cf. *D. impressus

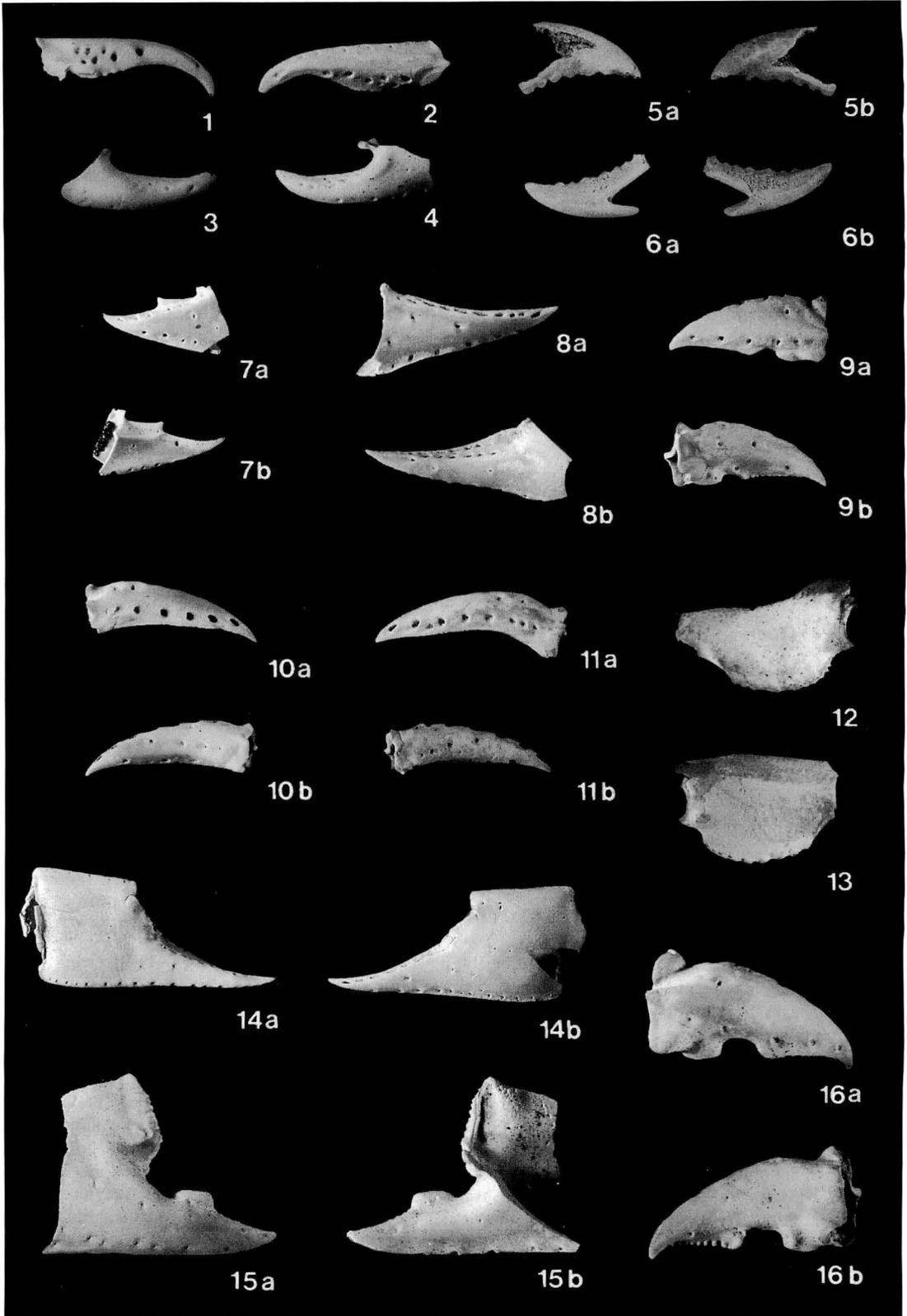
(de Haan, 1849)

(Pl. 1. 4, 9)

Dactyli and fixed fingers of the major cheli-

Pl. 1

1–3, 5–6. *Diogenes* sp. cf. *D. edwardsii* (de Haan). 1: dactylus of the left major cheliped. ×3.5. CBM-PI 00368. a, outer; b, inner view. 2: fixed finger of the right minor cheliped. ×3.5. CBM-PI 00267. outer view. 3: dactylus of the right minor cheliped. ×3.5. CBM-PI 00267. outer view. 5: dactylus of the left major cheliped. ×4.0. CBM-PI 00378. outer view. 6: manus of the left major cheliped. ×5.0. CBM-PI 00345. outer view. 4, 9. *Dardanus* sp. cf. *D. impressus* (de Haan). 4: dactylus of the left major cheliped. ×2.0. CBM-PI 00283. a, outer; b, lower view. 9: fixed finger of the left major cheliped. ×2.0. CBM-PI 00283. a, outer; b, inner view. 7–8. *Pagurus* sp. cf. *P. pectinatus* (Stimpson). 7 and 8: dactyli of the right major chelipeds. ×5.0. CBM-PI 00257. a, outer; b, inner view. 10–11. *Pagurus* sp. cf. *P. similis* (Ortmann). 10: dactylus of the right major cheliped. ×3.0. CBM-PI 00284. 11: fixed finger of the right major cheliped. ×3.0. CBM-PI 00284. a, outer; b, inner view. 12–14. *Pagurus* sp. cf. *P. megalops* (Stimpson). 12, 13: dactyli of the right major chelipeds. ×5.0. CBM-PI 00286. 12a, outer; 12 b, inner; 13, lower view. 14: fixed finger of the right major cheliped. ×5.0. CBM-PI 00286. a, outer; b, inner view. 15–17. *Pagurus* sp. cf. *P. constatus* (Stimpson). CBM-PI 00285. outer view. 15: dactylus of the right major cheliped. ×5.0. 16: fixed finger of the right major cheliped. ×5.0. 17: manus of the left minor cheliped. ×3.0. 18. *Ctenocheles?* sp. Fixed finger of the left minor cheliped. ×3.5. CBM-PI 00287. a, outer; b, upper view.



ped were obtained. The stout dactylus bears four rows of strongly pointed tubercles on the outer and upper surfaces. The fixed finger bears three rows of tubercles separated by deep, wide grooves on the outer surface. The occludent surfaces of both fingers are paved with subconical to irregular shaped, flattened large teeth.

Material. CBM-PI 00283; MFM 142211.

Locality. Ko-1.

Family Paguridae

Genus *Pagurus*

Pagurus sp. cf. *P. similis*

(Ortmann, 1892a)

(Pl. 1. 10–11)

A few dactyli and fixed fingers were obtained from Ko-1. The outer and upper surfaces of the dactylus of the major cheliped are covered with tubercles of various size, and the occludent surfaces are armed with two or three rows of flattened subconical teeth.

Material. CBM-PI 00284; MFM 142212.

Locality. Ko-1.

Pagurus sp. cf. *P. constatus*

(Stimpson, 1858b)

(Pl. 1. 15–17)

The fingers and chelae were obtained from Ko-1 and Yb-1. Two longitudinal rows of acute spines occur on the outer and upper surfaces of the dactylus. There are two rows of spines on the outer surface and lower margin of the fixed finger. Dactylus and fixed finger of the right major cheliped have clusters of conical teeth on the occludent surfaces, while in the minor cheliped the fixed finger has a finely serrated occludent margin.

Material. CBM-PI 00256, 00285; MFM

142200, 142213.

Localities. Yb-1; Ko-1.

Pagurus sp. cf. *P. pectinatus*

(Stimpson, 1858b)

(Pl. 1. 7–8)

A small number of right major dactyli were obtained. The upper surface is ornamented with two longitudinal rows of pointed tubercles. The occludent margin is armed with large distal and proximal teeth, with small conical teeth between them two; the spooned tip is lined with hollow of the corneous teeth.

Material. CBM-PI 00257; MFM 142201.

Locality. Yb-1.

Pagurus sp. cf. *P. megalops*

(Stimpson, 1858b)

(Pl. 1. 12–14)

A few dactyli and fixed finger of the right major chelipeds were obtained. The upper surface of the dactylus is bounded by two longitudinal rows of granules. The occludent margin is armed with a row of conical teeth which bifurcates into two rows proximally; the distal part shows a wide hollow of corneous teeth. The outer surface of the fixed finger bears distally pointed tubercles.

Material. CBM-PI 00286; MFM 142214.

Locality. Ko-1.

Infraorder BRACHYURA

Superfamily Doromioidea

Family Dromiidae

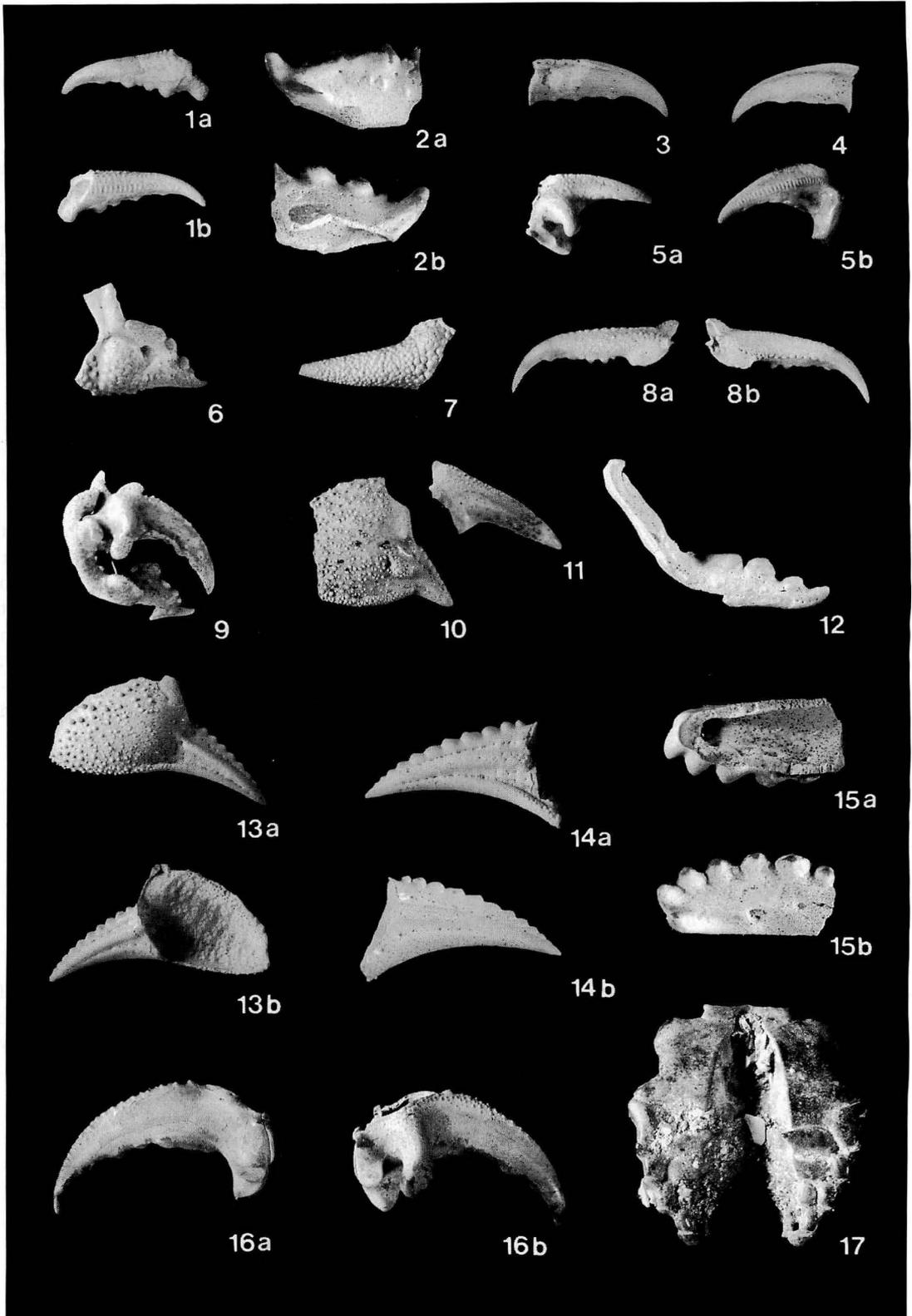
Dromiidae gen. et sp. indet. 1

(Pl. 3. 2, 12, 15)

A few strongly calcified distal portions of fingers representing an interlock structure were obtained. The dactylus is strongly

Pl. 2

1–4. '*Callianassa*' sp. 1 and 2: dactyli of the right and left chelipeds. 3 and 4: fixed fingers of the right and left chelipeds. $\times 4.5$. CBM-PI 00289. outer view. 5–6. Dromiidae gen. et sp. indet. 2. 5: dactylus of the right cheliped. 6: fixed finger of the left cheliped. $\times 3.5$. CBM-PI 00291. a, outer; b, inner view. 7–16. *Neocallichirus grandis* Karasawa and Goda. 7 and 15: fixed fingers of the left and right major chelipeds. $\times 2.0$. CBM-PI 00288. a, outer; b, inner view. 8: fixed finger of the right minor cheliped. $\times 2.0$. CBM-PI 00288. a, outer; b, inner view. 14: manus of the left minor cheliped. $\times 2.0$. CBM-PI 00288. a, inner; b, outer view. 9 and 16: dactyli of the left and right major chelipeds. $\times 2.5$. CBM-PI 00288. a, outer; b, inner view. 10 and 11: dactyli of the right and left minor chelipeds. $\times 2.5$. CBM-PI 00288. a, outer; b, inner view. 12: merus of the left major cheliped. $\times 2.5$. CBM-PI 00399. outer view. 13: merus of the right major cheliped. $\times 2.5$. CBM-PI 00379. outer view.



curved inward and armed with large, triangular teeth on the occulcent margin. The fixed finger is straight except for an upwardly curved tip. Sparse granules occupy the outer surface, and four conical teeth are on the occulcent margin of the finger.

Material. CBM-PI 00290; MFM 142217.

Locality. Ko-1.

Dromiidae gen. et sp. indet. 2

(Pl. 2. 5–6)

Another species belonging to the Dromiidae is apparently smaller than the former. The tips of the dactylus and fixed finger were separated from the less calcified other parts of fingers, and the boundaries show a v-shape indentation.

Material. CBM-PI 00291.

Locality. Ko-1.

Superfamily Raninoidea

Family Raninidae

Genus *Lyreidus*

***Lyreidus* sp.**

(Pl. 3. 3–4)

Several dactyli of chelipeds were obtained. They are thin and strongly down-curved; the upper margin is sharply rimed.

Material. CBM-PI 00292; MFM 142218.

Locality. Ko-1.

Superfamily Dorippoidea

Family Dorippidae

Genus *Paradorippe*

Paradorippe* sp. cf. *P. granulata

(de Haan, 1839)

(Pl. 3. 10–11, 13–14)

The dactyli and fixed fingers comparable

with the present species occurred in several localities of the Kioroshi Formation. The present material shows the conspicuous sexual dimorphism in the chelae of this species. The manus has unevenly granulated outer and inner surfaces; the male is strongly tumid near the basal part of the fixed finger. The dactylus of the male cheliped is steeply inclined downward with a cluster of granules on the proximal part of the upper surface. The fixed finger of the female cheliped is strongly arcuated downward; a strong, longitudinal ridge is intercalated by deep, wide grooves on the outer and inner surfaces; the lower margin is thickly rimmed.

Material. CBM-PI 00293, 00348, 00385, 00410, 00417; MFM 142219, 142263, 142274, 142294.

Localities. Ko-1, Ko-3, Ko-6, Ko-8, Ko-9.

Fossil record for the species. Nanyo Formation (Holocene).

Superfamily Calappoidea

Family Calappidae

Genus *Mursia*

***Mursia* sp. cf. *M. armata* de Haan, 1837**

(Pl. 3. 1, 5–7)

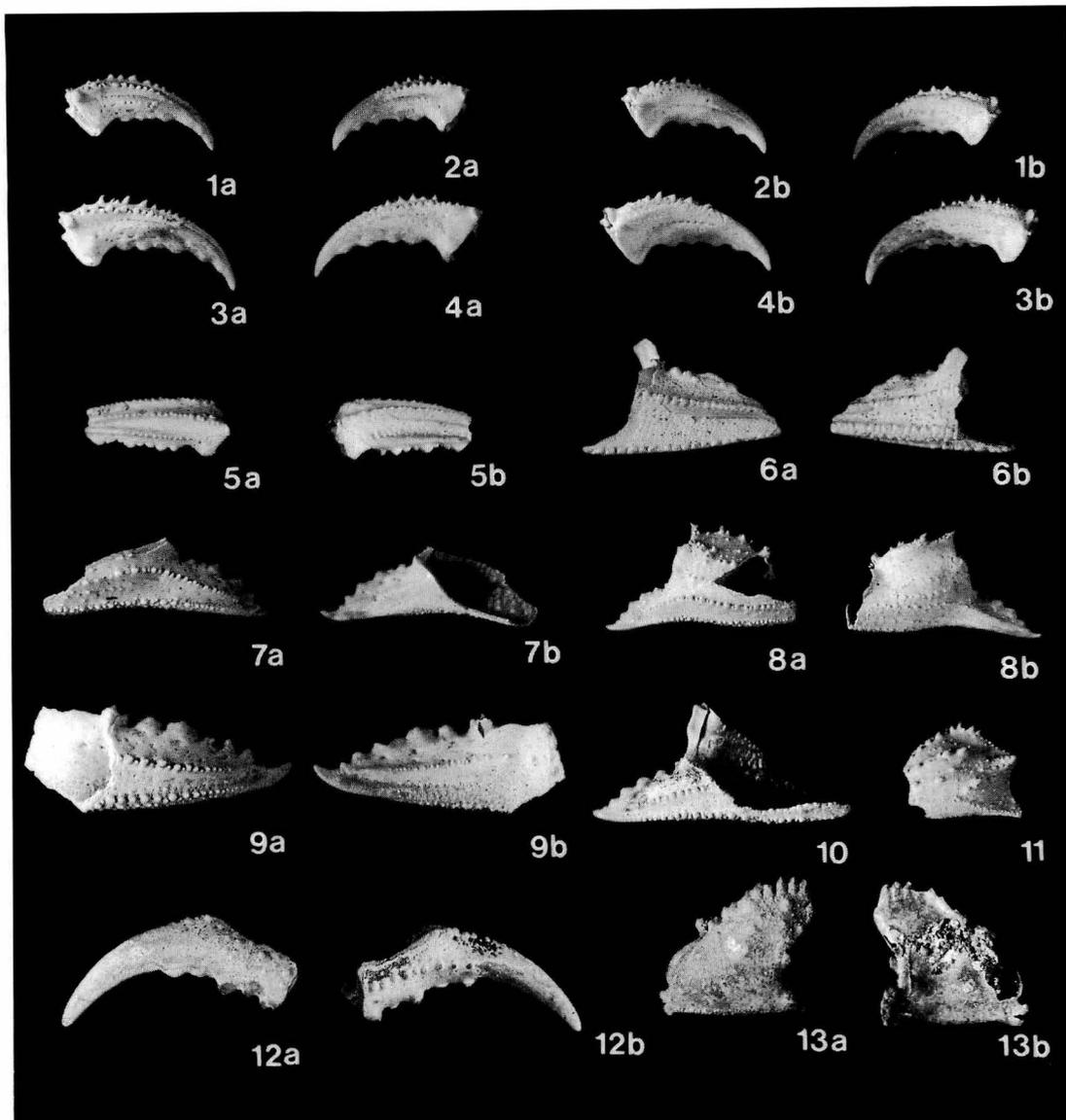
The striation on the longitudinal ridge of the inner surface of dactylus serves to distinguish the fingers of the genus *Mursia* from the other calappid ones. Based on the other fragmented parts of the carapace, the present material may be assignable to this species.

Material. CBM-PI 00294; MFM 142220.

Locality. Ko-1.

Pl. 3

1, 5–7. *Mursia* sp. cf. *M. armata* de Haan. CBM-PI 00294. 1: dactylus of the left cheliped. ×4.0. a, outer; b, inner view. 5: dactylus of the right cheliped. ×4.0. a, outer; b, inner view. 6: fixed finger of the right cheliped. ×3.0. outer view. 7: lateral spine of the carapace. ×2.0. dorsal view. 2, 12, 15. **Dromiidae gen. et sp. indet. 1.** ×2.0. CBM-PI 00290. 2: fixed finger of the left cheliped. a, outer; b, inner view. 12: fixed finger of the right cheliped. outer view. 15: dactylus of the left cheliped. a, upper; b, lower view. 3–4. *Lyreidus* sp. 3 and 4: dactyli of the right and left chelipeds. ×3.5. CBM-PI 00292. outer view. 8–9, 16–17. *Calappa* spp. 8: dactylus of the left cheliped. ×2.0. CBM-PI 00295. a, outer; b, inner view. 9: right chela. ×2.5. CBM-PI 00295. outer view. 16: dactylus of the right cheliped. ×1.0. CBM-PI 00295. a, inner; b, outer view. 17: thoracic sternum. ×2.0. CBM-PI 00349. ventral view. 10–11, 13–14. *Paradorippe* sp. cf. *P. granulata* (de Haan). 10 and 11: manus and dactylus of the male right cheliped. ×2.0. outer view. 13: fixed finger of the female right cheliped. ×4.0. a, outer; b, inner view. 14: fixed finger of the left cheliped. ×4.0. a, outer; b, inner view. CBM-PI 00293.



Pl. 4

1-4, 7-11. *Cancer* sp. cf. *C. gibbosulus* (de Haan). CBM-PI 00296. 1 and 3: dactyli of the right chelipeds. $\times 2.5$. a, outer; b, inner view. 2 and 4: dactyli of the left chelipeds. $\times 3.0$. a, outer; b, inner view. 7 and 9: fixed fingers of the right chelipeds. $\times 3.0$. a, outer; b, inner view. 8: manus of the left cheliped. $\times 3.0$. a, outer; b, inner view. 10: fixed finger of the left cheliped. $\times 2.5$. 11: carpus of the right cheliped. $\times 3.0$. outer view. 5-6. *Liocarcinus* sp. cf. *L. corrugatus* (Pennant). 5: dactylus of the left cheliped. 6: fixed finger of the right cheliped. $\times 4.0$. CBM-PI 00297. a, outer; b, inner view. 12-13. *Calappa* spp. 12: dactylus of the left cheliped. $\times 2.0$. CBM-PI 00295. a, outer; b, inner view. 13: manus of the right cheliped. $\times 2.0$. CBM-PI 00349. a, outer; b, inner view.

Genus *Calappa*

Calappa spp.

(Pl. 3. 8-9, 16-17, Pl. 4. 12-13)

The chelae, fingers and fragments of the

carapaces were obtained from several localities of the Kioroshi Formation. The stout fingers seem to have the highest preservable potential, but from only the fingers and few fragmented carapaces, it is difficult to determine the species.

Fukuda (1971) and Fukuda and Fukuda (1969a, 1969b, 1973) reported *C. lophos* (Herbst, 1785) from the Ko-3 and discussed its taphonomy and paleoecology.

Material. CBM-PI 00278, 00295, 00349, 00370, 00386; MFM 142221, 142264.

Localities. Kk-1; Ko-1, Ko-3, Ko-4, Ko-6.

Superfamily Canceroidea

Family Cancridae

Genus *Cancer*

Cancer* sp. cf. *C. gibbosulus

(de Haan, 1833)

(Pl. 4. 1-4, 7-11)

The fingers, chelae and fragments of the carapace are dominant elements at many localities. The upper margin of the propodus bears granulose spines and there are longitudinal rows of spinules on the outer surface.

Material. CBM-PI 00259, 00265, 00275, 00279, 00296, 00341, 00350, 00371, 00380, 00387, 00400, 00418; MFM 142204, 142205, 142222, 142265, 142275, 142286, 142295.

Localities. Yb-1; Km-1, Km-2; Kk-1; Ko-1, Ko-2, Ko-3, Ko-4, Ko-5, Ko-6, Ko-7, Ko-9.

Fossil records for the species. Toyohashi Formation (middle Pleistocene), Higashiya-tsu Formation (middle Pleistocene: Aiba *et al.*, 1997), Nanyo Formation (Holocene) and Kioroshi Formations (Ko-1).

Superfamily Portunoidea

Family Portunidae

Genus *Liocarcinus*

Liocarcinus* sp. cf. *L. corrugatus

(Pennant, 1777)

(Pl. 4. 5-6)

A left dactylus and right fixed finger were obtained from Ko-1. The dactylus is ornamented with three strongly granulated, sharp, longitudinal ridges; two on the outer surface and one on the upper margin. The grooves between the ridges are deep and broad with dense, microscopic setal pits. The inner surface is ornamented with two granulated ridges. The transverse section is rectangular to pentagonal. The outer surface of right fixed finger is also ornamented with two sharp, granulated longitudinal ridges.

The depression between the ridges is deep and wide with dense, microscopic setal pits. Two ridges on the inner surface and the lower margin of the fixed finger show squamiform surfaces protruded by gathered large granules.

Material. CBM-PI 00297.

Locality. Ko-1.

Genus *Charybdis*

***Charybdis* sp.**

(Pl. 5. 7)

Dactyli of the left and right chelipeds were obtained from Ko-1. They are strongly calcified with stout, acutely pointed tips. Deep, distinct grooves on the outer surface nearly reach the tip. The basal part of the ridges near the upper margin is decorated with sparse granules. There are three distinct, long grooves on the inner surface. The basal part of the occuldent margin of the left dactylus is armed with a molar-like tooth.

These features resemble those of *Charybdis* (*Charybdis*) *granulata* de Haan, 1833, *C. (C.) natator* (Herbst, 1794) or *C. (Goinohellenus) truncata* (Fabricius, 1798), but exact specific assignment is impossible.

Material. CBM-PI 00299; MFM 142225.

Locality. Ko-1.

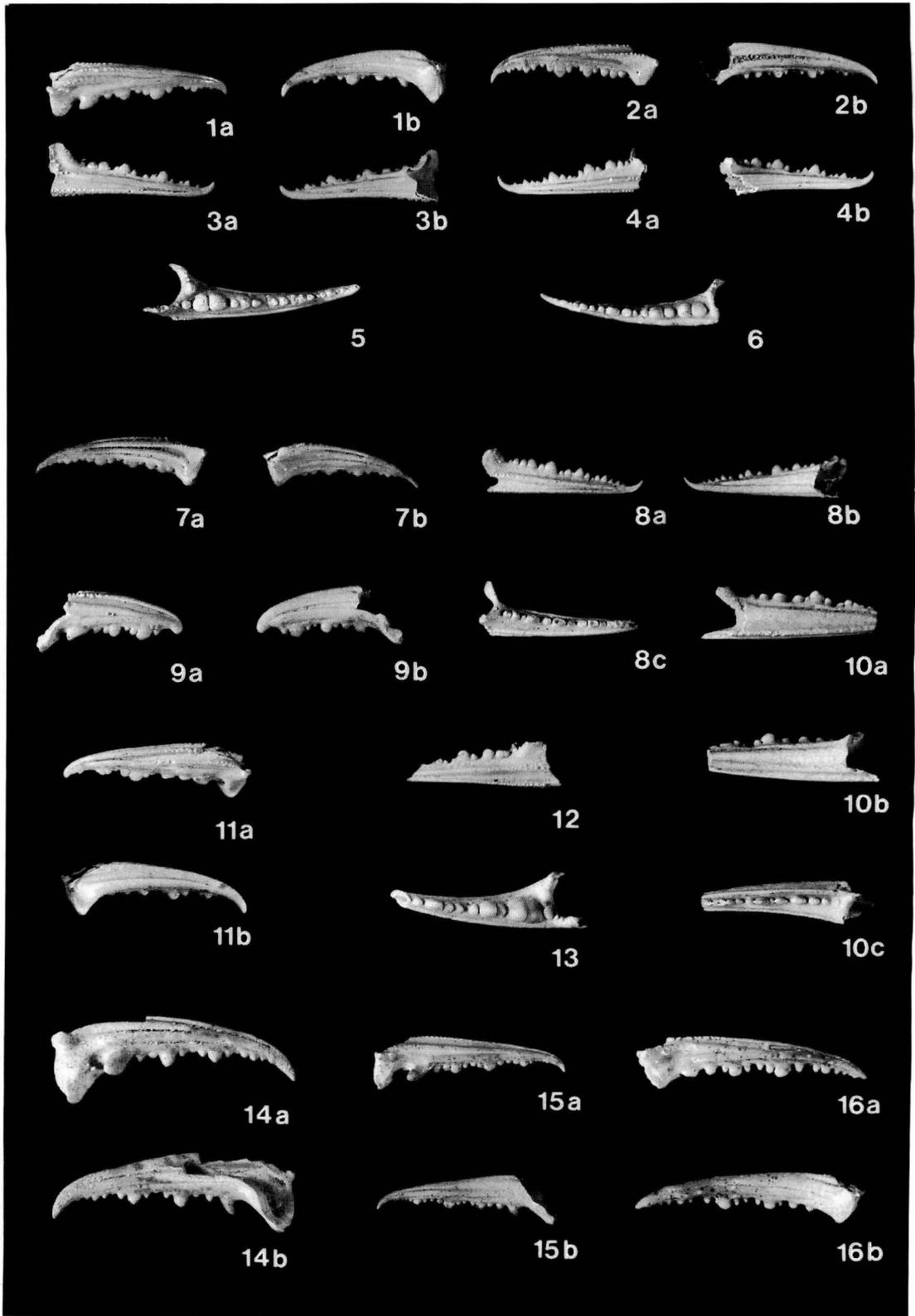
Subgenus *Gonioneptunus*

***Charybdis* (*Gonioneptunus*) sp. cf.**

***C. (G.) bimaculata* (Miers, 1886)**

(Pl. 5. 1-6)

A large number of dactyli and fixed fingers were obtained. The fingers are relatively small and slender for the genus. The dactylus is gently curved downward. Two longitudinal grooves defined by three ridges are arranged on the outer surface; the upper one reaches a strongly calcified tip, while the lower one terminates more proximally than the longitudinal midpoint; there is a deep, wide groove on the upper surface. Granules are longitudinally arranged on the proximal portion of the ridges, especially on the upper two. The basal portion of the occuldent margin of the right dactylus bears a large, molar-shaped tooth, which is absent on the left dactylus. Three deep, narrow longi-



tudinal grooves line the inner surface; the uppermost is very short; the lower two reach a strongly calcified tip. The fixed fingers are almost straight except for the upwardly curved tip. The basal part of the occudent margin of the right fixed finger consists of two transversally arranged, small teeth proximally, followed by, two longitudinally arranged, large, conical, molar-shaped teeth. The left fixed finger lacks such crushing structure, but bears relatively pointed teeth on the occudent margin.

Material. CBM-PI 00298, 00419; MFM 142224.

Localities. Ko-1, Ko-9.

Fossil record for the species. Shimosueyoshi Formation (upper Pleistocene).

Portunidae gen. et sp. indet. 1

(Pl. 5. 15)

A right dactylus is relatively straight; the largest, lowermost groove nearly reaches a strongly calcified tip. These features of grooves and strongly granulated ridges resemble those of *Portunus gladiator* Fabricius, 1798.

Material. CBM-PI 00300.

Locality. Ko-1.

Portunidae gen. et sp. indet. 2

(Pl. 5. 9)

We could not find comparable species with a stumpy right dactylus which was obtained from Ko-1. It may be a partially regenerated.

Material. CBM-PI 00301.

Locality. Ko-1.

Portunidae gen. et sp. indet. 3

(Pl. 5. 12–13)

The left fixed fingers resemble those of *Charybdis (Gonioneptunus) bimaculata*. However, they are armed with conical crushing teeth like those, *C. (G.) bimaculata* normally has on the right fixed finger. The present left fixed finger is wider than those of *C. (G.) bimaculata*.

Material. CBM-PI 00302; MFM 142226.

Locality. Ko-1.

Portunidae gen. et sp. indet. 4

(Pl. 5. 11)

The left dactylus is almost coincident with those of the *C. (G.) bimaculata* except for having a large molar-like tooth proximally on the occudent margin.

Material. CBM-PI 00303; MFM 142227.

Locality. Ko-1.

Portunidae gen. et sp. indet. 5

(Pl. 5. 16)

This type of dactylus of the right cheliped resembles that of *C. (G.) bimaculata*, but is slightly slender and the lowermost groove on the outer surface is extremely short.

Material. CBM-PI 00304; MFM 142228.

Locality. Ko-1.

Portunidae gen. et sp. indet. 6

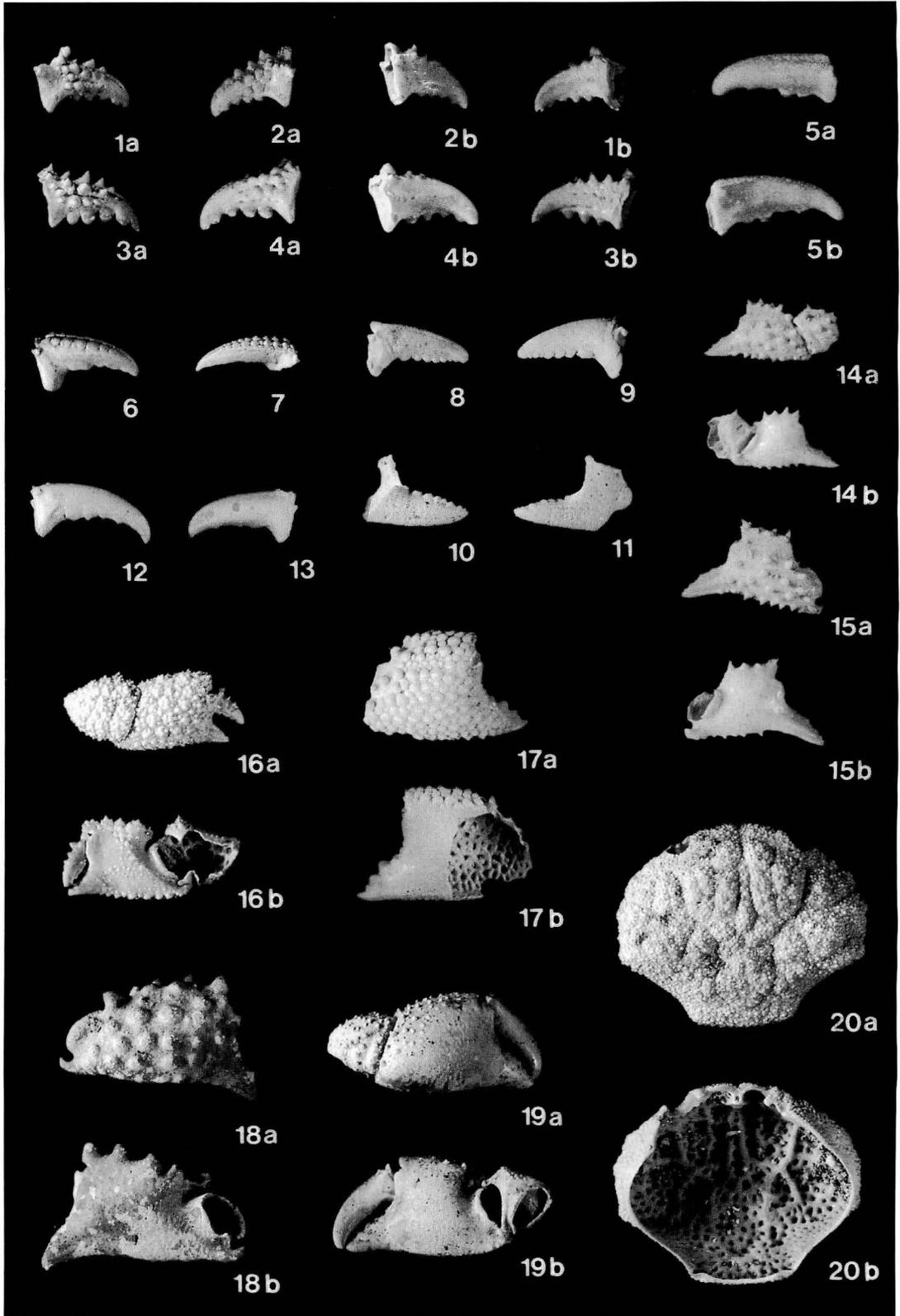
(Pl. 5. 8)

This type of the fixed finger of the right cheliped resembles that of *C. (G.) bimaculata*, but the conical crushing teeth on the basal part are absent.

Material. CBM-PI 00305; MFM 142229.

Pl. 5

1–6. *Charybdis (Gonioneptunus) sp. cf. C. (G.) bimaculata (Miers)*. ×2.0. CBM-PI 00298. 1: dactylus, 3 and 5 : fixed fingers of the right chelipeds. 2: dactylus; 4 and 6: fixed fingers of the left chelipeds. a, outer; b, inner; 5 and 6, upper view. 7. *Charybdis sp.* Dactylus of the left cheliped. ×2.5. CBM-PI 00299. a, outer; b, inner view. 8. *Portunidae gen. et sp. indet. 6*. Fixed finger of the right cheliped. ×2.5. CBM-PI 00305. a, outer; b, inner; c, upper view. 9. *Portunidae gen. et sp. indet. 2*. Dactylus of the right cheliped. ×2.5. CBM-PI 00301. a, outer; b, inner view. 10. *Portunidae gen. et sp. indet. 7*. Fixed finger of the right cheliped. ×2.5. CBM-PI 00306. a, outer; b, inner; c, upper view. 11. *Portunidae gen. et sp. indet. 4*. Dactylus of the left cheliped. ×2.5. CBM-PI 00303. a, outer; b, inner view. 12–13. *Portunidae gen. et sp. indet. 3*. Fixed fingers of the left chelipeds. ×3.0. CBM-PI 00302. 12, outer; 13, upper view. 14. *Portunidae gen. et sp. indet. 8*. Dactylus of the right cheliped. ×2.5. CBM-PI 00307. a, outer; b, inner view. 15. *Portunidae gen. et sp. indet. 1*. Dactylus of the right cheliped. ×2.0. CBM-PI 00300. a, outer; b, inner view. 16. *Portunidae gen. et sp. indet. 5*. Dactylus of the right cheliped. ×2.5. CBM-PI 00304. a, outer; b, inner view.



Locality. Ko-1.

Portunidae gen. et sp. indet. 7

(Pl. 5. 10)

The incomplete fixed finger shows nearly square in the cross section. There is a broad, longitudinal depression between the ridges on the outer surface.

Material. CBM-PI 00306; MFM 142230.

Locality. Ko-1.

Portunidae gen. et sp. indet. 8

(Pl. 5. 14)

The dactylus of the right cheliped is strongly calcified. The lowermost groove on the outer surface extends further than the longitudinal midpoint.

Material. CBM-PI 00307; MFM 142231.

Locality. Ko-1.

Superfamily Xanthoidea

Family Xanthidae

Genus Halimede

Halimede* sp. cf. *H. othodes

(Herbst, 1783)

(Pl. 6. 18)

A manus with an incomplete fixed finger was obtained from Ko-5. The manus is thick and the outer surface is covered with large node-like tubercles which are hemispherical and generally increase in size upward. The fixed finger is bent downward. These features closely resemble the manus of *H. othodes*.

Material. CBM-PI 00381.

Locality. Ko-5.

Genus Actaea

***Actaea semblatae* Guinot, 1976**

(Pl. 6. 1-4, 16, 20)

The carapace and the outer surface of the chela are covered with the characteristic cauliflower-like clustered granules. Specimens are quite outstanding among many localities.

Material. CBM-PI 00281, 00309, 00352, 00373, 00402, 00421; MFM 142210, 142233, 142267, 142281.

Localities. Kk-1; Ko-1, Ko-3, Ko-4, Ko-7, Ko-9.

Fossil record. Toyohashi Formation (middle Pleistocene), Nanyo Formation (Holocene) and Kioroshi Formation (Ko-1).

Genus Macromedaeus

Macromedaeus* sp. cf. *M. distinguendus

(de Haan, 1835)

(Pl. 6. 5)

A dactylus was obtained from Ko-1. It is moderately arcuate; the upper surface forms three longitudinal keels proximally, which have coarse surfaces and taper distally. The occulcent margin bears four conical teeth and a spoon-shaped tip.

Material. CBM-PI 00313, 00389.

Localities. Ko-1, Ko-6.

Fossil record. Nanyo Formation (Holocene).

Family Pilumnidae

Genus Pilumnus

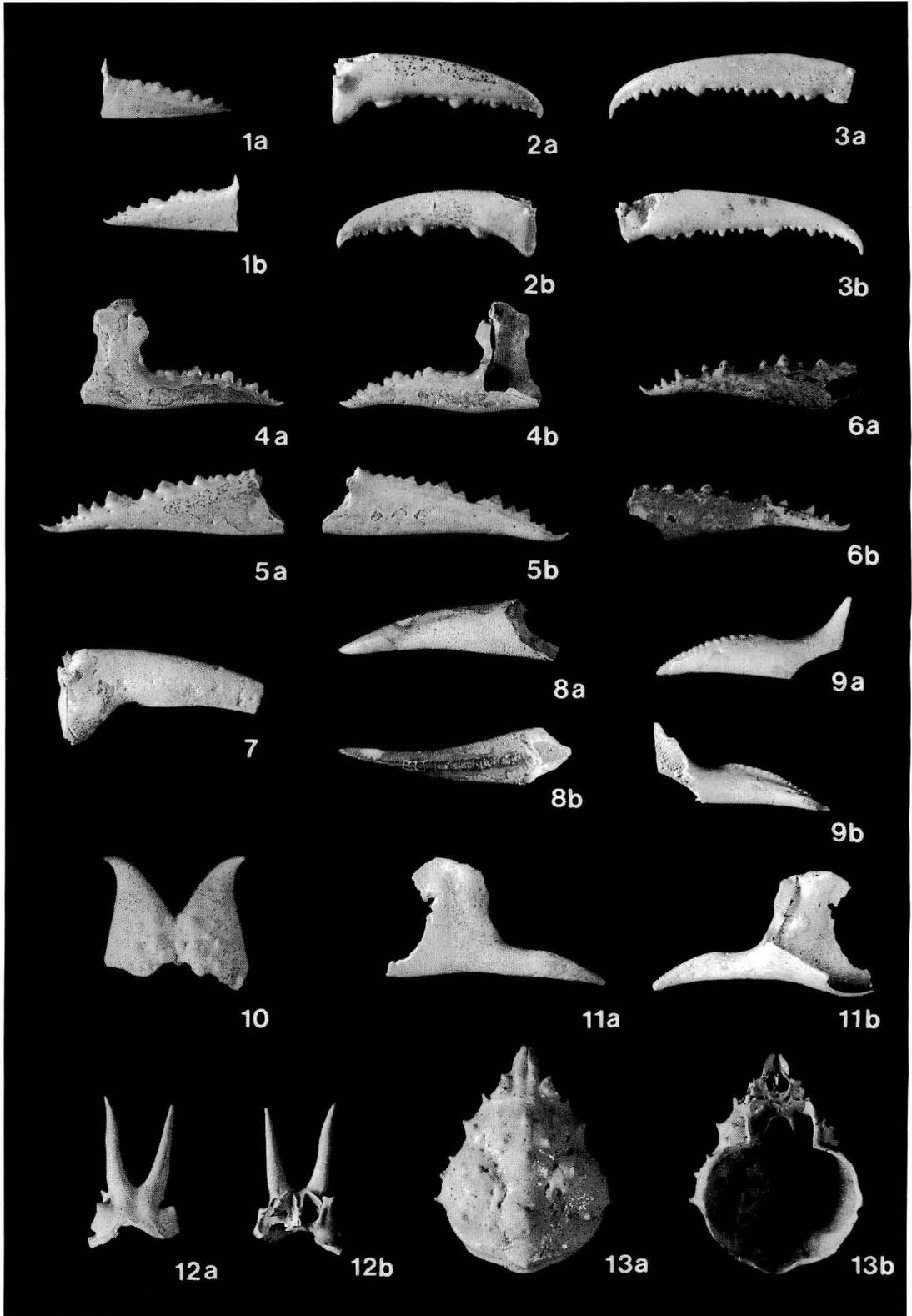
***Pilumnus* sp.**

(Pl. 6. 14-15)

The chelae have a spinose outer surface of

Pl. 6

1-4, 16, 20. *Actaea semblatae* Guinot. 1 and 3: dactyli of the right chelipeds. ×3.0. CBM-PI 00309. a, outer; b, inner view. 2 and 4: dactyli of the left chelipeds. ×3.0. CBM-PI 00309. a, outer; b, inner view. 16: right chela. ×3.0. CBM-PI 00309. a, outer; b, inner view. 20: carapace. ×2.0. CBM-PI 00352. a, dorsal; b, ventral view. 5. *Macromedaeus* sp. cf. *M. distinguendus* (de Haan). Dactylus of the left cheliped. ×3.0. CBM-PI 00313. a, outer; b, inner view. 6-7, 17. *Actumnus* sp. cf. *A. squamosus* (de Haan). CBM-PI 00310. 6 and 7: dactyli of the right and left chelipeds. ×3.0. outer view. 17: right chela. ×4.0. a, outer; b, inner view. 8-11. *Xanthoidea* fam. gen. et sp. indet. 1. 8 and 9: dactyli of the right and left chelipeds. 10 and 11: fixed fingers of the right and left chelipeds. ×3.5. CBM-PI 00314. outer view. 12-13, 19. *Pilumnidae* gen. et sp. indet. CBM-PI 00312. 12 and 13: dactyli of the right and left chelipeds. ×4.0. outer view. 19: right chela. ×2.5. a, outer; b, inner view. 14-15. *Pilumnus* sp. 14 and 15: left chelae. ×4.0. CBM-PI 00311. a, outer; b, inner view. 18. *Halimede* sp. cf. *H. othodes* (Herbst). Manus of the right cheliped. ×1.5. CBM-PI 00381. a, outer; b, inner view.



the manus and carpus. These features and the shape of the fixed finger resemble those of *P. minutus* de Haan, 1833, *P. dofleini* Balss, 1933 and *P. orbitospinis* Rathbun, 1911. However, the above mentioned features are common in this genus, therefore specific assignment is impossible.

Material. CBM-PI 00311; MFM 142235.

Locality. Ko-1.

Genus *Actumnus*

Actumnus* sp. cf. *A. squamosus

(de Haan, 1835)

(Pl. 6. 6-7, 17)

A propodus covered with squamiform tubercles was obtained from Ko-1. The proximal part of the upper surface of the dactylus is ornamented with two or three rows of similar tubercles.

Material. CBM-PI 00310; MFM 142234.

Locality. Ko-1.

Pilumnidae gen. et spp. indet.

(Pl. 6. 12-13, 19)

The chelae are less spinose than those of *Pilumnus* sp. The tubercles are dense in the upper part of the outer surface of the manus; the lower margin is fringed by faint granules. There is a small cluster of granules on the proximal part of the upper surface of the dactylus. Two extremely different size groups were discriminated.

Material. CBM-PI 00312, 00382, 00422; MFM 142236.

Localities. Ko-1, Ko-5, Ko-9.

Family Menippidae?

Genus *Ozius*?

***Ozius*? spp.**

Poorly preserved, extremely short fixed

fingers with sharp grooves on the outer surface were obtained.

Material. CBM-PI 00374, 00403.

Localities. Ko-4, Ko-7.

Family Goneplacidae

Genus *Ommatocarcinus*

Ommatocarcinus* sp. cf. *O. macgillivrayi

White, 1852

(Pl. 7. 1-6)

Considerable numbers of relatively ill preserved fingers most resemble those of the *Ommatocarcinus macgillivrayi*. Since *O. macgillivrayi* shows apparent sexual dimorphism in their chelae, we considered the long, stout and slightly sinuous fingers with largely projected teeth on the occuldent margins as those of males, and relatively short one with rather blade-shaped teeth as those of females. Although the arrangement of the teeth on the occuldent margins closely resembles that of *O. macgillivrayi* in both sexes, size of the teeth and shape of the apex of fingers are slightly different between the present fossil and the examined Recent material.

Material. CBM-PI 00316; MFM 142239.

Locality. Ko-1.

Fossil record for the species. Australia (Pliocene and Holocene: Jenkins, 1975), Taiwan (upper Pliocene and Pleistocene: Hu and Tao, 1996).

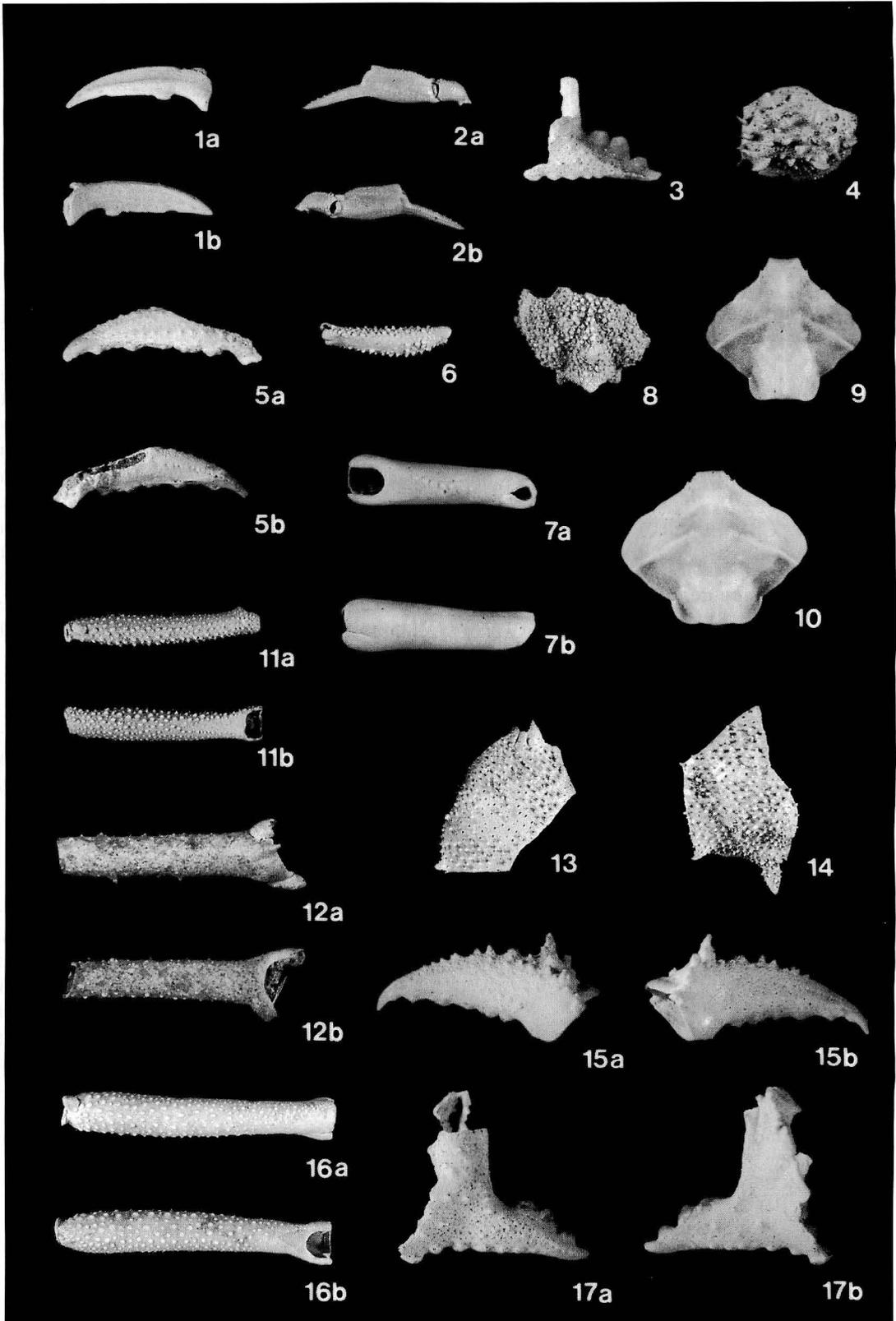
Fam. gen. et sp. indet. 1

(Pl. 6. 8-11)

Fingers that seems to be assignable to Xanthoidea were obtained from several localities. They are relatively short and show coarse surfaces. There is an inconspicuous row of pits on the upper part of the outer surface of the dactylus. The teeth on the occuldent margin are conical and diminish in size dis-

Pl. 7

1-6. *Ommatocarcinus* sp. cf. *O. macgillivrayi* White. CBM-PI 00316. a, outer; b, inner view. 1: fixed finger of the right cheliped. $\times 3.0$. 2: dactylus of the right cheliped. $\times 2.0$. 3: dactylus of the left cheliped. $\times 1.5$. 4: fixed finger of the right cheliped. $\times 1.5$. 5: fixed finger of the left cheliped. $\times 3.0$. 6: fixed finger of the left cheliped. $\times 1.5$. 7-8. *Leptomithrax* sp. cf. *L. edwardsii* (de Haan). $\times 3.0$. CBM-PI 00318. 7: dactylus of the right cheliped. outer view. 8: fixed finger of the left cheliped. a, outer; b, upper view. 9, 11-12. *Hyastenus* spp. $\times 2.0$. CBM-PI 00319. 9 and 11: fixed fingers of the left and right chelipeds. a, outer; b, inner view. 12: rostrum. a, dorsal; b, ventral view. 10. *Micippa* sp. cf. *M. thalia* (Herbst). Rostrum. $\times 5.0$. CBM-PI 00320. dorsal view. 13. *Pisoides ortomanni* (Balss). Carapace. $\times 3.0$. CBM-PI 00317. a, dorsal; b, ventral view.



tally. The fixed finger is rather short; there is a row of the pits on the outer surface and the occudent margin bears large, conical teeth.

Material. CBM-PI 00271, 00314, 00342, 00390, 00411, 00424; MFM 142237.

Localities. Kk-2; Ko-1, Ko-2, Ko-6, Ko-8, Ko-9.

Fam. gen. et sp. indet. 2

A small number of dactyli assignable to the Pilumnidae or Xanthidae were obtained from Ko-1. The dactylus is strongly curved downward. A long, sharp groove on the upper margin almost reaches the tip of the finger, and two rows of granules are aligned behind the groove near the articulation. Four blunt teeth line on the occudent margin.

Material. CBM-PI 00315; MFM 142300.

Locality. Ko-1.

Superfamily Majoidea

Family Majidae

Genus *Pisoides*

Pisoides ortomanni (Balss, 1924)

(Pl. 7. 13)

Large numbers of the carapaces in all respects identical to those of the Recent forms were obtained.

Material. CBM-PI 00317, 00404, 00425; MFM 142240.

Localities. Ko-1, Ko-7, Ko-9.

Genus *Leptomithrax*

Leptomithrax sp. cf. *L. edwardsii*

(de Haan, 1837)

(Pl. 7. 7-8)

The elongate, conical fingers are similar to

those of *Leptomithrax edwardsii*, a very common Recent species around the Boso Peninsula.

Material. CBM-PI 00318; MFM 142242.

Locality. Ko-1.

Genus *Hyastenus*

***Hyastenus* spp.**

(Pl. 7. 9, 11-12)

Fragments of the carapace retaining the rostrum and orbital region, and a few fingers are referable to this genus.

Material. CBM-PI 00319, 00355; MFM 142243.

Localities. Ko-1, Ko-3.

Genus *Micippa*

Micippa sp. cf. *M. thalia*

(Herbst, 1803)

(Pl. 7. 10)

A single, typically arched rostrum was obtained from Ko-1. O'hara *et al.* (1976) reported the present species from this locality.

Material. CBM-PI 00320.

Locality. Ko-1.

Fossil record for the species. Nanyo Formation (Holocene) and Kioroshi Formation (Ko-1).

Majidae gen. et sp. indet.

(Pl. 8. 1, 12)

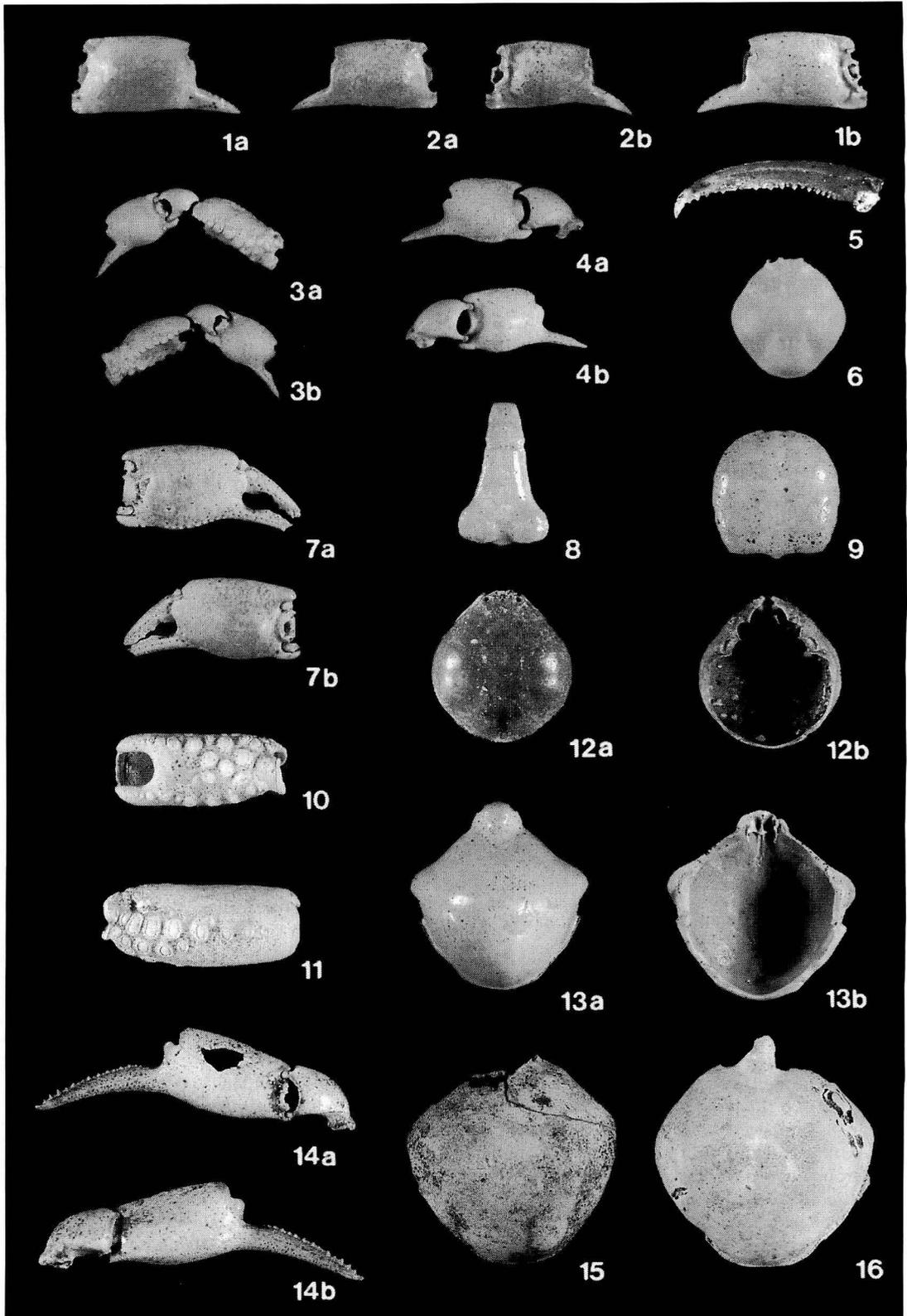
Dactylus of cheliped with large tooth proximally and cylindrical right merus of the pereopod, comparable with those of the Majidae were obtained.

Material. CBM-PI 00321, 00322, 00356.

Localities. Ko-1, Ko-3.

Pl. 8

1. **Majidae gen. et sp. indet.** Dactylus of the left cheliped. $\times 3.0$. CBM-PI 00321. a, outer; b, inner view. 2, 6, 8. *Ebalia longimana* Ortman. 2: left chela. a, outer; b, inner view. 6: left merus. dorsal view. 8: carapace. dorsal view. $\times 4.0$. CBM-PI 00328. 3, 5, 15, 17. *Parthenope* spp. CBM-PI 00323. 3: fixed finger of the right cheliped. $\times 4.0$. outer view. 5 and 15: dactyli of the left chelipeds. $\times 2.0$. a, outer; b, inner view. 17: fixed finger of the right cheliped. $\times 1.5$. a, outer; b, inner view. 4. *Arcania* sp. cf. *A. globata* Stimpson. Carapace. $\times 2.0$. CBM-PI 00330. dorsal view. 7. **Leucosiidae gen. et sp. indet.** Merus of the pereopod. $\times 4.0$. CBM-PI 00434. a, inner; b, outer view. 9-10. *Nursia* sp. aff. *N. japonica* Sakai. Carapaces. $\times 4.0$. CBM-PI 00327. dorsal view. 11, 16. *Arcania* spp. Meri of the right chelipeds. $\times 1.5$. CBM-PI 00332. a, outer; b, inner view. 12. **Majidae gen. et sp. indet.** Right merus. $\times 2.0$. CBM-PI 00322. a, outer; b, inner view. 13-14. *Arcania* sp. cf. *A. undesimspinosa* de Haan. Carapace. $\times 2.0$. CBM-PI 00331. dorsal view.



Superfamily Parthenopoidea
Family Parthenopidae
Genus *Parthenope*

***Parthenope* spp.**
 (Pl. 8. 3, 5, 15, 17)

Fingers assignable to the genus *Parthenope* were obtained from several localities. Several longer dactyli with large occudent teeth and sparse granules on the inner and outer surfaces resemble those of *Parthenope valida* de Haan, 1837. Several more short dactyli bearing smaller occudent teeth and a well developed granulated spine on the upper surface of the base of dactylus resemble those of *P. laciniata* de Haan, 1839. Despite of these resemblances we could not refer the present material to species level, because the fingers of small female individuals *P. valida* resemble the corresponding part of *P. laciniata* in the Recent material.

Fukuda and Fukuda (1973) and O'hara *et al.* (1976) reported *P. valida* from Ko-3 and *Parthenope* sp. from Ko-1.

Material. CBM-PI 00323, 00343, 00391, 00405, 00427; MFM 142245.

Localities. Ko-1, Ko-2, Ko-6, Ko-7, Ko-9.

Superfamily Leucosiidea
Family Leucosiidae
Genus *Ebalia*

***Ebalia longimana* Ortmann, 1892b**
 (Pl. 8. 2, 6, 8)

Two fragments of the carapace retaining posterior portion, a manus and a left chela were obtained from Ko-1. The carapace is covered all over with dense, flattened granules. The largest granule is situated near the

corner of the antero- and posterolateral margins. The cardiac and intestinal regions are strongly convex. There is a pair of tubercles on the posterior margin. The propodus is thin and finely granulated. The fixed finger is nearly as long as the manus and bears two or three longitudinal ridges on the both surfaces. The occudent margin is finely serrated.

Material. CBM-PI 00328; MFM 142249.

Locality. Ko-1.

Fossil record. Taiwan (Pleistocene: Hu and Tao, 1996).

Genus *Nursia*

***Nursia* sp. aff. *N. japonica* Sakai, 1935**
 (Pl. 8. 9–10)

Considerable numbers of the carapaces of *Nursia* were obtained from Ko-1. They resemble *N. japonica* especially in the size and general shape of the carapace, but differ in lacking granules on the dorsal surface. In the examined Recent material, however, the density of granules is variable, thus the exact conclusion requires further consideration.

Material. CBM-PI 00327, 00358, 00392; MFM 142248.

Localities. Ko-1, Ko-3, Ko-6.

Fossil record. Kioroshi Formation (Ko-1).

Genus *Arcania*

Arcania* sp. cf. *A. undesimspinosa
 de Haan, 1841
 (Pl. 8. 13–14)

Four fragments of carapaces, covered with minute spinous granules and large granulated spines were obtained from Ko-1. A considerable number of large meri of chelipeds which may be referable to the genus *Arcania*

Pl. 9

1–2. **Leucosiidae? gen. et sp. indet.** 1 and 2: right and left manus. ×4.0. CBM-PI 00326. a, outer; b, inner view. 3–4, 7, 10–11, 15–16. ***Leucosia anatum* (Herbst).** 3 and 4: right and left chelae. ×2.0. CBM-PI 00324. a, outer; b, inner view. 7: left chela. ×2.0. CBM-PI 00357. a, outer; b, inner view. 10 and 11: left and right meri of the chelipeds. ×2.0. CBM-PI 00324. 10, inner; 11, outer view. 15–16: carapace. dorsal view. ×1.5. 15, CBM-PI 00255; 16, CBM-PI 00324. 5, 12, 14. ***Philyra syndactyla* Ortmann.** 5: dactylus of the left cheliped. ×4.0. CBM-PI 00359. outer view. 12: carapace. ×2.0. CBM-PI 00282. a, dorsal; b, ventral view. 14: left chela. ×4.0. CBM-PI 00272. a, outer; b, inner view. 6. ***Philyra* sp.** Carapace. ×4.0. CBM-PI 00329. dorsal view. 8–9. **Leucosiidae gen. et sp. indet.** 8: male abdominal somite. ×4.0. CBM-PI 00334. ventral view. 9: female abdominal somite. ×2.5. CBM-PI 00414. ventral view. 13. ***Leucosia haematosticta* Adams and White.** Carapace. ×2.0. CBM-PI 00325. a, dorsal; b, ventral view.

were also obtained (as *Arcania* spp. in pl. 8, 11, 16).

Material. CBM-PI 00331; MFM 142251.

Locality. Ko-1.

Fossil record for the species. Ozone Formation (upper Pleistocene: Umemoto *et al.*, 1994), Nanyo Formation (Holocene) and Kioroshi Formation (Ko-1).

Arcania* sp. cf. *A. globata

Stimpson, 1858a

(Pl. 8. 4)

Three fragments of carapaces covered with acute spines, comparable with those of Recent forms, were obtained.

Material. CBM-PI 00330; MFM 142250.

Locality. Ko-1.

Genus *Philyra*

Philyra syndactyla Ortmann, 1892b

(Pl. 9. 5, 12, 14)

The carapace, chelipeds and fingers were obtained from several localities. The chelae are flattened with long, slender fingers. Slightly sinuous fixed finger bears longitudinal rows of pits. The dactylus also shows longitudinal rows of pits and the occulental margin is armed with the serrated teeth.

Material. CBM-PI 00272, 00282, 00359, 00377, 00393, 00408, 00412, 00429; MFM 142208, 142276, 142284, 142289, 142290, 142296.

Localities. Kk-1, Kk-2; Ko-3, Ko-4, Ko-6, Ko-7, Ko-8, Ko-9.

Fossil record. Shimosueyoshi Formation (upper Pleistocene).

***Philyra* sp.**

(Pl. 9. 6)

The carapace which is considerably smaller than that of the former species. Since the lateral and ventral surfaces are entirely lacking, specific assignment is impossible.

Material. CBM-PI 00329.

Locality. Ko-1.

Genus *Leucosia*

Leucosia anatum (Herbst, 1783)

(Pl. 9. 3-4, 7, 10-11, 15-16)

Carapaces and disarticulated chelipeds

were obtained from Jz-1, Ko-1 and Ko-3. Although carapaces are rare, the material from Ko-1 includes articulated chelipeds among the majority of the fragmented ones. On the other hand, the carapaces obtained from Ko-3 and Jz-1 were accompanied with the sternal somites.

Material. CBM-PI 00255, 00324, 00357; MFM 142246, 142269.

Localities. Jz-1; Ko-1, Ko-3.

Fossil record. Toyohashi Formation (middle Pleistocene), Nanyo Formation (Holocene) and Kioroshi Formation (Ko-1).

Leucosia haematosticta

Adams and White, 1848

(Pl. 9. 13)

A relatively well preserved carapace was obtained from Ko-1.

Material. CBM-PI 00325.

Locality. Ko-1.

Fossil record. Toyohashi Formation (middle Pleistocene).

Leucosiidae gen. et spp. indet.

(Pl. 8. 7; 9. 8-9)

Other fragmented material assignable to the family Leucosiidae occurred in several localities. Since the most of those are composed of fragmented appendages and/or abdominal somites, we consider that the exact determinations are impossible.

Material. CBM-PI 00334, 00394, 00414, 00430, 00434; MFM 142247, 142277.

Localities. Ko-1, Ko-6, Ko-8, Ko-9.

Leucosiidae? gen. et spp. indet

(Pl. 9. 1-2; 10. 10-11)

Rectangular manus with short, serrated fixed finger and merus with sharp ridges on upper and lower margins of the outer surface may be assignable to this family.

Material. CBM-PI 00326, 00433; MFM 142247, 142255.

Locality. Ko-1.

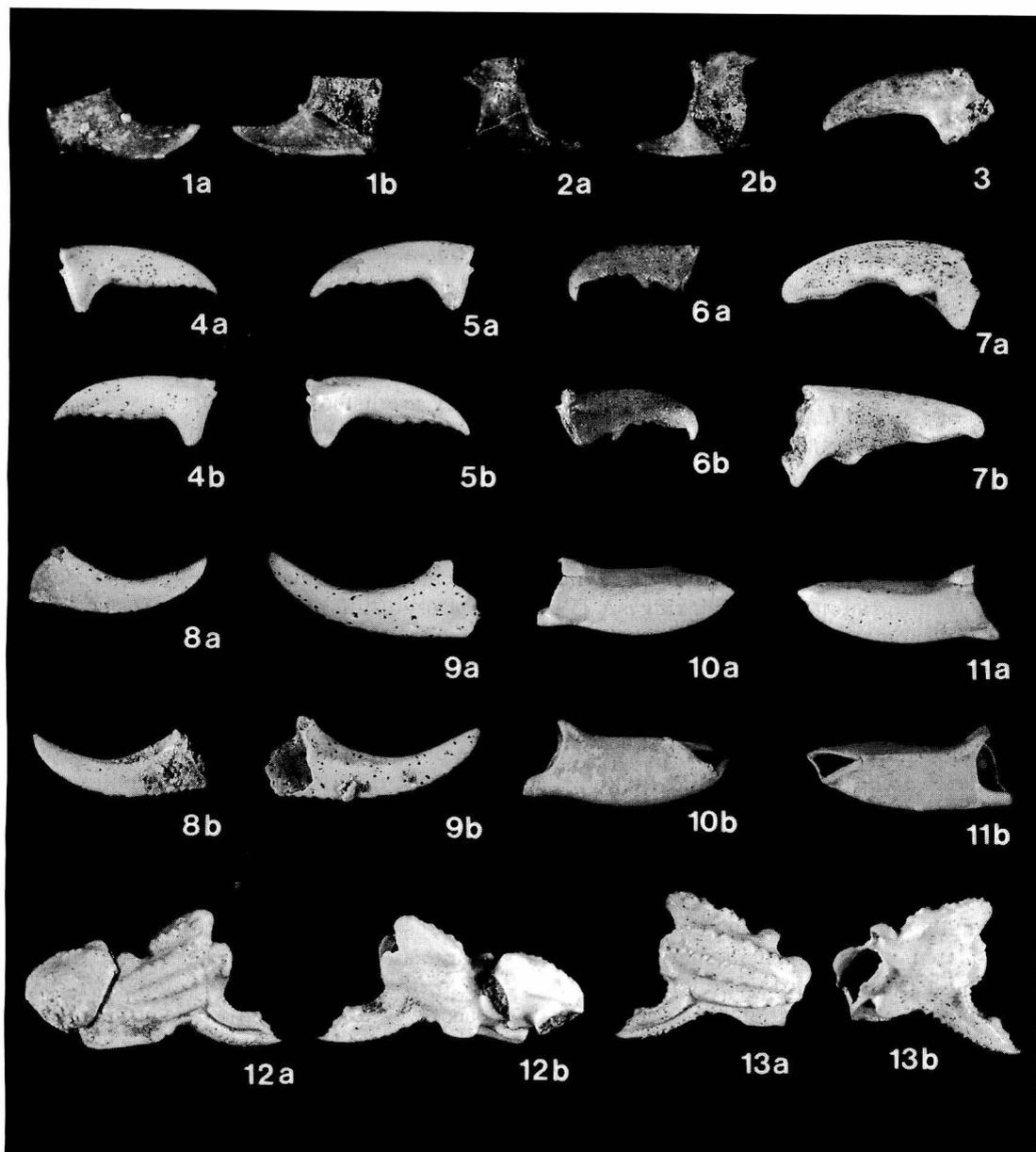
Superfamily Ocypodoidea

Family Ocypodidae

Genus *Macrophthalmus*

***Macrophthalmus?* sp.**

A poorly preserved internal mould of the



PL.10

1-3. **Unidentified species 4.** 1 and 2: fixed fingers of the right chelipeds. $\times 4.5$. CBM-PI 00364. a, outer; b, inner view. 3: dactylus of the left cheliped. $\times 4.5$. CBM-PI 00364. outer view. 4-5. **Unidentified species 1.** 4 and 5: dactyli of the right and left chelipeds. $\times 4.0$. CBM-PI 00337. a, outer; b, inner view. 6-7. **Unidentified species 5.** 6 and 7: dactyli of the left chelipeds. $\times 6.0$. CBM-PI 00365. a, outer; b, inner view. 8-9. **Unidentified species 3.** 8 and 9: fixed fingers of the right and left chelipeds. $\times 4.0$. CBM-PI 00396. a, outer; b, inner view. 10-11. **Leucosiidae? gen. et sp. indet.** 10 and 11: meri of the left and right chelipeds. $\times 3.0$. CBM-PI 00433. a, outer; b, inner view. 12-13. **Unidentified species 2.** 12 and 13: manus of the right and left chelipeds. $\times 4.0$. CBM-PI 00338. a, outer; b, inner view.

carapace obtained from Ko-1 seems to have been derived from another stratigraphic horizon.

Material. CBM-PI 00336.

Locality. Ko-1.

Infraorder et Superfamily indet.

Unidentified species 1

(Pl. 10. 4–5)

The right and left dactyli are probably ascribed to one species. They are weakly inclined downward and have strongly calcified tips and blunt, blade-shaped teeth on the occudent margin. These fingers resemble those of the Xanthoidea or Majoidea to some extent.

Material. CBM-PI 00263, 00337, 00395, 00432; MFM 142257.

Localities. Yb-1; Km-1; Ko-1, Ko-6.

Unidentified species 2

(Pl. 10. 12–13)

Peculiar right and left chelae were obtained from Ko-1. The outer surface ornamented with longitudinal, deep, wide grooves and granulated strong ridges. The fixed finger is strongly inclined downward, but apparently arcuated upward with a narrow occudent margin on the tip. The upper margin of the distal part of the manus is strongly projected.

Material. CBM-PI 00338; MFM 142258.

Locality. Ko-1.

Unidentified species 3

(Pl. 10. 8–9)

A small number of fixed fingers are strongly arcuated. The occudent margin is flattened and forms a narrow longitudinal depression along the granulated longitudinal ridge of the inner surface. The setal pits directing distally are aligned on the lower margin.

Material. CBM-PI 00363, 00396; MFM 142298, 142299.

Localities. Ko-3, Ko-6.

Unidentified species 4

(Pl. 10. 1–3)

Blunt, conical small dactylus and fixed fingers with faint, granule-like teeth on the occudent margin were obtained from Ko-3. The surfaces are flat except for the rimmed lower margin of the inner surface of the fixed finger.

Material. CBM-PI 00364.

Locality. Ko-3.

Unidentified species 5

(Pl. 10. 6–7)

Small dactyli, obtained from Ko-3, have a large triangular tooth on the basal part and a broad depression on the middle part of the occudent surface. The tip is strongly curved downward.

Material. CBM-PI 00365.

Locality. Ko-3.

Discussion

All fossil decapods examined in the present study are listed in the Appendix. The relative abundance of each family from selected localities (yielded more than 50 specimens) is shown in Fig. 3. Although the sample sizes in these localities are considerably different, some remarkable features are recognized. The most diversified assemblage is observed in Ko-1 (Cliff at Sakurai: Kioroshi Formation); this consists of at least 32 genera in 17 families. O'hara *et al.* (1976) reported 12 species of crabs from the same locality. Most of them correspond to the species described in the present study.

Based on the dominant families, four types of decapod assemblage, namely the Callianassidae dominant-assemblage (Ko-7, Ko-2), Cancridae-Leucosiidae dominant-assemblage (Ko-3, Ko-9), Leucosiidae dominant-assemblage (Ko-6) and Paguridae dominant-assemblage (Yb-1), can be recognized.

No thalassinidean and anomuran carapaces were found. In the case of brachyuran crabs, however, certain families in the present material were represented only by fingers despite their abundant specific occurrences (*e.g.*, Portunidae, Goneplacidae etc.). On the other hand, carapaces of the Leucosiidae, Majidae and Xanthidae together with fragments of Cancridae and Calappidae, occurred. These may be related with the different processes of decay, depending on the textures or compositions of the integuments of each family.

Further discussion concerning the decapod assemblages, paleoecology and taphonomy requires more large and representative material, especially from the Jizodo, Yabu, Kamiizumi, and Kiyokawa Formations, as well as the Kioroshi Formation, including that col-

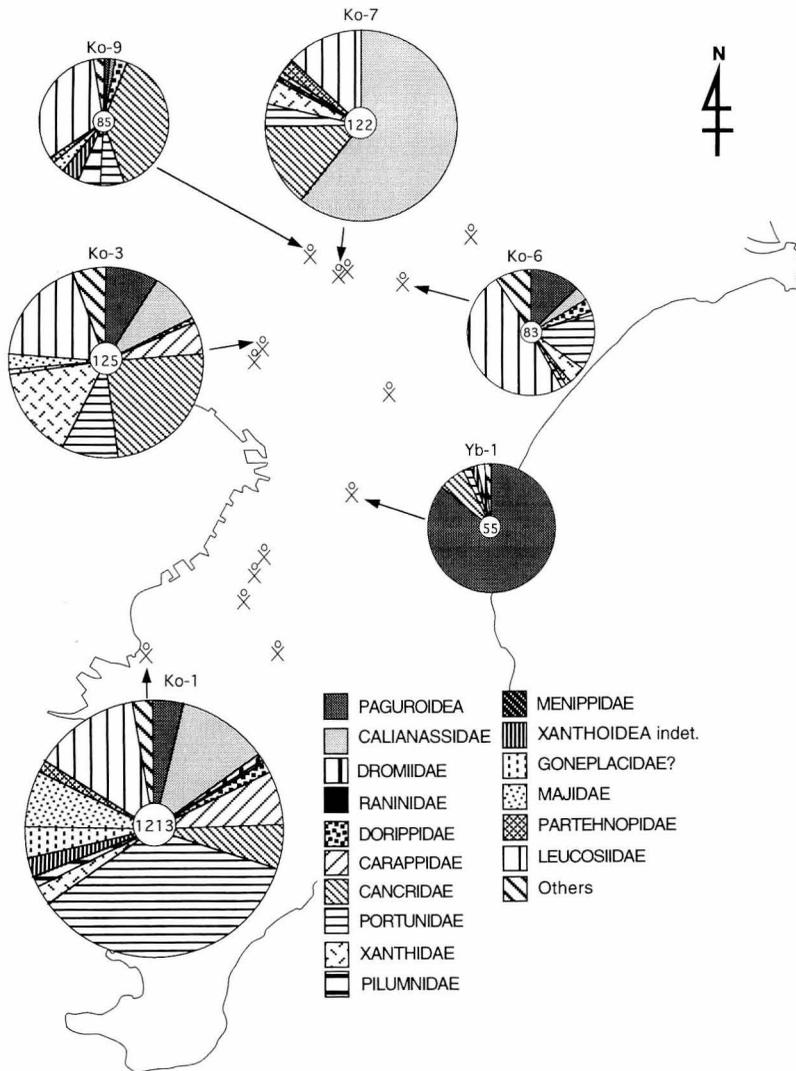


Fig. 3. Composition of the material in the selected localities of the Simosa Group. Value in the inner circle indicates the total number of the specimens.

lected by the quantitative method.

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房総半島の更新世十脚甲殻類化石

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千葉県内に分布する中-上部更新統の下総層群地蔵堂・藪・上泉・清川・木下層の15地点から得られた約2000点の標本に基づき、18科32属64種に及ぶ十脚甲殻類化石を記載する。これらは多くが鉗脚や背

甲の断片であるが、日本の更新統から報告される十脚甲殻類ローカルファウナとしては種構成が最も多様で、化石記録として初めての種を多数含む。科のレベルでの卓越種の構成から判断して、スナモグリ科卓越

群集、イチョウガニ科-コブシガニ科卓越群集、コブシガニ科卓越群集、ホンヤドカリ科卓越群集の4タイプが識別された。

Appendix. List of the decapod fossils from the Shimosa Group.

Formation	Jizodo		Yabu		Kamiizumi		Kiyokawa		Kioroshi							TOTAL NUMBER
	Jz-1	Yb-1	Km-1	Km-2	Kk-1	Kk-2	Ko-1	Ko-2	Ko-3	Ko-4	Ko-5	Ko-6	Ko-7	Ko-8	Ko-9	
CTENOCHELIDAE?																
<i>Ctenocheles?</i> sp.							1									1
CALIANASSIDAE																
<i>Neocallichirus grandis</i>				7	1		135	24	11	2	1		74	1		256
' <i>Callianassa</i> ' sp.						2	6	1							1	10
DIOGENIDAE																
<i>Diogenes</i> sp. cf. <i>D. edwardsii</i>						4			7	3	1	11			1	27
<i>Dardanus</i> sp. cf. <i>D. impressus</i>							13									13
PAGURIDAE																
<i>Pagurus</i> sp. cf. <i>P. similis</i>							5									5
<i>Pagurus</i> sp. cf. <i>P. constatus</i>															34	56
<i>Pagurus</i> sp. cf. <i>P. pectinatus</i>															4	4
<i>Pagurus</i> sp. cf. <i>P. megalops</i>							7									7
Paguroidea fragments												2				11
DROMIIDAE																
Dromiidae gen. et sp. indet. 1							6									6
Dromiidae gen. et sp. indet. 2							2									2
RANINIDAE																
<i>Lyreidus</i> sp.							3									3
DORIPPIDAE																
<i>Paradorippe</i> sp. cf. <i>P. granulata</i>							17		1			3		1	2	24
CARAPPIDAE																
<i>Mursia</i> sp. cf. <i>M. armata</i>							22									22
<i>Calappa</i> spp.						2	61		8	1		1				73
CANCRIDAE																
<i>Cancer</i> sp. cf. <i>C. gibbosulus</i>			4	2	1	2	71	2	29	2	1	12	17		28	171
PORTUNIDAE																
<i>Liocarcinus</i> sp. cf. <i>L. corrugatus</i>							2									2
<i>Charybdis</i> sp.							4									4
<i>Charybdis</i> (<i>Gonioneptunus</i>) sp. cf. <i>C. (G.) bimaculata</i>							310								1	311

Pleistocene decapods from Boso Peninsula

Appendix. (Continued)

Formation	Jizodo	Yabu	Kamiizumi	Kiyokawa		Kioroshi									TOTAL NUMBER	
Locality	Jz-1	Yb-1	Km-1	Km-2	Kk-1	Kk-2	Ko-1	Ko-2	Ko-3	Ko-4	Ko-5	Ko-6	Ko-7	Ko-8	Ko-9	
Portunidae gen. et sp. indet. 1							1									1
Portunidae gen. et sp. indet. 2							1									1
Portunidae gen. et sp. indet. 3							5									5
Portunidae gen. et sp. indet. 4							4									4
Portunidae gen. et sp. indet. 5							2									2
Portunidae gen. et sp. indet. 6							8									8
Portunidae gen. et sp. indet. 7							2									2
Portunidae gen. et sp. indet. 8							2									2
Portunidae fragments		2	1		3	4	81		9	4		6	5		3	118
XANTHIDAE																
<i>Halimede</i> sp. cf. <i>H. othodes</i>											1					1
<i>Actaea semblatae</i>					3		30		19	2			5		1	60
<i>Macromedaeus</i> sp. cf. <i>M. distinguendus</i>							1					1				2
PILUMNIDAE																
<i>Pilumnus</i> sp.							3									3
<i>Actumnus</i> sp. cf. <i>A. squamosus</i>							4									4
Pilumnidae gen. et spp. indet.							10				1				3	14
MENIPPIDAE?																
<i>Ozius</i> ? spp.										2			1			3
GONEPLACIDAE																
<i>Ommatocarcinus</i> sp. cf. <i>O. macgillivrayi</i>							48									48
Xanthoidea fam. gen. et sp. indet 1					2		17	2				3		3	2	29
Xanthoidea fam. gen. et sp. indet 2							7									7
Xanthoidea fragments					2				1	1					1	5
MAJIDAE																
<i>Pisoides ortomanni</i>							61						1		1	63
<i>Leptomithrax</i> sp. cf. <i>L. edwardsii</i>							5									5
<i>Hyastenus</i> spp.							10		1							11
<i>Micippa</i> sp. cf. <i>M. thalia</i>							1									1

Appendix. (Continued)

Formation	Jizodo		Yabu		Kamiizumi		Kiyokawa		Kioroshi								TOTAL NUMBER
	Jz-1	Yb-1	Km-1	Km-2	Kk-1	Kk-2	Ko-1	Ko-2	Ko-3	Ko-4	Ko-5	Ko-6	Ko-7	Ko-8	Ko-9		
Majidae gen. et spp. indet.							3		2							5	
Majidae fragments							10								1	11	
PARTEHNOPIDAE																	
<i>Parthenope</i> spp.							14	1				1	3		1	20	
LEUCOSIIDAE																	
<i>Ebalia longimana</i>							3									3	
<i>Nursia</i> sp. aff. <i>N. japonica</i>							26		1			1				28	
<i>Arcania</i> sp. cf. <i>A. undesimspinosa</i>							4									4	
<i>Arcania</i> sp. cf. <i>A. globata</i>							3									3	
<i>Arcania</i> ? spp.							25		1							26	
<i>Philyra syndactyla</i>					1							10			4	15	
<i>Philyra</i> sp. cf. <i>P. syndactyla</i>						4				5	3		14	15		41	
<i>Philyra</i> sp.							1									1	
<i>Leucosia anatum</i>	2						23			6						31	
<i>Leucosia haematosticta</i>							1									1	
<i>Leucosia</i> sp.							17									17	
Leucosiidae, cf. <i>Leucosia</i> sp.							26			5			2		18	51	
Leucosiidae, cf. <i>Phylira</i> sp.						25	2		5					20		52	
Leucosiidae gen. et spp. indet.							2					30		2	17	51	
Leucosiidae? gen. et spp. indet.							30		10							40	
Leucosiidae fragments			1				3									4	
OCYPODIDAE																	
<i>Macrophthalmus</i> ? sp.							1									1	
INFRAORD. et SUPERFAM. Indet.																	
Unidentified species 1		1	1				21					2				25	
Unidentified species 2							8									8	
Unidentified species 3										2		2				4	
Unidentified species 4										2						2	
Unidentified species 5										3						3	
TOTAL NUMBER	2	55	4	8	12	43	1213	30	125	25	6	83	122	42	85	1854	

Pleistocene decapods from Boso Peninsula