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# Reappraisal of anomuran and brachyuran decapods from the lower Miocene Morozaki Group, Japan, collected by the Tokai Fossil Society

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**Abstract**

A collection of anomuran and brachyuran decapods from the lower Miocene Morozaki Group of Aichi Prefecture, obtained by the Tokai Fossil Society, has led to revisions of previously known and unrecorded species. *Mizunotengus makiguchimai* Karasawa and Ando, a new genus and species of Munidopsidae is described. *Mizunotengus* is the secondary known extinct genus within the Miocene munidopsids. *Paralithodes bishuensis* Karasawa and Ando, a new species of Lithodidae, represents the first record for the genus. Munididae, *Dicranodromia* sp. (Homolodromidae), *Hyastenus* sp. (Epialtidae), *Pisoides*? sp. (Epialtidae), and *Hexapinus* sp. (Hexapodidae) are recognized. A remarkable preservation of *Mizunotengus makiguchimai* is briefly discussed.

*Key words*: Decapoda, Anomura, Brachyura, Miocene, Morozaki Group, Aichi, Japan

## Introduction

The fossil marine pancrustaceans were collected from the lower Miocene Morozaki Group in Aichi Prefecture, Japan, during the field survey of the Tokai Fossil Society in 1983–1991. Takeda, Mizuno, and Yamaoka (1986) examined these specimens and described a thoracican *Lepas* sp., an amphipod *Megaceradocus* sp. cfr. *M. gigas*, and eight decapods, *Callianopsis titaensis* (Nagao, 1941) (as *Callianassa titaensis* Nagao, 1941), *Munida* sp., *Munidopsis* sp., *Paralomis* sp., *Dicranodromia* sp., *Achaeus* sp., *Pisoides*? sp., and *Hexapinus* sp. Subsequently, Mizuno and Takeda (1993) refigured these specimens and described an additional species, *Tricopeltarion huziokai* (Imaizumi, 1951) (as *Trachycarcinus huziokai* Imaizumi, 1951).

The purpose of the present work is to document reassignment of anomuran and brachyuran decapods recorded by Takeda *et al.* (1986) and Mizuno and Takeda (1993), adding the unrecorded specimens. The specimens described herein were collected from the Toyohama and Yamami formations (lower Miocene) exposed at five localities in Minamichita-cho, Aichi Prefecture, Japan. The detailed information on geology for each locality has been given by Mizuno (1992), Yamaoka (1993), and Hachiya *et al.* (1993). Therefore, we do not repeat it here. Additionally, we noted that the geologic age of the Morozaki Group was early Miocene (the middle to upper part of *Crucidenticula sawamurae* Zone of Diatom zonation by Yanagisawa and Akiba (1998)) (Ito *et al.*, 1999).

The specimens described here are deposited in the Mizunami Fossil Museum (MFM).

## Systematic Accounts

By H. Karasawa and Y. Ando

Infraorder Anomura MacLeay, 1838
Superfamily Galatheoidea Samouelle, 1819
Family Munididae Ahyong, Baba, Macpherson, and Poore, 2010

### Munididae

(Pl. 1, figs. 1–3)

*Material examined*: MFM83998 and 83999 from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ06, collected by T. Mizuno; MFM84000, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ05, collected by Y. Mizuno.

*Remarks*: The carapace, pleon, and some pereiopods remain in the present specimens, but the anterior part of the carapace is not preserved. Takeda *et al.* (1986) identified these with *Munida* sp. However, Ahyong *et al.* (2010) indicated that the family was represented by 20 extant and

two extinct genera with more than 350 species. Most recently, two new genera, *Juracrista* Robbins, Feldmann, and Schweitzer, 2012 (only fossil) and *Hendersonida* Cabezas and Macpherson, 2014 (only extant), were added. *Munida* Leach, 1820, and its allied genera usually have transverse striae on the dorsal carapace and the anterior part of the carapace is needed to establish the generic and specific identification (Ahyong *et al*., 2010); therefore, it is difficult to classify the present specimens with any genus.

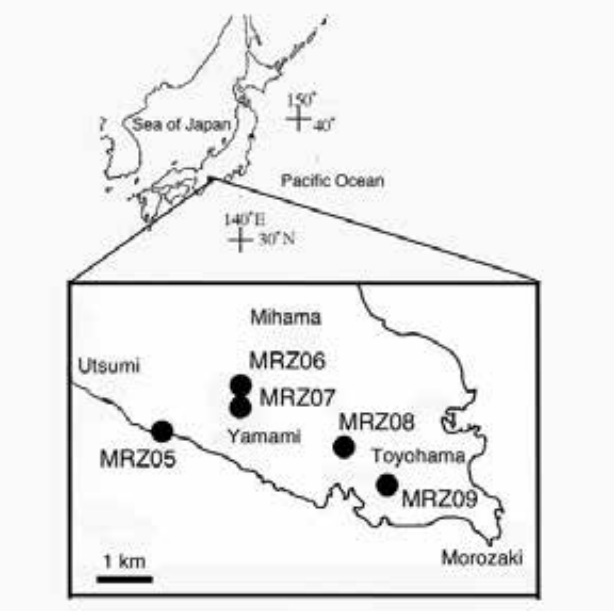



Fig. 1. Map showing the fossil-bearing locality. **Loc**. **MRZ05** (=Loc. 3 of Hachiya *et al*., 1993): beach of Hashizume, Yamami, Minamichita-cho, Aichi Prefecture, Japan; tuffaceous sandstone of the Yamami Formation, Morozaki Group. **Loc. MRZ06** (=Loc. 4 of Mizumo, 1992; =Loc. 1 of Hachiya *et al*., 1993): cliff of Iwaya, Yamami, Minamichita-cho, Aichi Prefecture, Japan; tuffaceous sandstone of the middle part of the Yamami Formation, Morozaki Group. **Loc. MRZ07** (=Loc. 7 of Mizuno, 1992; =Loc. 2 of Hachiya *et al*., 1993): cliff of Oodomari, Yamami. Minamichita-cho, Aichi Prefecture, Japan; tuffaceous sandstone of the lower part of the Yamami Formation, Morozaki Group. **Loc. MRZ08** (=Loc. 2 of Mizuno, 1992): cliff of Kaigatsubo, Toyohama, Minamichita-cho, Aichi Prefecture, Japan; sandstone of the uppermost part of the Toyohama Formation, Morozaki Group. **Loc. MRZ09** (=Loc. 6 of Hachiya *et al*., 1993): cliff of Ozagahama, Toyohama, Minamichita-cho, Aichi Prefecture, Japan; tuffaceous mudstone of the lower-middle part of the Toyohama Formation, Morozaki Group.

Family Munidopsidae Ortmann, 1898

### Genus *Mizunotengus*, new genus

*Type species*: *Mizunotengus makiguchimai*, new species, by monotypy; musculine gender.

*Diagnosis*: As for species.

*Etymology*: The generic name is derived from "Mizuno", a family name of a senior researcher of fossils from the Morozaki Group plus "Tengu", a Japanese god name. Therefore, the name is an arbitral combination of letters.

*Remarks*: *Mizunotengus* is refer to Munidopsidae in that the carapace has a well-developed cervical groove, the supraocular spine is absent, and pleonal somites 2 and 3 have a transverse ridge. Within the extant munidopsids, the present new genus might be closely related to *Munidopsis* Whiteaves, 1874. *Munidopsis* is the most diverse group within Galatheoidea and contains 225 species with variable forms (Macpherson and Baba, 2011). Based upon molecular work Ahyong *et al*. (2011a) suggested that *Munidopsis* was para- or polyphyletic and was divided into eight species-groups: *Anoplonotus*-, *Bathyankyristes*-, *Dasypus*-, *Elasmonotus*-, *Galathodes*-, *Galathopsis*-, and *Orophorhynchus*- group, and *Munidopsis* s.s. However, within their work, all known extant genera have not yet been examined. The characters of the carapace, pleon, and pereiopods within *Mizunotengus* do not fit with those of any group mentioned by Ahyong *et al*. (2011a). *Mizunotengus* differs from *Munidopsis* s.l. in that a pyriform carapace is slightly longer than wide and lacks transverse ridges or striations on the dorsal carapace, with a weak, arcuate branchial ridge, the convex lateral margin bears well defined spines, long, slender pereiopods 1 are ornamented with well-developed spines, and other pereiopods are also well defined.

The absence of dorsal carapace spines distinguishes *Mizunotengus* from *Galacantha* A. Milne Edwards, 1880. The new genus differs from *Leiogalathea* Baba, 1969, by lacking the dorsal transverse ridges. *Shinkaia* Baba and Williams, 1998, exhibit a smooth carapace without well-developed carapace grooves and short, stout pereiopods 1; therefore, *Mizunotengus* is not referable to *Shinkaia*.

*Palmunidopsis* Fraaije, 2014, from the upper Miocene of Cyprus, has been only known as a late Cenozoic extinct genus. *Mizunotengus* is clearly distinguished from *Palmunidopsis* in the general characters of the carapace and propodus of pereiopod 1.

### *Mizunotengus makiguchimai*, new species

(Pl. 2–Pl. 11)

*Diagnosis*: Moderate-sized munidopsid. Carapace, pyriform, slightly longer than wide, weakly vaulted transversely and longitudinally. Fronto-orbital margin about 40 percent of maximum carapace width. Rostrum long, acute, about 35 percent of maximum carapace length, gently downturned, with unarmed lateral margins and medial, dorsal keel extending onto carapace. Supraocular

spine absent. Upper orbital margin concave, entire. Outer orbital spine long, needle-like, directed forward. Anterolateral spine much shorter than outer orbital margin, needle-like, directed forward. Lateral margin convex with forwardly directed spines; anterior three spines long, needle-like; fifth spine triangular; reminder of 6–7 lateral spines short, triangular, closely spaced. Posterior margin slightly concave. Dorsal surface finely tuberculate, without transverse ridge. Cervical groove well defined, sinuous. Cardiac region inverted triangular, separated from anterior branchial regions by rather deep posterior cervical groove. Branchiocardiac groove shallow. Branchial region with weak arcuate ridge parallel to lateral margin. Thoracic sternum broadly triangular, gently concave axially, with smooth surface. Sternites 3–7 fused, separated from one another by deep groove, bearing deep, axial, median groove. Sternite 3 small, subrectangular, about as long as wide, with posteriorly diverged lateral margin. Sternite 4 subhexagonal, wider than long, longest of all sternites; anterolateral margin concave; posterolateral margin nearly straight. Sternite 5–7 rectilinear, concave forward, much wider than long. Surfaces of pleonal somites 1–6, smooth or finely tuberculate dorsally; somite 1 narrow, reduced; terga of somites 2 and 3 with anterior transverse ridge; pleura of somites 2–5 well developed; tergum of somite 6 with shallow, longitudinal median groove; posterior margin convex; pleura of somite 6, much wider than long, diverging laterally, divided from tergum by rather deep groove converged distally. Telson tuberculate dorsally, consisting of several plates. Peduncle of uropod tuberculate dorsally. Eye small, oblique; eye stalk much longer than cornea without lateral eyespine. Basal article of antennule with strong dorsolateral and distolateral spines. Basal article of antennule with strong dorsolateral and distolateral spines. Basal article of antenna with sharp distolateral spine.

Pereiopod 1 chelate, long, slender, subcylindrical, about 3 times carapace length including rostrum. Dactylus and fixed finger thin, slender, about 40 percent propodus length, with finely serrated dorsal and occlusal margins; occlusal margins of both fingers not gaped; surface of palm, carpus, and merus sparsely covered with irregular-sized spines inclined anteriorly; dorsal, lateral, and ventral rows of spines present, mesial spines long, well developed; carpus about 40 percent propodus length; merus about 1.4 times longer than carpus, spines largest distally. Pereiopods 2–4 long, slender, flattened, ornamented with variably-sized spines, narrower than pereiopod 1; merus long, slender, with a medial row of short spines, flexor margin with long, sparsely arranged spines inclined distally and extensor margin with short spines directed distally.

*Material examined*: Holotype, MFM83078, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ07, collected by T. Mizuno. Seventeen paratypes, MFM83079, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ07, collected by Y. Imai; MFM83080, MFM83081, MFM83082-1–14, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ08, collected by T. Makiguchi. No numbered specimens associated with the holotype, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ07, collected by T. Mizuno.

*Etymology*: The specific name is derived from members of the Tokai Fossil Society, Y. Imai and T. Makiguchi, who collected the specimens described here. Therefore, the name is an arbitral combination of letters.

*Description*: Moderate-sized munidopsid. Carapace pyriform, slightly longer than wide, widest at about posterior fifth, weakly vaulted transversely and longitudinally. Fronto-orbital margin about 40 percent of maximum carapace width. Rostrum long, acute, about 35 percent of maximum carapace length, gently downturned; margins unarmed; dorsal surface with medial keel extending onto carapace. Supraocular spine absent. Upper orbital margin concave, entire. Outer orbital spine long, needle-like, directed forward. Anterolateral spine much shorter than outer orbital spine, needle-like, directed forward. Lateral margin convex with forwardly directed spines; anterior three spines long, needle-like, about as long as anterolateral spine; fourth spine triangular, smaller than anterior spines; reminder of lateral spines numbered six or seven, short, triangular, closely spaced, diminishing in size posteriorly. Posterior margin slightly concave.

Dorsal surface finely tuberculate without transverse ridge. Epi-, meso-, and protogastric regions not differentiated, weakly ridged medially. Hepatic region separated from gastric regions by shallow groove. Cervical groove well defined, sinuous, extending from margin just anterior third lateral spines to posteriorly along margins of metagastric region; lateral elements nearly straight; axial element deep, concave. Cardiac region inverted triangular, separated from anterior branchial regions by rather deep posterior cervical groove. Branchiocardiac groove shallow, curving arcuately from margin just anterior to fifth lateral spine to posterior margin. Branchial region with weak arcuate ridge parallel to lateral margin.

Thoracic sternum broadly triangular, gently concave axially, with smooth surface. Sternites 3–7 fused, separated from one another by deep groove, bearing deep, axial, median groove. Sternites 1–2 unknown. Sternite 3 small, subrectangular, about as long as wide, with posteriorly diverged lateral margin. Sternite 4 subhexagonal, wider than long, longest of all sternites; anterolateral margin concave; posterolateral margin nearly straight. Sternite 5 rectilinear, concave forward, much wider than long.

Sternite 6 rectilinear, concave forward, slightly shorter than sternite 5. Sternite 7 elongate rectilinear, short, steeply inclined posteriorly. Sternite 8 poorly preserved and separated from sternite 7.

Surfaces of pleonal somites 1–6, smooth or finely tuberculate dorsally. Somite 1 much narrower and shorter than other somites, pleura reduced. Terga of somites 2–5 decreased in length posteriorly. Terga of somites 2 and 3 with anterior transverse ridge. Pleura of somites 2–5 well developed. Pleura of somite 2 subquadrate, about as long as wide; anterior, lateral, and posterior margins convex with broadly rounded corners. Pleura of somites 3–5 much wider than long, tapering laterally; anterior margin slightly concave; lateral margin convex; posterior margin slightly sinuous; corners rounded. Tergum of somite 6 with shallow, longitudinal median groove; posterior margin convex. Pleura of somite 6, much wider than long, diverging laterally, divided from tergum by rather deep groove converging distally; anterior and posterior margins nearly straight, lateral margin rounded. Telson poorly preserved, crumpled; therefore, outline not known. Isolated uropodal exopod preserved with medial ridge. Telson incompletely preserved, tuberculate dorsally, consisting of several plates. Peduncle of uropod tuberculate dorsally. Uropodal exopod and endopod poorly preserved.

Eye small, oblique; eye stalk much longer than cornea without lateral eyespine. Basal article of antennule with strong dorsolateral and distolateral spines.

Maxilliped 3 incompletely preserved, elongate, marginal spines not observed; exopod long, elongate.

Pereiopod 1 chelate, long, slender, subcylindrical, about 3 times carapace length including rostrum. Dactylus thin, slender, about 40 percent propodus length, gently curved to apex; dorsal and occlusal margins finely serrated. Fixed finger thin, slender, about as long as dactylus, slightly curved to apex; dorsal and occlusal margins finely serrated. Occlusal margins of both fingers not gaped. Surface of palm, carpus, and merus sparsely covered with variably-sized spines inclined anteriorly; dorsal, lateral, and ventral rows of spines present, mesial spines long, well developed. Carpus about 30 percent propodus length. Merus about 1.4 times as long as carpus, spines largest distally. Basi-ischium and coxa preserved.

Pereiopods 2–4 long, slender, flattened, ornamented with variably-sized spines, narrower than pereiopod 1. Long, slender propodus and short carpus poorly preserved, details of ornamentation unknown. Carpus short. Merus long, slender, with a medial row of short spines; flexor margin with long, sparsely arranged spines inclined distally; extensor margin with short spines directed distally. Basi-ischium and coxa preserved. Pereiopod 5 poorly-preserved, much shorter than pereiopod 4.

*Remarks*: Takeda *et al*. (1986) and Mizuno and Takeda (1993) allied the present species with *Munidopsis*. However, the species is moved to *Mizunotengus makiguchimai*, new genus and new species, as discussed above.

Preservation of 14 specimens (MFM83082-1–83082-14) is unusual. These specimens occur on the same small rock (about 19 × 10 × 3 cm). Among the specimens, the carapace and thoracic sternum associated with the pleon, pereiopods, and other appendages are preserved. Within the rock, the telson, uropods, and fragments of cephalic appendages are recognized. Additionally, the holotype (MFM83078), surrounded by some individuals with the pleonal somite 6, telson, and uropods, is preserved. A high-density occurrence of a munidopsid, *Sinkaia katapsyxis* Schweitzer and Feldmann, 2008, has been reported from the Eocene hydrothermal vent deposit of Washington, U.S.A. (Schweitzer and Feldmann, 2008). Extant exemplars of high population densities of Munidopsidae include *Sinkaia crosnieri* Baba and Williams, 1998 (Baba and Williams, 1998; Dong and Li, 2015), *Munidopsis lentigo* Williams and Van Dover, 1983 (Macpherson and Segonzac, 2006), and *Munidopsis myojinensis* Cubelio *et al*., 2007 (Cubelio *et al*., 2007), *Munidopsis polymorpha* (Koelbel, 1892) (Cabezas *et al*., 2012), and *Munidopsis* spp. (Lovrich and Thiel, 2011). These species have been recorded from the chemosynthetic ecosystems of deep seas except for an anchialine species, *M. polymorpha*. Therefore, preservation of the specimens (MFM83082-1–83082-14) might derive from chemosynthetic, deep sea environments. However, these specimens were associated with woods and echinoids, *Brissopsis* sp. and *Phormosoma* sp., neither of which are elements of chemosynthetic communities. Interestingly, Amano and Little (2005) described a whale-fall community from the Morozaki Group. The detailed sedimentological and taphonomic work by Ando *et al*. is now in progress.

Small unidentified balanomorph barnacles are attached on the surface of pleonal somites in the specimen (MFM83080; pl. 6, fig. 2b). The balanomorph epibionts on decapods are often known from present oceans (Key *et al*., 1997; Waugh *et al*., 2004), but these are quite rare in the fossil record (Feldmann, 2003; Waugh *et al*., 2004).

Superfamily Lithodoidea Samouelle, 1819
Family Lithodidae Samouelle, 1819
Genus *Paralithodes* Brandt, 1848

*Type species*: *Lithodes brevipes* H. Milne Edwards and Lucas 1841, by monotypy.

### ***Paralithodes bishuensis*, new species**

(Pl. 12, figs. 1–3)

*Diagnosis*: Juvenile lithodid. Carapace excluding rostrum pyriform, slightly longer than wide, widest at posterior

third. Fronto-orbital regions about 1/3 as long as maximum carapace width. Lateral margin sinuous, divergent posteriorly, with short anterolateral spine directed anterolaterally. Posterior margin gently concave, tuberculate, rimmed. Dorsal carapace covered with pointed tubercles; gastric region with tubercles; hepatic region with 2 tubercles transversely arranged; cardiac and intestinal regions with 2 axial rows of tubercles; branchial region with 4 oblique rows of tubercles. Cervical groove weakly defined. Pereiopod 1 chelate; basi-ischium with mesio-distal spine; merus with long, mesio-medial spine; propodus with sparsely arranged spines dorsally and ventrally. Pereiopod 2 basi-ischium with distal spine on flexor margin; merus with small spines on extensor margin. Merus of pereiopod 3 slightly longer than that of pereiopod 2; extensor margin with 3 long spines. Merus of pereiopod 4 shorter than those of pereiopods 2 and 3; extensor margin with 6 long, irregular-sized spines. Article 2 of antennae with sharp distal spines.

*Material examined*: Holotype, MFM83077, from the Yamami Formation of Morozaki Group (Early Miocene), at Loc. MRZ06, collected by Y. Mizuno.

*Etymology*: The species name is derived from "Bishu", an ancient place name of the western part of Aichi Prefecture.

*Description*: Small-sized lithodid (juvenile). Carapace and pereiopods deformed, dorso-ventrally depressed. Carapace excluding rostrum pyriform, slightly longer than wide, widest at posterior third. Fronto-orbital regions broken, about 35 percent of maximum carapace width. Trace of rostrum present, appears to be triangular, accessory spine not present. Lateral margin sinuous, divergent posteriorly, with short anterolateral spine directed anterolaterally, other spines broken, not preserved. Posterior margin gently concave, tuberculate, rimmed.

Carapace covered with well-defined, pointed tubercles. Gastric region with tubercles. Hepatic region with 2 tubercles transversely arranged. Cervical groove weakly defined. Cardiac and intestinal regions with 2 axial rows of tubercles. Branchial region with 4 oblique rows of tubercles.

Pereiopods generally poorly-preserved, remaining surface sparsely covered with spines. Pereiopod 1 chelate. Right pereiopod 1 merus with long, mesio-medial spine; carpus about 2/3 times as long as merus; propodus about 4.5 times as long as carpus with sparsely arranged spines dorsally and ventrally; fixed finger about half length of propodus; dactylus about as long as fixed finger. Left pereiopod 1 similar to right one; basi-ischium with mesio-distal spine; merus with long, mesio-medial spine. Basi-ischium of pereiopod 2 with distal spine on flexor margin; merus much longer than high, armed with small spines on extensor margin; flexor marginal spines not observed. Merus of pereiopod 3 slightly longer than that of pereiopod 2; extensor margin with 3 long spines; flexor marginal spines not observed. Merus of pereiopod 4 shorter than those of pereiopods 2 and 3; extensor margin with 6 long, irregular-sized spines; marginal spines on flexor margin of merus and carpus, propodus, and dactylus appear to be not preserved; carpus about half of merus length; propodus about 1.8 times as long as carpus; dactylus about half of propodus length. Merus and carpus of left pereiopod 5 reduced, much shorter than other pereiopods.

Left antenna present, but poorly preserved; article 2 with sharp distal spines.

Pleonal somite 1 small, visible dorsally.

Ventral aspects unknown.

*Remarks*: Takeda *et al.* (1986) did not refer to the present material. Ahyong *et al.* (2011b) showed that Lithodidae comprised 121 species in 10 genera at the present oceans. In the most recent work (Bracken-Grissom *et al.*, 2013) the monophyly of each lithodid genus was questioned based upon examination of seven genera using molecular and morphological character analysis. However, representatives of three genera have not yet been examined in their work; therefore, 10 genera were placed in the family, based upon the previous work (Ahyong *et al.*, 2011b). The sternum and abdominal characters are unique for the generic identification (Ahyong, 2010). The sternum and abdomen were not preserved in the present species. However, the carapace characters in the species largely differ from those of species of *Cryptolithodes* Brandt, 1848, *Glyptolithodes* Faxon, 1895, *Lopholithodes* Brandt, 1848, *Phyllolithodes* Brandt, 1848, *Rhinolithodes* Brandt, 1848, and *Sculptolithodes* Makarov, 1934. The present species resembles species of *Lithodes* Latreille, 1806, *Neolithodes* A. Milne-Edwards and Bouvier, 1894, *Paralithodes* Brandt, 1848, and *Paralomis* White, 1856, by having a pyriform carapace. *Lithodes*, *Neolithodes*, *Paralithodes*, and *Paralomis* have usually a large-sized carapace (Zaklan, 2002), but the carapace in the specimen is about 12 mm in length; therefore, the specimen is thought to be a juvenile individual. Within lithodid crabs, dorsal carapace spines in juveniles are longer and more dense than those of adults (Ahyong, 2010; Hall and Thatje, 2010). The carapace of *Lithodes* and *Neolithodes* in juveniles and adults is usually covered with numerous long spines (Ahyong, 2010); therefore, the species cannot refer to both genera. The present species differs from species of *Paralomis* by having the carapace with sparsely arranged tubercles. *Paralomis* in juveniles has the carapace densely decorated with well-developed spines and/or tubercles (Ahyong, 2010; Hall and Thatje, 2010). The carapace of the present species is similar to those of juveniles of three species, *Paralithodes brevipes* (H. Milne Edwards and Lucas 1841), *P. camtschaticus* (Tilesius, 1815), and *P. platypus* (Brandt, 1850), within

*Paralithodes* by having low, pointed dorsal tubercles arranged sparsely; therefore, it is considered best to place the species in *Paralithodes*, while juveniles of the above mentioned three species are sparsely decorated with short dorsal spines (Kurata, 1956; Sato, 1958; Sasaki and Yoshida, 1999; Epelbaum *et al*., 2006).

Lithodidae has extremely rare in the fossil records: *Paralomis* sp. from the lower Miocene Morozaki Group, Japan (Takeda *et al*., 1986; Mizuno and Takeda, 1993), *Paralomis debodeorum* Feldmann, 1998, from the middle-late Greta Siltstone of New Zealand, and Lithodidae genus and species indeterminate from the middle Miocene Carmen Silva Formation of Argentina (Feldmann *et al*., 2011) and from the early Miocene Kumano Group of Japan (Karasawa and Ohara, 2012). Among these, *Paralomis* sp. described by Takeda *et al*. (1986) appears to be lost (Hachiya personal commun. August, 2016). The present species represents the first record of *Paralithodes* as fossils. The discovery of the species extends the geologic range for *Paralithodes* back to the early Miocene.

Infraorder Brachyura Linnaeus, 1758
Section Dromiacea de Haan, 1839
Superfamily Homolodromioidea Alcock, 1900
Family Homolodromiidae Alcock, 1900
Genus *Dicranodromia* A. Milne Edwards, 1880

*Type species*: *Dicranodromia ovata* A. Milne Edwards, 1880, by monotypy.

### ***Dicranodromia* sp.**

(Pl. 13, figs. 1, 2)

*Material examined*: MFM84001, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ06, collected by Y. Mizuno.

*Remarks*: Takeda *et al*. (1986) described the present species as *Dicranodromia* sp. The specimen is identical with a female individual based upon pleonal characters. However, the key-morphology of the extant members, including the detail characters of the fronto-orbital margin, dorsal ornamentation, and pereiopods, is not available for study in fossil material.

Section Eubrachyura de Saint Laurent, 1980
Superfamily Goneplacoidea MacLeay, 1838, *sensu* Karasawa and Schweitzer (2006)
Family Hexapodidae Miers, 1886
Genus *Hexapinus* Manning and Holthuis, 1981

*Type species*: *Hexapus latipes* de Haan, 1835, by original designation.

### ***Hexapinus* sp.**

(Pl. 13, figs. 2, 3)

*Material examined*: MFM84002, from the Toyohama Formation of the Morozaki Group (lower Miocene), at Loc. MRZ09, collected by M. Umemoto; MFM84003, from the Toyohama Formation of the Morozaki Group (lower Miocene), at Loc. MRZ09, collected by T. Niwa.

*Remarks*: Takeda *et al*. (1986) identified the present species with Hexapinus sp. In one specimen (MFM84002) the sternum, male pleon, and pereiopods are well preserved and in another one (MFM84003) the damaged and deformed carapace with pereiopods remain. The specific identification of this species must await the discovery of a better preserved carapace.

Superfamily Majoidea Samouelle, 1819
Family Epialtidae MacLeay, 1838
Subfamily Pisinae Dana, 1851
Genus *Hyastenus* White, 1847

*Type species*: *Hyastenus sebae* White, 1847, by monotypy.

### ***Hyastenus* sp.**

(Pl. 13, fig. 5)

*Material examined*: MFM84004, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ06, collected by Y. Mizuno.

*Remarks*: Takeda *et al*. (1986) assigned the present species of the inachid genus *Achaeus* Leach, 1817. However, the examination of a further preparation of the material shows that it has long, divergent rostral spines. Therefore, the species cannot be identical with *Achaeus*. The species is moved to *Hyastenus* by having a pyriform carapace outline with long, slender, divergent rostral spines. The genus has been known by two unnamed Miocene species from the middle Miocene Mizunami Group of Japan (Karasawa, 1991) and the upper Miocene Sandakan Formation of Sabah (Collins *et al*., 2003). Both species lack well-preserved rostra, but differs from the present species by having well-defined tubercles on the dorsal carapace regions.

Genus *Pisoides* H. Milne Edwards and Lucas, 1843

*Type species*: *Pisoides tuberculosus* H. Milne Edwards and Lucas, 1843, by monotypy.

### ***Pisoides*? sp.**

(Pl. 13, fig. 6)

*Material examined*: MFM84005, from the Yamami Formation of the Morozaki Group (lower Miocene), at Loc. MRZ07, collected by Y. Mizuno.

*Remarks*: The present species was originally described as *Pisoides*? sp. by Takeda *et al*. (1986). We concur, but cannot make sufficient comparison with other species because of the damaged and deformed carapace.

## Acknowledgements

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## References

Ahyong, S. T. 2010. The Marine Fauna of New Zealand: King Crabs of New Zealand, Australia and the Ross Sea (Crustacea: Decapoda: Lithodidae). NIWA Biodiversity Memoir 123: 1–195.

Ahyong, S. T., K. Baba, E. Macpherson, and G. C. B. Poore. 2010. A new classification of the Galatheoidea (Crustacea: Decapoda: Anomura). Zootaxa 2676: 57–68.

Ahyong, S. T., N. Andreakis, and J. Taylor. 2011a. Mitochondrial phylogeny of the deep-sea squat lobsters, Munidopsidae (Galatheoidea). Zoologischer Anzeiger 250: 367–377.

Ahyong, S. T., J. K. Lowry, M. Alonso, R. N. Bamber, G. A. BoxshalL, P. Castro, S. Gerken, G. S. Karaman, J. W. Goy, D. S. Jones, K. Meland, D. C. Rogers, and J. Svavarsso. 2011b. Subphylum Crustacea Brünnich, 1772. In: Z.-Q. Zhang (ed.), Animal Biodiversity: An Outline of Higher-Level Classification and Survey of Taxonomic Richness. Zootaxa 3148: 165–191.

Alcock, A., 1900. Materials for a carcinological fauna of India. No. 5. Brachyura Primigenia or Dromiacea. Journal of the Asiatic Society of Bengal 68: 123–169.

Amano, K., and C. T. S. Little. 2005. Miocene whale-fall community from Hokkaido, northern Japan. Palaeogeography, Palaeoclimatology, Palaeoecology 215: 345–356.

Baba, K. 1969. Four new genera with their representatives and six new species of the Galatheidae in the collection of the Zoological Laboratory, Kyushu University, with redefinition of the genus *Galathea*. Ohmu 2: 1–32.

Baba, K., and A. B. Williams. 1998. New Galatheoidea (Crustacea, Decapoda, Anomura) from hydrothermal systems in the West Pacific Ocean: Bismarck Archipelago and Okinawa Trough. Zoosystema 20: 143–156.

Bracken-Grissom, H. D., M. E. Cannon, P. Cabezas, R. M. Feldmann, C. E. Schweitzer, S. T. Ahyong, D. L. Felder, R. Lemaitre, and K. E. Crandall. 2013. A comprehensive and integrative reconstruction of evolutionary history for Anomura (Crustacea: Decapoda). BMC Evolutionary Biology 13: 128.

Brandt, J. F. 1848. Die Gattung *Lithodes* Latreille nebst vier neuer ihr verwandten von Wosnessenski entdeckten, als Typen einer besondern unterabtheilung (Tribus Lithodes) der Edward'shen Anomuren. Bulletin de la Classe physico-mathématique de l'Académie Impériale des Sciences de Saint Pétersbourg 7: 7–76.

Brandt, J. F. 1850. Vorläuge Bermerkungen über eine aus zwei noch unbeschreibenen Gattungen und Arten gebildete unterabtheilung (Hapalogastrica) der Tribus Lithodina, begleitet von einer Charakteristik der eben genannten Tribus der Anomuren. Bulletin de la Classe physico-mathématique de l'Académie Impériale des Sciences de Saint Pétersbourg 8: 266–269.

Cabezas, O., F. Alda, E. Macpherson, and A. Machordom. 2012. Genetic characterization of the endangered and endemic anchialine squat lobster *Munidopsis polymorpha* from Lanzarote (Canary Islands): management implications. ICES Journal of Marine Science 69: 1030–1037.

Cabezas, P., and E. Macpherson. 2014. A new species of *Paramunida* Baba, 1988 from the Central Pacific Ocean and a new genus to accommodate *P. granulata* (Henderson, 1885). ZooKeys 425: 15.

Collins, J. S. H., C. Lee, and J. Noad. 2003. Miocene and Pleistocene crabs (Crustacea, Decapoda) from Sabah and Sarawak. Journal of Systematic Palaeontology 1: 187–226.

Cubelio, S. S., S. Tsuchida, M. E. Hendrickx, R. Kado, and S. Watanabe. 2007. A new species of vent associated *Munidopsis* (Crustacea: Decapoda: Anomura: Galatheidae) from the Western Pacific, with notes on its genetic identification. Zootaxa 1435: 25–36.

Dana, J. D. 1851. On the classification of the Maioid Crustacea or Oxyrhyncha. American Journal of Science, Series 2 5: 425–434.

Dong, D., and X. Li. 2015. Galatheid and chirostylid crustaceans (Decapoda: Anomura) from a cold seep environment in the northeastern South China Sea. Zootaxa 4057: 91–105.

Epelbaum, A. B., B. R. Borisov, and N. P. Kovatcheva. 2006. Early development of the red king crab *Paralithodes camtschaticus* from the Barents Sea reared under laboratory conditions: morphology and behavior. Journal of the Marine Biological Association of the UK 86: 317–333.

Faxon, W. 1895. Reports on an exploration off the west

coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U.S. Fish Commission Steamer Albatross during 1891, Lieut.-Commander Z.L. Tanner, U.S.N., commanding. XV. The stalk-eyed Crustacea. Memoirs of the Museum of Comparative Zoölogy at Harvard College 8: 1–292.

Feldmann, R. M. 1998. *Paralomis debodeorum*, a new species of decapod crustacean from the Miocene of New Zealand: first notice of the Lithodidae in the fossil record. New Zealand Journal of Geology and Geophysics 41: 35–38.

Feldmann, R. M. 2003. The Decapoda: new initiatives and novel approaches. Journal of Paleontology 77: 1021–1039.

Feldmann, R. M., C. E. Schweitzer, S. Casadío, and M. Griffin. 2011. New Miocene Decapoda (Thalassinidea: Brachyura) from Tierra del Fuego, Argentina: paleobiogeographic implications. Annals of Carnegie Museum 79: 91–123.

Fraaije, R. H. B. 2014. A new shallow-marine munidopsid (Anomura, Galatheoidea) from the Upper Miocene in the Maroni-Psematismenos Basin of Cyprus. In: R. H. B. Fraaije, M. Hyžný, M., J. W. M. Jagt, M. Krobicki, and B. W. M. Van Bakel (eds.), Proceedings of the 5th Symposium on Mesozoic and Cenozoic Decapod Crustaceans, Krakow, Poland, 2013: A tribute to Pál Mihály Müller. Scripta Geologica 147: 233–239.

Haan, W. de. 1833–1850. Crustacea. In: Siebold, P. F. von, Fauna Japonica sive Descriptio Animalium, Quae in Itinere per Japoniam, Jussu et Auspiciis Superiorum, qui Summum in India Batava Imperium Tenent, Suscepto, Annis 1823–1830 Collegit, Noitis, Observationibus et Adumbrationibus Illustravit. Leiden, Lugduni-Batavorum: i–xvii, i–xxxi, ix–xvi, 1–243, plates A–J, L–Q, 1–55.

Hachiya, K., M. Yamaoka, and Y. Mizuno. 1993. 5. Description of characteristic fossil beds. In: Tokai-kaseki-morozaki-sougun-kankou-kai (ed.), Fossils from the Miocene Morozaki Group—Fossils of Aichi Prefecture, no. 2, Tokai Fossil Society, Nagoya, Japan: 27–40.

Hall, S., and S. Thatje. 2010. King crabs up-close: ontogenetic changes in ornamentation in the family Lithodidae (Crustacea, Decapoda, Anomura), with a focus on the genus *Paralomis*. Zoosystema 32: 495–524.

Imaizumi, R. 1951. *Trachycarcinus huziokai* n. sp. from Yamagata Prefecture. Short Papers, IGPS (Short Papers from the Institute of Geology and Palaeontology, Tohoku University) 3: 33–40, pl. 6.

Ito, C., T. Irizuki, and M. Iwai. 1999. Daiatom zonal key species and geologic ages of the Miocene Morozaki, Iwamura and Tomikusa Groups in the First Setouchi Province, central Japan. The Journal of the Geological Society of Japan 105: 152–155.

Karasawa, H. 1991. Decapod crustaceans from the Miocene Mizunami Group, central Japan. Part 3. Decapod crustacean assemblage and paleoecology, with description of two species. Bulletin of the Mizunami Fossil Museum 18: 1–18.

Karasawa, H., and M. Ohara. 2012. Decapoda from the Miocene Kumano Group, Wakayama Prefecture, Japan. Bulletin of the Mizunami Fossil Museum 38: 53–57.

Karasawa, H., and C. E. Schweitzer. 2006. A new classification of the Xanthoidea sensu lato (Crustacea: Decapoda: Brachyura) based on phylogenetic analysis and traditional systematics and evaluation of all fossil Xanthoidea sensu lato. Contributions to Zoology 75: 23–73.

Key, M. M. Jr., J. W. Volpe, W. B. Jefferies, and H. K. Voris. 1997. Barnacle fouling of the blue crab *Callinectes sapidus* at Beaufort, North Carolina. Journal of Crustacean Biology 17: 424–439.

Koelbel, C. 1892. Beitraege zur Kenntnis der Crustaceen der Canarischen Inseln. Annalen des Naturhistorischen Museums in Wien 7: 105–116.

Kurata, H. 1956. The larval stages of *Paralithodes brevipes* (Decapoda, Anomura), Bulletin of the Hokkaido Regional Fisheries Research Laboratory 14: 25–34.

Latreille, P. A. 1806. Genera Crustaceorum et Insectorum secundum Ordinem naturalem in Familias disposita, iconibus, exemplisque plurimus explicata. Paris, Apud Amand Koenig Bibliopolam. Vol. 1: 302 pp.

Leach, W. E. 1815–1875. Malacostraca Podophthalmata Britanniæ; or Descriptions of Such British Species of the Linnean Genus Cancer as Have Their Eyes Elevated on Footstalks. London, Sowerby: 124 pp., pls. 1–45.

Linnaeus, C. 1758. Systema Naturae per Regna tria Naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Edition 10. Holmiae. Vol. 1: 1–824.

Lovrich, G. A., and M. Thiel. 2011. Ecology, Physiology, feeding and trophic role of Squat Lobsters. In: G. C. B. Poore, S. T. Ahyong, and J. Taylor (eds.), The Biology of Squat Lobsters, CSIRO Publishing, Australia and CRC Press, USA: p. 183–222.

MacLeay, W. S. 1838. On the brachyurous decapod Crustacea brought from the Cape by Dr. Smith. In Smith, A., Illustrations of the Annulosa of South Africa; being a portion of the objects of natural history chiefly collected during an expedition into the interior of South Africa, under the direction of Dr. Andrew Smith, in the

years 1834, 1835. and 1836; fitted out by "The Cape of Good Hope Association for Exploring Central Africa...". London: 53–71, 2 pls.

Macpherson, E., and M. Segonzac. 2006. Arthropoda: Decapoda, Anomura. In: D. Desbruyères, M. Segonzac, and M. Bright, M. (eds), Handbook of deep-sea hydrothermal vent fauna. *Denisia* 18: 436, 437, 439, 441–443, 447.

Macpherson, E., and K. Baba. 2011. Taxonomy of Squat Lobsters. In: G. C. B. Poore, S. T. Ahyong, and J. Taylor (eds.), The Biology of Squat Lobsters, CSIRO Publishing, Australia and CRC Press, USA: p. 40–71.

Makarov, V. V. 1934. Eine neue Gattung der Familie Lithodidae aus dem japanischen Meer. Zoologischer Anzeiger 108: 251–254.

Manning, R. B., and L. B. Holthuis. 1981. West African Brachyuran Crabs (Crustacea: Decapoda). Smithsonian Contribution of Zoology 306: 1–379.

Miers, E. J. 1886. Part II. Report on the Brachyura collected by H.M.S. Challenger during the years 1873–76. In: Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873–1876 under the command of Captain George S. Nares, N.R., F.R.S. and the late Captain Frank Tourle Thomson, R.N. prepared under the Superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S. & c. Regius Professor of Natural history in the University of Edinburgh of the civilian scientific staff on board and now of John Murray one of the naturalists of the Expedition. Zoology, Published by Order of Her Majesty's Government. London, Edinburgh and Dublin 17: i–l+1–362, pls. 1–29.

Milne Edwards, A. 1880. Études préliminaires sur les Crustacés, 1re Partie. In, Reports on the Results of Dredging under the Supervision of Alexander Agassiz, in the Gulf of Mexico, and in the Caribbean Sea, 1877, '79, by the U.S. Coast Survey Steamer."Blake", Lieut-Commander C.D. Sigsbee, U.S.N., and Commander. J.R. Bartlett, U.S.N., Commanding. Bulletin of the Museum of Comparative Zoology 8: 1–68.

Milne Edwards, A., and E. L. Bouvier. 1984. Troisième campagne du yacht l'Hirondelle, 1887. *Neolithodes*, genre nouveau de la sous-famille des Lithodinés. Bulletin de la Société Zoologique de France 9: 20–22.

Milne Edwards, H., and H. Lucas. 1841. Description des Crustacés nouveaux ou peu connus conserves dans la collection du museum. Archives du Muséum national d'Histoire naturelle Paris 2: 461–483.

Milne Edwards, H., and H. Lucas. 1843. Crustacés. In: A. D. d'Orbigny (éditeur), Voyage dans l' Amérique Méridionale (Le Brésil, la République orientale de l'Urugauy, la République Argentine, la Patagonie, la République du Chili, la République de Bolivie, la République du Pérou), exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1831, 1832 et 1833. Bertrand, Paris: pp. 1–39.

Mizuno, Y. 1992. Fossil echinoids from the Miocene Morozaki Group. Bulletin of the Mizunami Fossil Museum 19: 337–346, pls. 52, 53.

Mizuno, Y., and M. Takeda. 1993. 6-3. Crustacea. In: Tokai-kaseki-morozaki-sougun-kankou-kai (ed.), Fossils from the Miocene Morozaki Group—Fossils of Aichi Prefecture, no. 2, Tokai Fossil Society, Nagoya, Japan: 77–90.

Nagao, T. 1941. On some fossil Crustacea from Japan. Hokkaido Imperial University, Journal of the Faculty of Science, Series 4 6: 86–100.

Ortmann, A. E. 1898. Crustacea, Malacostraca. In: A. Gerstäcker and A. E. Ortmann (eds.), Die Klassen und Ordnungen der Arthropoden wissenschaftlich dargestellt in Wort und Bild, in H.G. Bronn's Die Klassen und Ordnungen der Thier-Reichs wissenschaftlich dargestellt in Wort und Bild, C. F. Winter'sche Verlagshandlung, Leipzig 5(2): 1057–1168, pls 109–116.

Robins, C. M., R. M. Feldmann, and C. E. Schweitzer. 2012. The oldest Munididae (Decapoda: Anomura: Galatheoidea) from Ernstbrunn, Austria (Tithonian). Annalen des Naturhistorischen Museums in Wien. Serie A für Mineralogie und Petrographie, Geologie und Paläontologie, Anthropologie und Prähistorie 114: 289–300.

Saint Laurent, M. de. 1980. Sur la classification et la phylogénie des Crustacés Décapodes Brachyoures. I. Podotremata Guinot, 1977, et Eubrachyura sect. nov. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, Paris, (D) 290: 1265–1268.

Samouelle, G. 1819. The entomologist's useful compendium, or an introduction to the British insects, etc. T. Boys, London: 496 pp.

Sasaki, J., and H. Yoshida. 1999. Growth of juvenile Hanasaki crabs, *Paralithodes brevipes* (Lithodidae, Anomura, Decapoda) in the littoral zone, northwestern North Pacific off Hokkaido. Scientific reports of Hokkaido Fisheries Experimental Station 55: 155–160.

Sato, S. 1958. Studies on larval development and fishery biology of king crab, *Paralithodes camtschatica* (Tilesius). Bulletin of the Hokkaido Regional Fisheries Research Laboratory 17: 1–103.

Schweitzer, C. E., and R. M. Feldmann. 2008. New Eocene hydrocarbon seep decapod crustacean (Anomura: Galatheidae: Shinkaiinae) and its paleobiology. Journal of Paleontology 82: 1021–1029.

Takeda, M., Y. Mizuno, and M. Yamaoka. 1986. Some fossil crustaceans from the Miocene Morozaki Group in the

Chita Peninsula, central Japan. Kaseki-no-tomo (Publication of the Tokai Fossil Society) 28: 12–22.

Tilesius, W. C. 1815. De Cancris Camtschaticis, Oniscis, Entomostracis et Cancellus marinis microscopicis noctilucentibus cum tabulis IV: Aenaeis et appendice adnexo de Acaris et Ricinis Camtschaticis. Auctore Tilesio. Mémoires de l'Académie Impériale de Sciences de St Pétersbourg 5: 33–405.

Waugh, D. A., R. M. Feldmann, R. S. Crawford, S. L. Jakobsen, and K. B. Thomas. 2004. Epibiont preservational and observational bias in fossil marine decapods. Journal of Paleontology 78: 961–972.

White, A. 1847. List of species in the collections of the British Museum. London, British Museum: viii+1–143 pp.

White, A. 1856. Some remarks on Crustacea of the genus *Lithodes* with a brief description of a species apparently hitherto unrecorded. Proceedings of the Zoological Society of London 1856: 32–35.

Whiteaves, J. F. 1874. On recent deep-sea dredging operations in the Gulf of St. Lawrence. American Journal of Science, ser. 3 7: 210–219.

Williams, A. B., and C. L. Van Dover. 1983. A new species of *Munidopsis* from submarine thermal vents of the East Pacific Rise at 21° N (Anomura: Galatheidae). Proceedings of the Biological Society of Washington 96: 481–488.

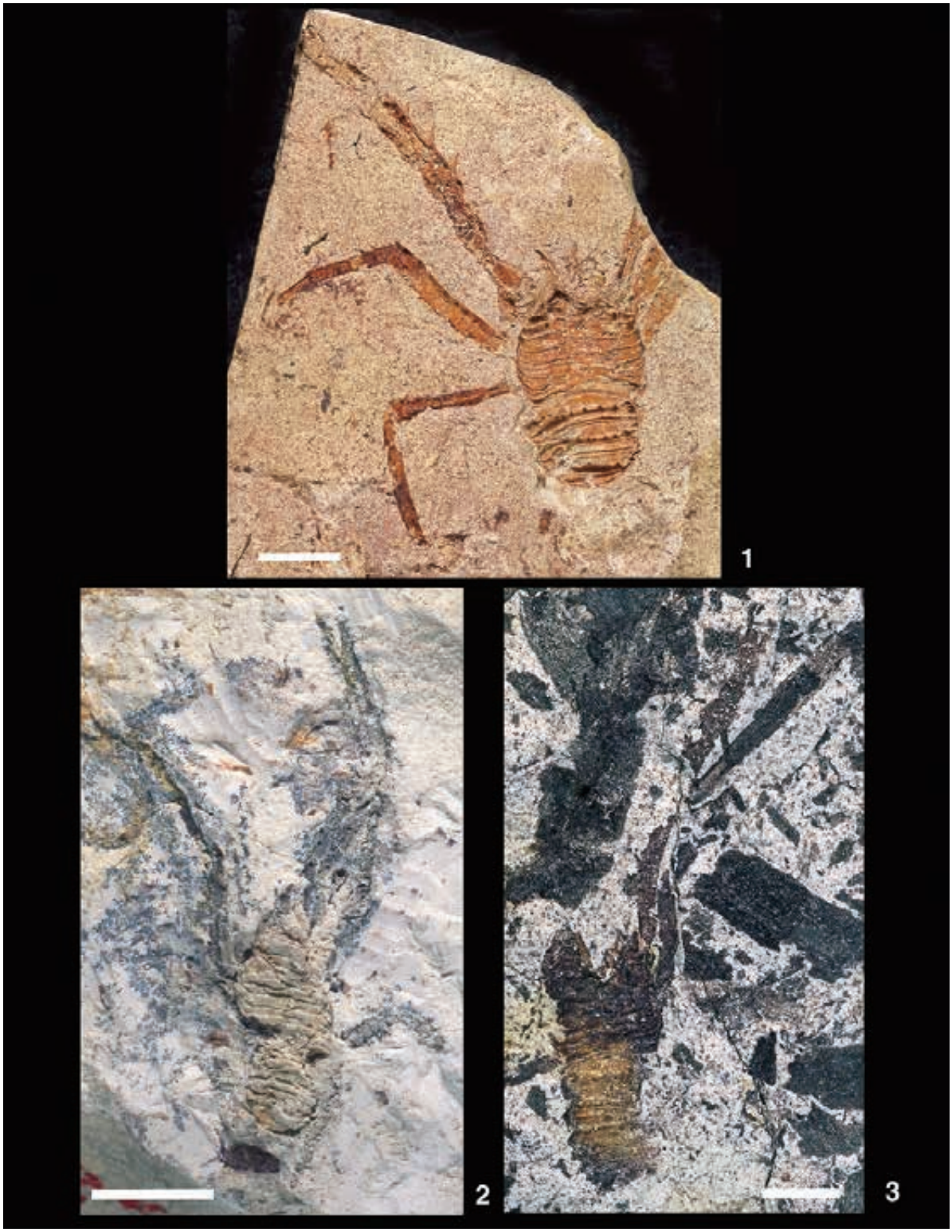
Yamaoka, M. 1993. 3. Geology of Morozaki Group. In: Tokai-kaseki-morozaki-sougun-kankou-kai (ed.), Fossils from the Miocene Morozaki Group—Fossils of Aichi Prefecture, no. 2, Tokai Fossil Society, Nagoya, Japan: 11–22.

Yanagisawa, Y., and F. Akiba. l998. Refined Neogene diatom biostratigraphy for the northwest Pacific around Japan, with an introduction of code numbers for selected diatom biohorizons. The Journal of the Geological Society of Japan 104: 395–414.

Zaklan, S. D. 2002. Review of the family Lithodidae (Crustacea: Anomura: Paguroidea): distribution, biology and fisheries. In: A. J. Paul, E. G. Dawe, R. Elner, G. S. Jamieson, G. H. Kruse, R. S. Otto, B. Sainte-Marie, T. C. Shirley, and D. Woodby (eds.), Crabs in Cold Water Regions: biology, management, and economics, university of Alaska Sea Grant Program. Fairbanks, Alaska: 75–845.

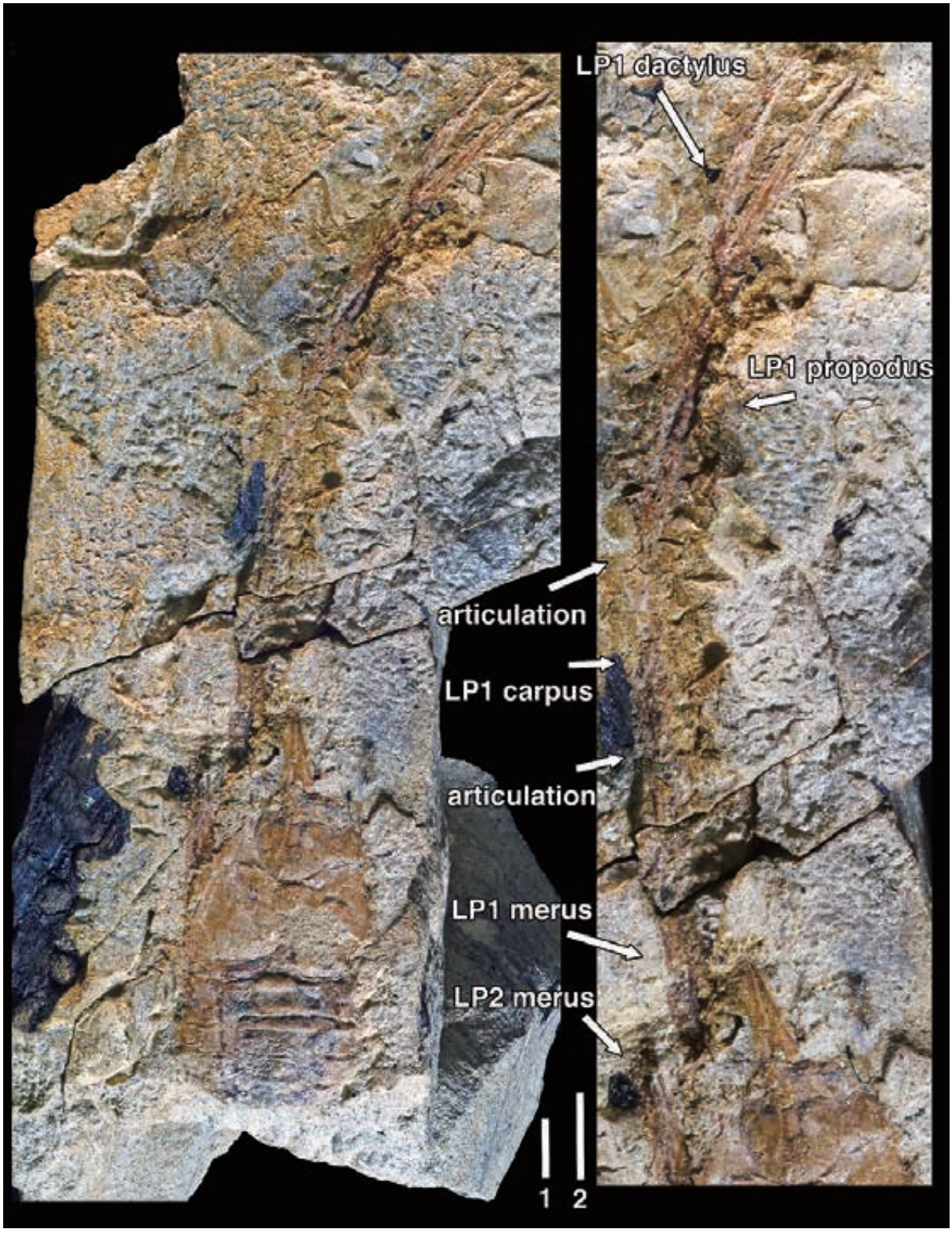
Manuscript accepted on November 5, 2016

**Plate 1**



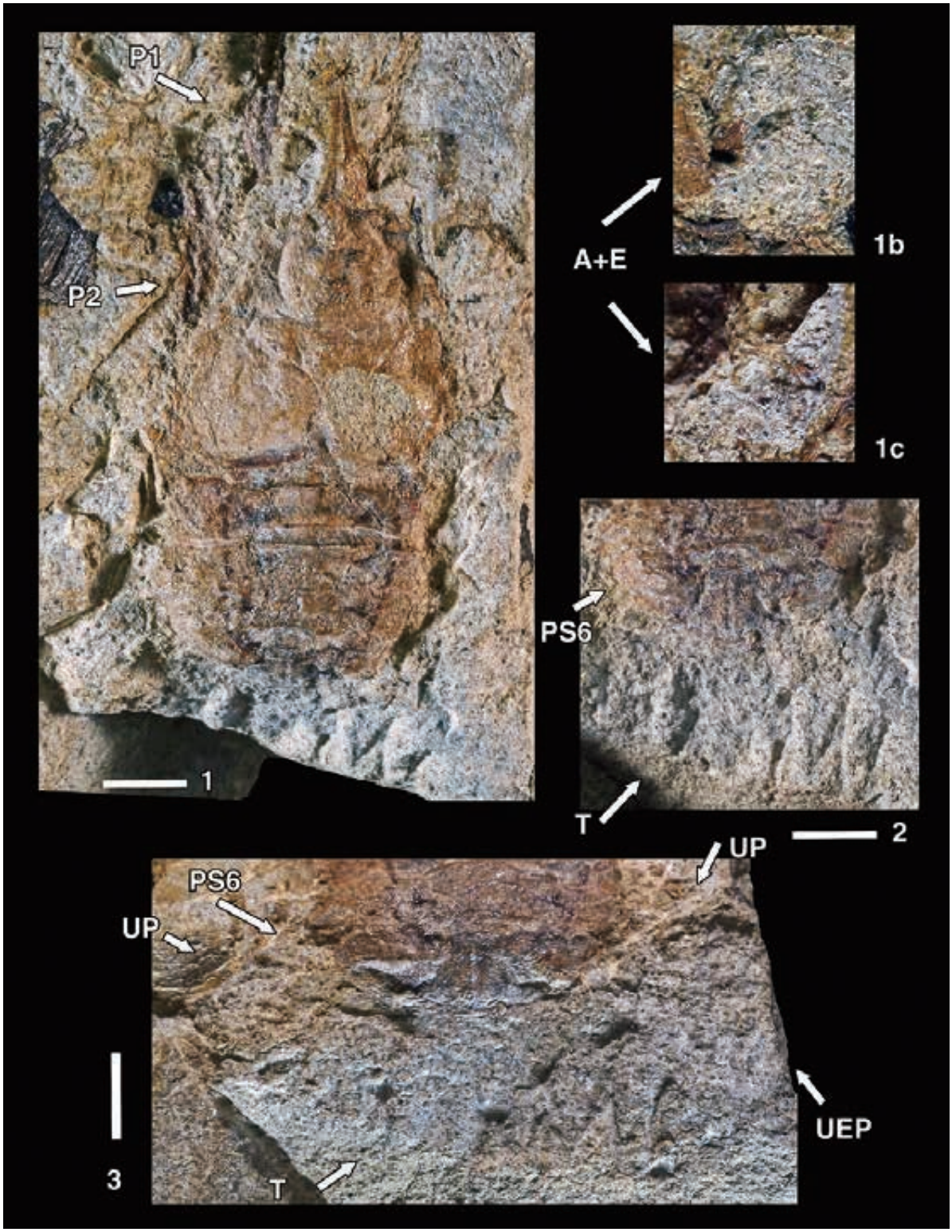

**1–3. Munididae**. ***1*,** MFM83998, external mold of carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ06; ***2*,** MFM83999, carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ06, dorso-lateral view; ***3*,** MFM84000, external mold of carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ05. Scale bar = 1.0 cm.

**Plate 2**



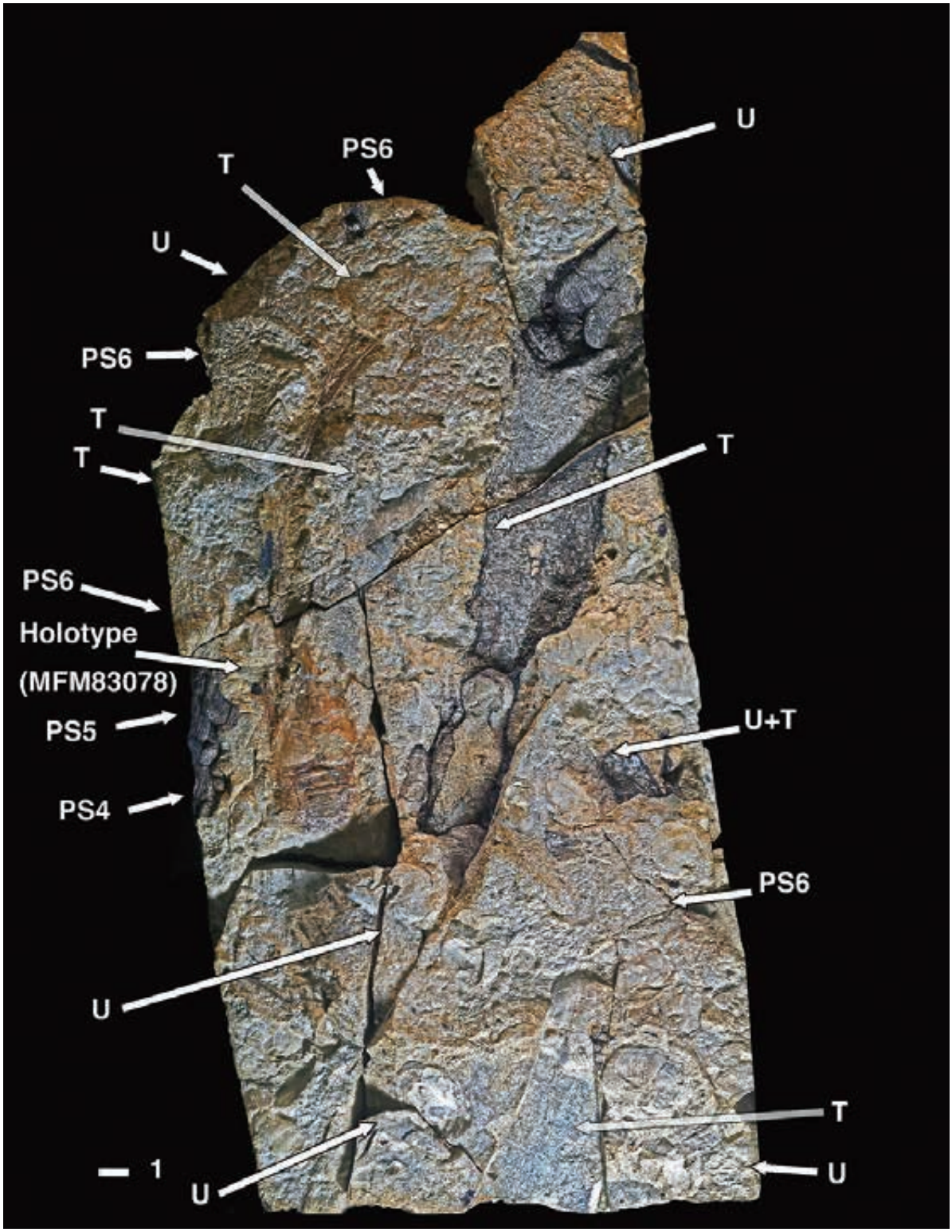

**1, 2. *Mizunotengus makiguchimai*, new genus and new species. *1*,** holotype, MFM83078, carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view; ***2*,** close-up image of pereiopods 1 of holotype (MFM83078), dorsal view. **Abbreviations**: LP1, left pereiopod 1;LP2, left pereiopod 2. Scale bar = 1.0 cm.

**Plate 3**



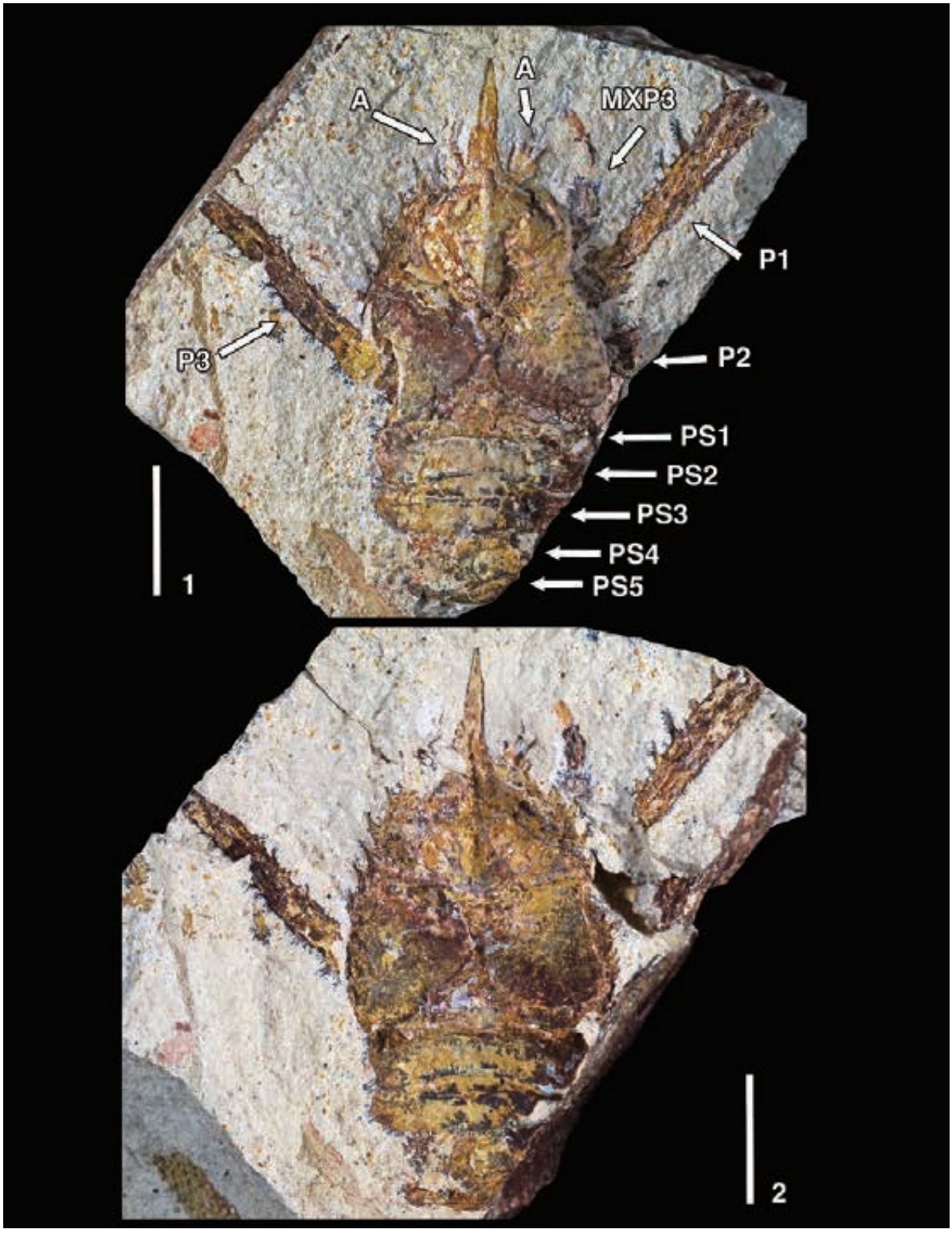

**1–3. *Mizunotengus makiguchimai*, new genus and new species. *1*,** holotype (MFM83078), carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view; ***1b*,** close-up image of right orbital area of holotype (MFM83078); ***1c*,** close-up image of left orbital area of holotype (MFM83078); ***2,3*,** pleon, telson, and uropods of holotype (MFM83078), dorsal view. **Abbreviations**: P1, pereiopod 1; P2, pereiopod 2; A+E, antennule and eye; PS6, pleonal somite 6; T, Telson; UP, peduncle of uropod; UEP, uropodal endopod. Scale bar = 1.0 cm.

**Plate 4**



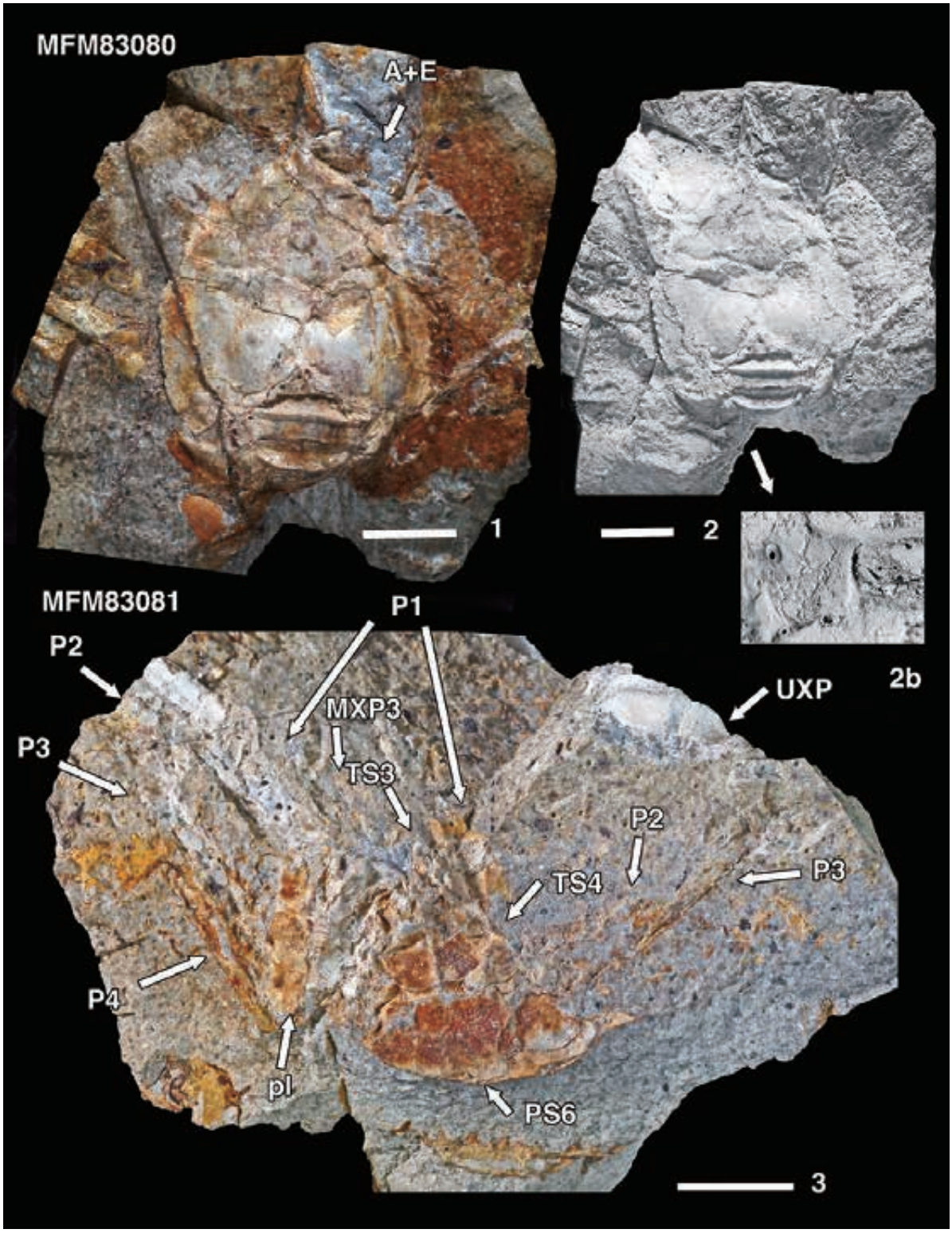

**1. *Mizunotengus makiguchimai*, new genus and new species. *1*,** occurrence of holotype (MFM83078), surrounded by some individuals (no number) with pleonal somites (PS), telson (T), and uropods (U). Scale bar = 1.0 cm.

**Plate 5**



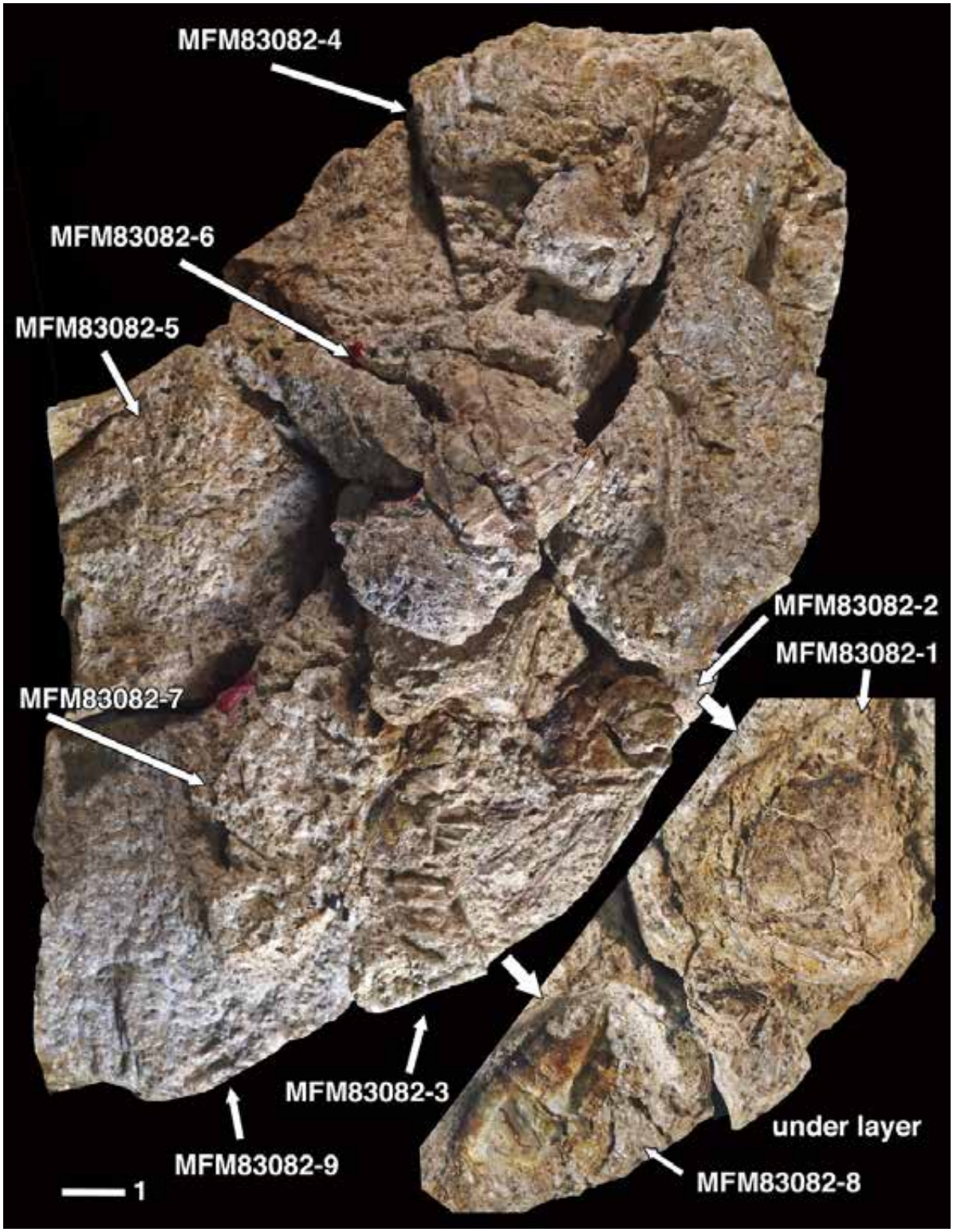

**1, 2. *Mizunotengus makiguchimai*, new genus and new species. *1*,** paratype (MFM83079), carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view; ***2*,** reversed image of external mold of paratype (MFM83079). **Abbreviations**: A, antennule; MXP3, maxilliped 3; P1, pereiopod 1; P2, pereiopod 2; PS1, pleonal somite 1; PS2, pleonal somite 2; PS3, pleonal somite 3; PS4, pleonal somite 4; PS5, pleonal somite 5. Scale bar = 1.0 cm.

**Plate 6**



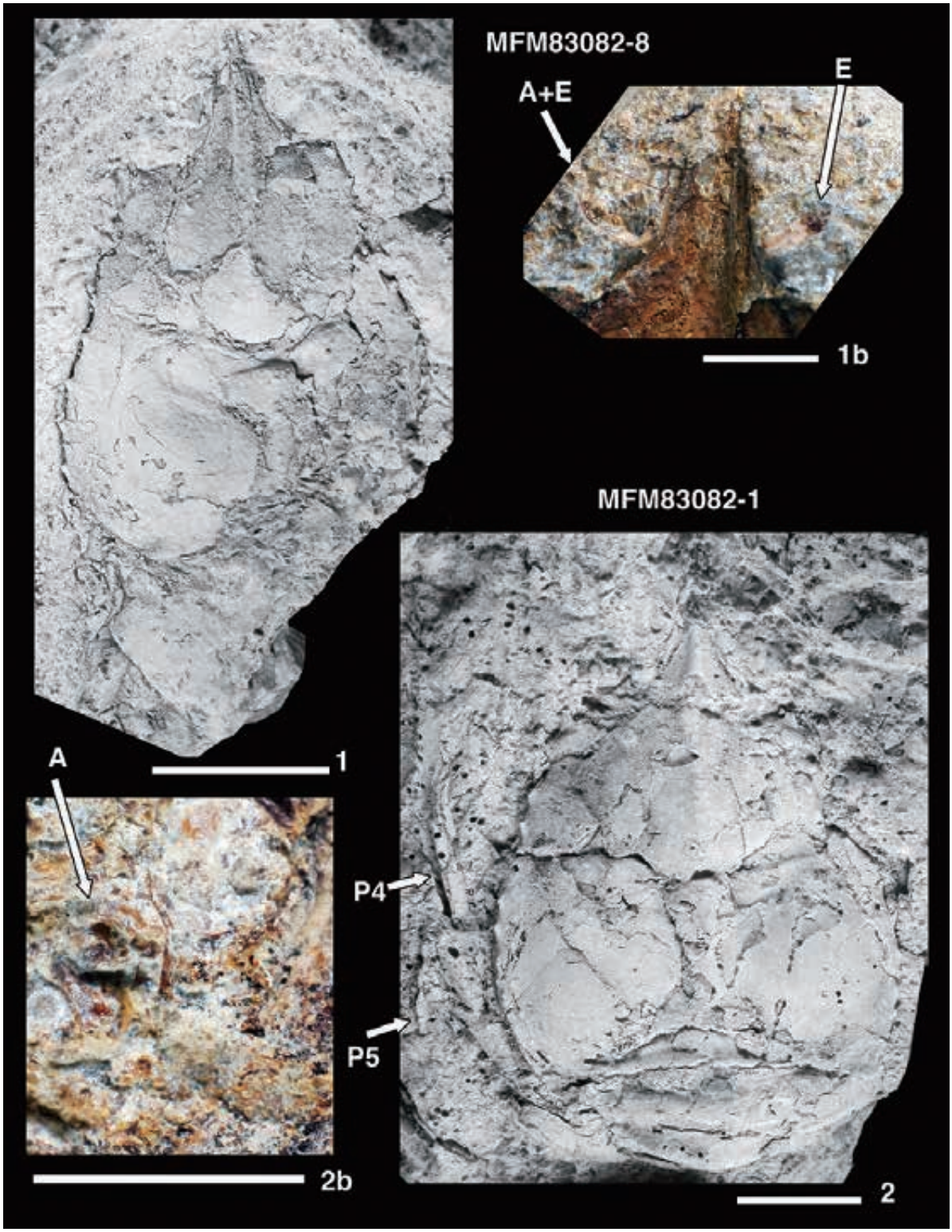

**1–3. *Mizunotengus makiguchimai*, new genus and new species. *1*,** paratype (MFM83080), carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ08, dorsal view; ***2*,** paratype (MFM83080), coated with ammonium chloride sublimate, dorsal view ***2b*,** close-up image of barnacle epibionts attached on pleonal somites; ***3*,** paratype (MFM83081), thoracic sternum, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ08. **Abbreviations**: A+E, antennule and eye; MXP3, maxilliped 3; P1, pereiopod 1; P2, pereiopod 2; P3, pereiopod 3; P4, pereiopod 4; pl, pleurites; PS6, pleonal somite 6; TS, thoracic sternum; TS3, thoracic sternite 3; TS4, thoracic sternite 4; UEP, uropodal endopod. Scale bar = 1.0 cm.

**Plate 7**



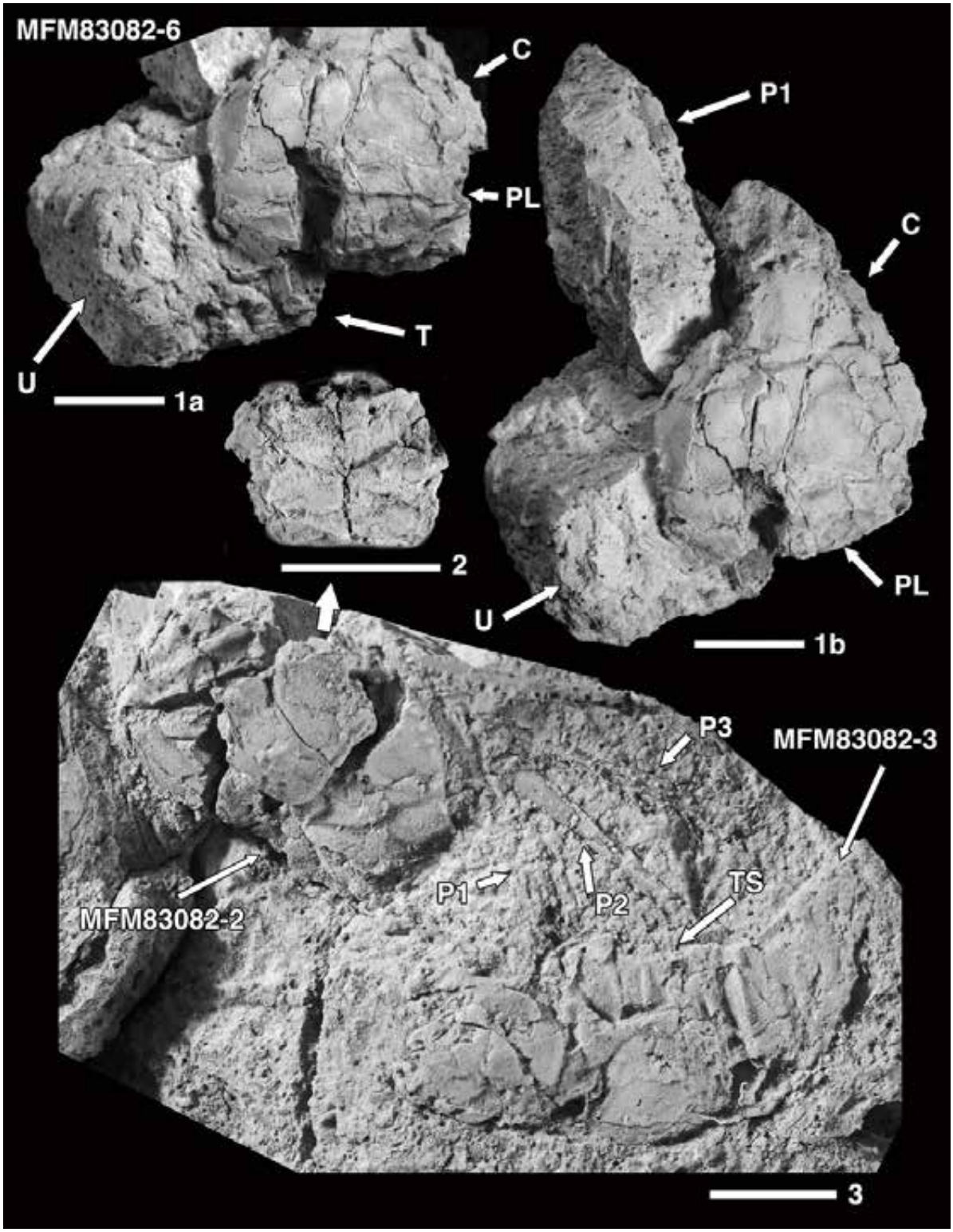

**1. *Mizunotengus makiguchimai*, new genus and new species.** Occurrences of paratype specimens (MFM83082-1–9) preserved within the matrix from the Yamami Formation (lower Miocene), at Loc. MRZ08. Scale bar = 1.0 cm. Note: Pleon, telson and uropods are indistinguishably preserved within MFM83082-5, MFM83082-7, and MFM83082-9.

**Plate 8**



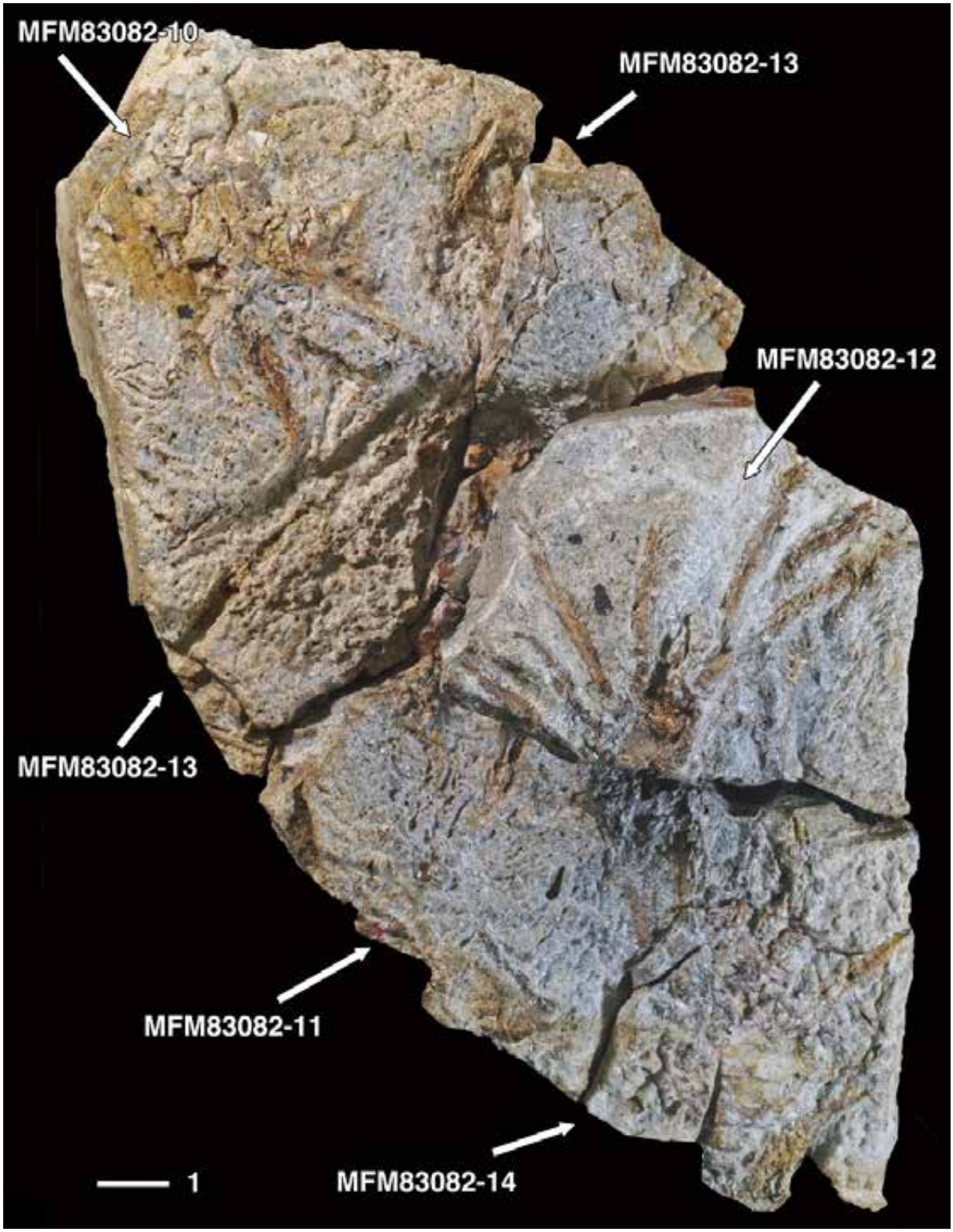

**1–2b.** ***Mizunotengus makiguchimai*****, new genus and new species.** ***1*****,** paratype (MFM83082-8), carapace and pleon, coated with ammonium chloride sublimate, from the Yamami Formation (lower Miocene), at Loc. MRZ08, dorsal view; ***1b*****,** close-up image of right eye (E) and left eye and antennule (A+E) of paratype (MFM83082-8). ***2*****,** paratype (MFM83082-1), carapace, pleon, and pereiopods, coated with ammonium chloride sublimate, from the Yamami Formation (lower Miocene), at Loc. MRZ08, dorsal view; ***2b*****,** close-up image of left antennule (A) of paratype (MFM83082-1). **Abbreviations**: A, antennule; A+E, antennule and eye; E, eye; P4, pereiopod 4; P5, pereiopod 5. 1, 2, Scale bar = 1 cm; 1b, 2b, scale bar = 2.5 mm.

**Plate 9**



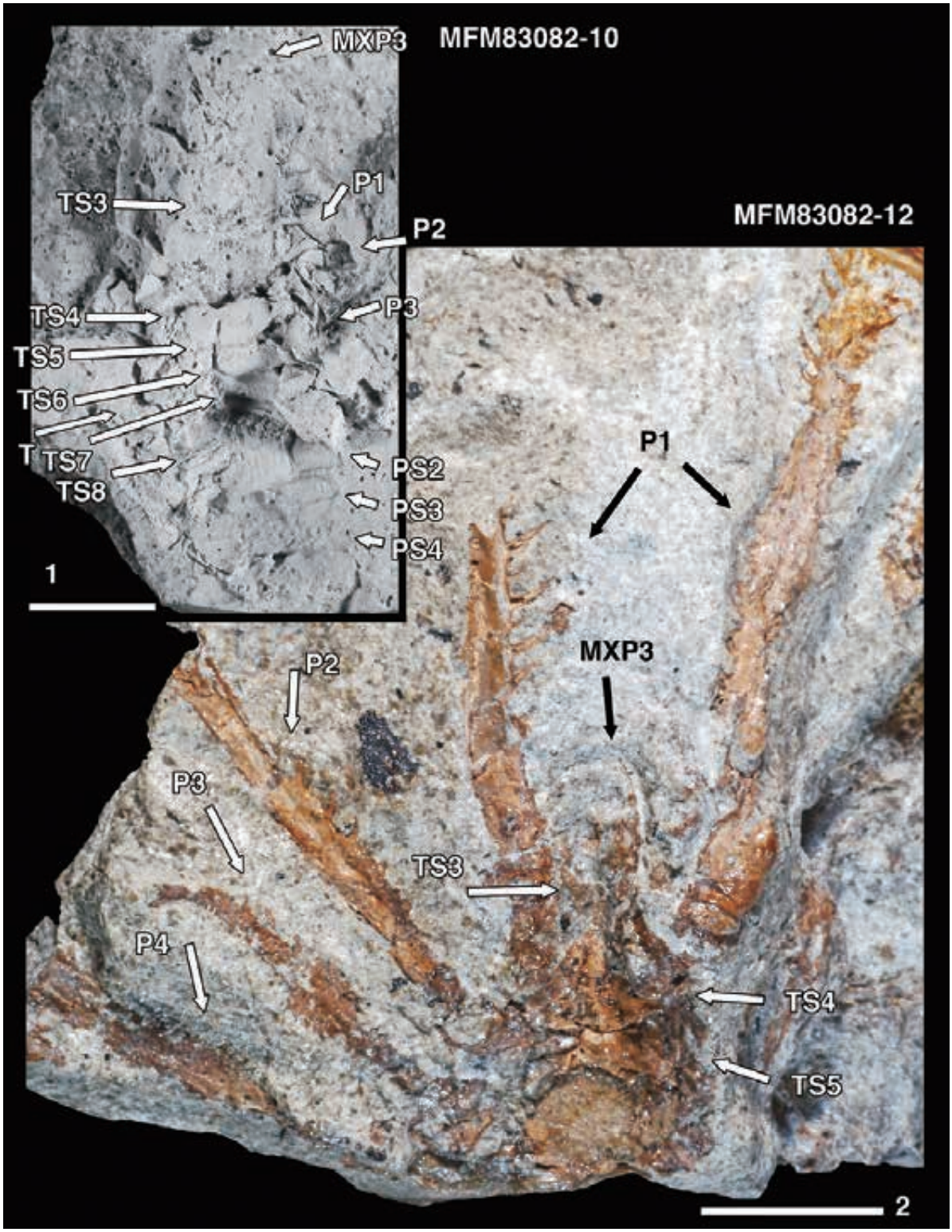

**1a–3.** ***Mizunotengus makiguchimai*****, new genus and new species.** ***1a***, ***b*****,** paratype (MFM83082-6), carapace, pleon, uropods, and pereiopod 1, from the Yamami Formation (lower Miocene), at Loc. MRZ07, a (dorso-posterior view), b (dorsal view); ***2*****,** thoracic sternum of paratype (MFM83082-2), ventral view; ***3*****,** paratype (MFM83082-2), carapace, pleon, and pereiopods, and paratype (MFM83082-3), carapace, thoracic sternum, and pleon, from the Yamami Formation (lower Miocene), at Loc. MRZ08, dorsal view. **Abbreviations**: C, carapace; P1, pereiopod 1; P2, pereiopod 2; P3, pereiopod 3; PL; pleon; T, Telson; TS, thoracic sternum; U, uropods. Scale bar = 1.0 cm. All specimens are coated with ammonium chloride sublimate.

**Plate 10**



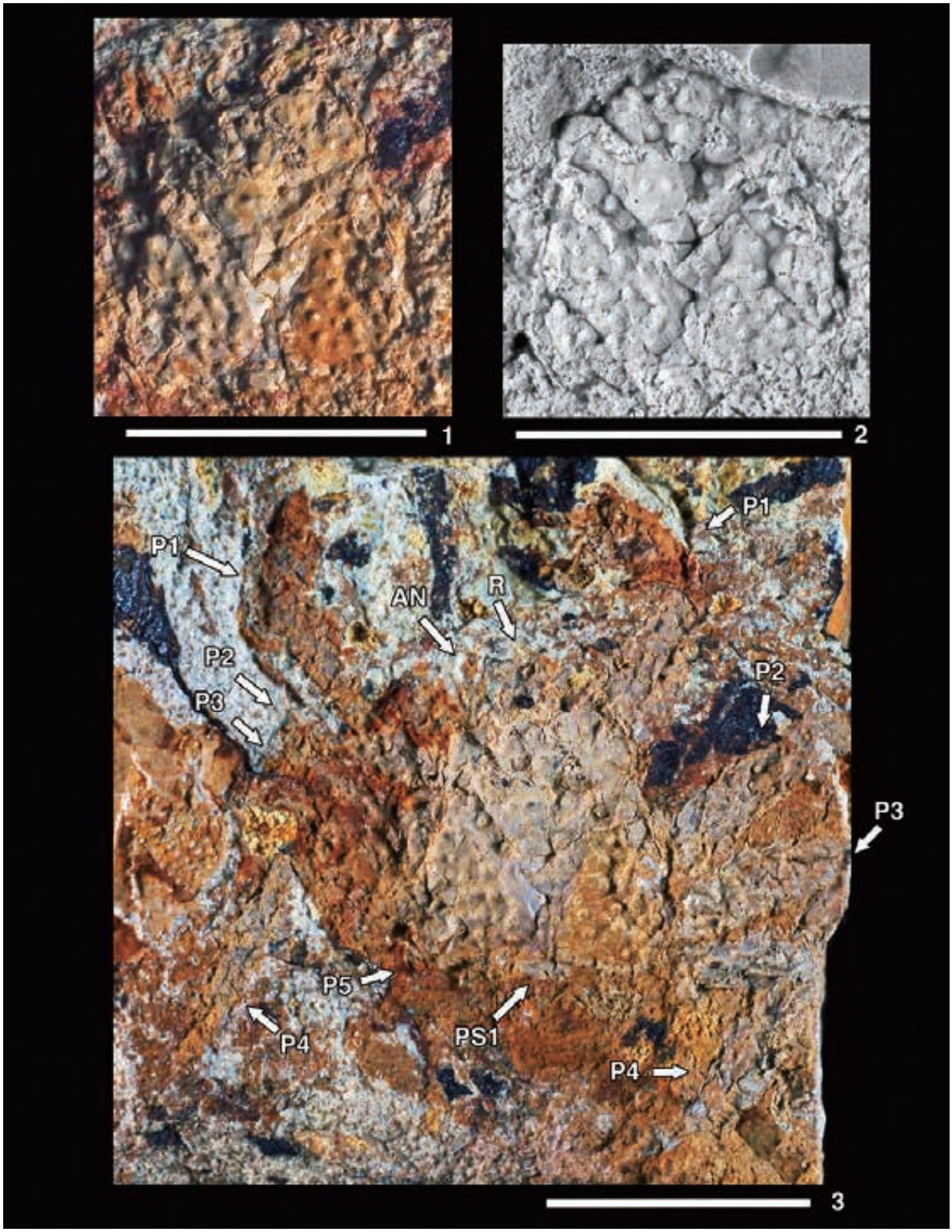

**1. *Mizunotengus makiguchimai*, new genus and new species.** Occurrences of the paratypes (MFM83082-10–14), preserved within the matrix from the Yamami Formation (lower Miocene), at Loc. MRZ08. Scale bar = 1.0 cm. Note: Pleon, telson and uropods are indistinguishably preserved within MFM83082-11, MFM83082-13, and MFM83082-14.

**Plate 11**



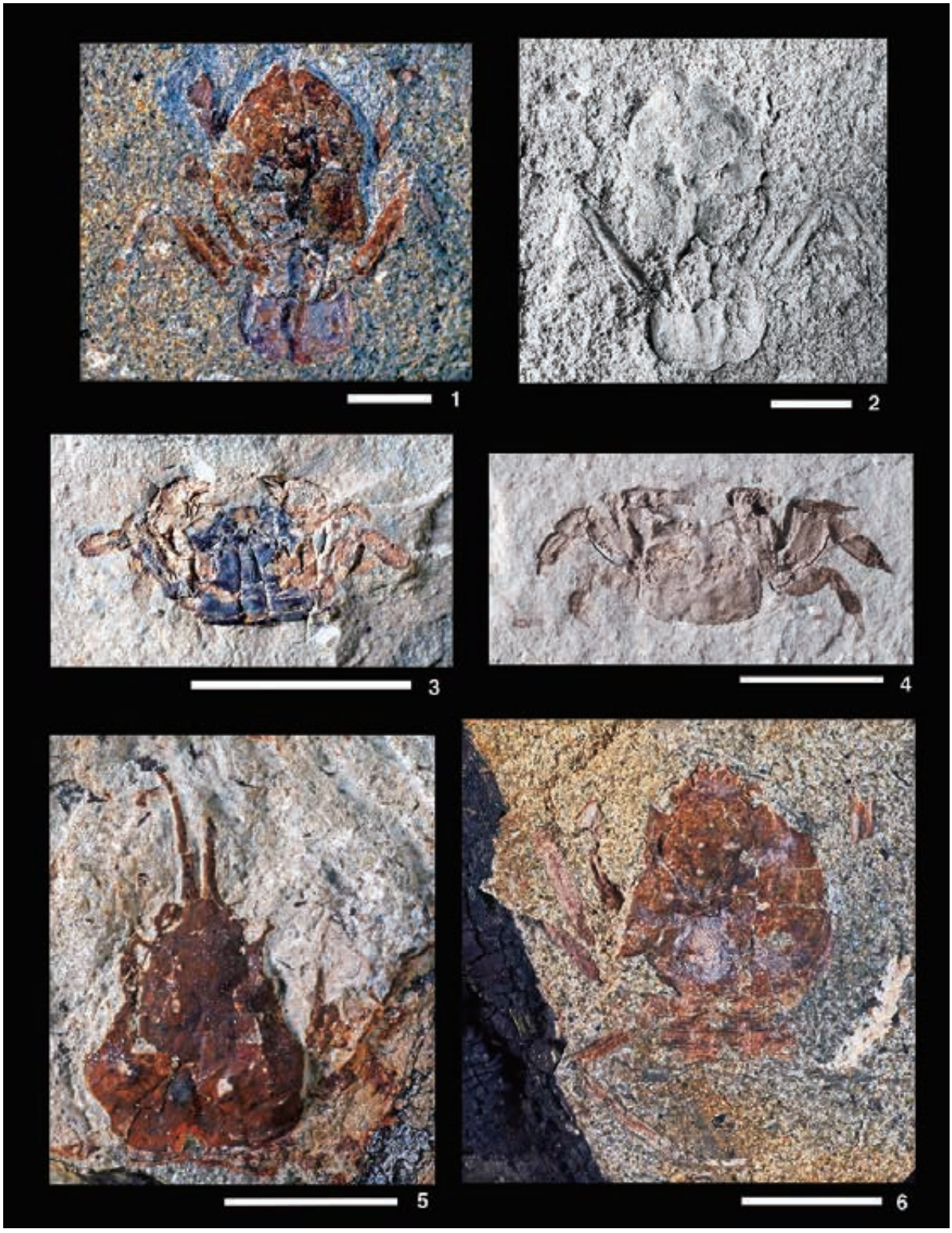

**1, 2. *Mizunotengus makiguchimai*, new genus and new species.** Paratypes (MFM83082-10 and MFM83082-12), thoracic sternum and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ08, ventral view. **Abbreviations**: MXP3, maxilliped 3; P1, pereiopod 1; P2, pereiopod 2; P3, pereiopod 3; P4, pereiopod 4; PS2, pleonal somite 2; PS3, pleonal somite 3; PS4, pleonal somite 4; T, telson; TS3, thoracic sternite 3; TS4, thoracic sternite 4; TS5, thoracic sternite 5; TS6, thoracic sternite 6; TS7, thoracic sternite 7; TS8, thoracic sternite 8. Fig. 1 coated with ammonium chloride sublimate. Scale bar = 1.0 cm.

**Plate 12**




**1-3. *Paralithodes bishuensis*, new species. *1*,** Close-up image of carapace of holotype (MFM83077), dorsal view; ***2*,** latex cast derived from external mold of carapace of MFM83077, coated with ammonium chloride sublimate; ***3*,** holotype, MFM83077, carapace, pleon, pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ06, dorsal view. **Abbreviations**: AN, antenna; P1, pereiopod 1; P2, pereiopod 2; P3, pereiopod 3; P4, pereiopod 4; P5, pereiopod 5; PS1, pleonal somite 1; R, tip of rostrum. Scale bar = 1.0 cm.

**Plate 13**




**1, 2. *Dicranodromia* sp. *1*,** MFM84001, carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ06, dorsal view; ***2*,** close-up image of external cast of MFM84001, coated with ammonium chloride sublimate. **3, 4. *Hexapinus* sp. *3*,** MFM84002, thoracic sternum, pleon, and pereiopods, from the Toyohama Formation (lower Miocene), at Loc. MRZ09, ventral view; ***4*,** MFM84003, carapace and pereiopods, from the Toyohama Formation (lower Miocene), at Loc. MRZ09, dorsal view. **5. *Hyastenus* sp.** MFM84004, carapace and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ06, dorsal view. **6. *Pisoides*? sp.** MFM84005, carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view. Scale bar = 1.0 cm.