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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.

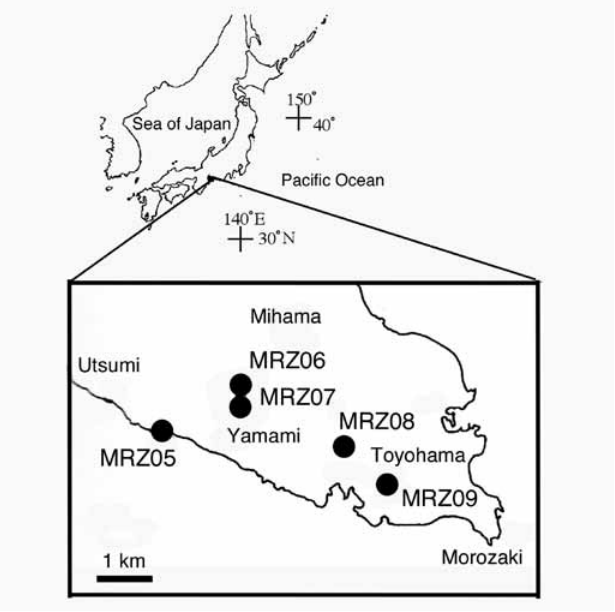


Fig. 1. Map showing the fossil-bearing locality. **Loc**. **MRZ05** (=Loc. 3 of Hachiya *et al*., 1993): beach of Hashizume, Yamami, Minamichita-cho, Aichi Prefecture, Japan; tuffaceous sandstone of the Yamami Formation, Morozaki Group. **Loc. MRZ06** (=Loc. 4 of Mizumo, 1992; =Loc. 1 of Hachiya *et 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

We wish to express our sincere gratitude to members of the Tokai Fossil Society, Y. Imai, M. Umemoto, T. Niwa, T. Yokoi, T. Makiguchi, and T. Mizuno, for offering their specimens for our study. We thank K. Konishi (Research Center for Fisheries Oceanography & Marine Ecosystem, National Research Institute of Fisheries Science) for providing useful literatures and T. Kaede (Mizunami) and T. Goda (Konan) for assisting preparation to our material. R. M. Feldmann (Department of Geology, Kent State University) is gratefully acknowledged for his review of our manuscript.

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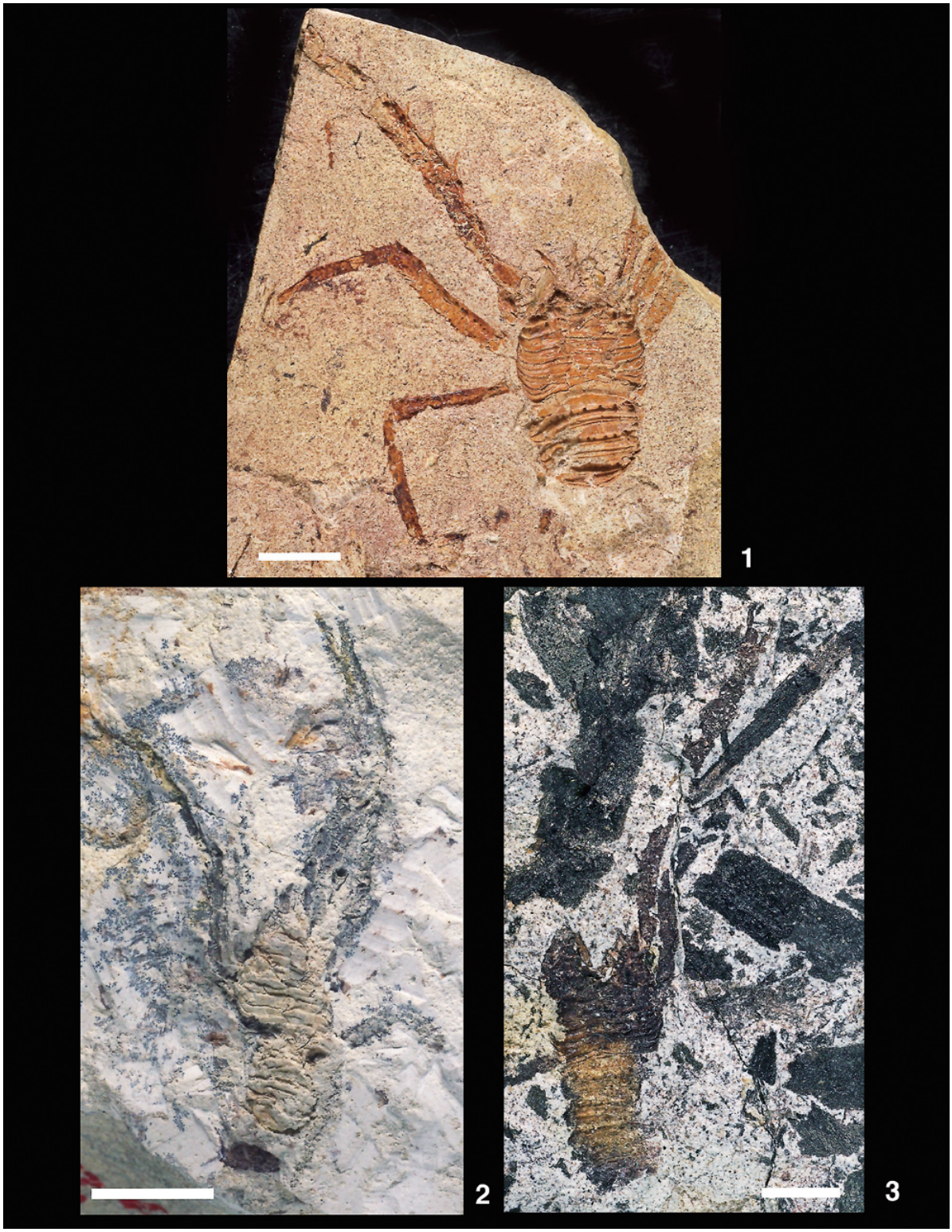
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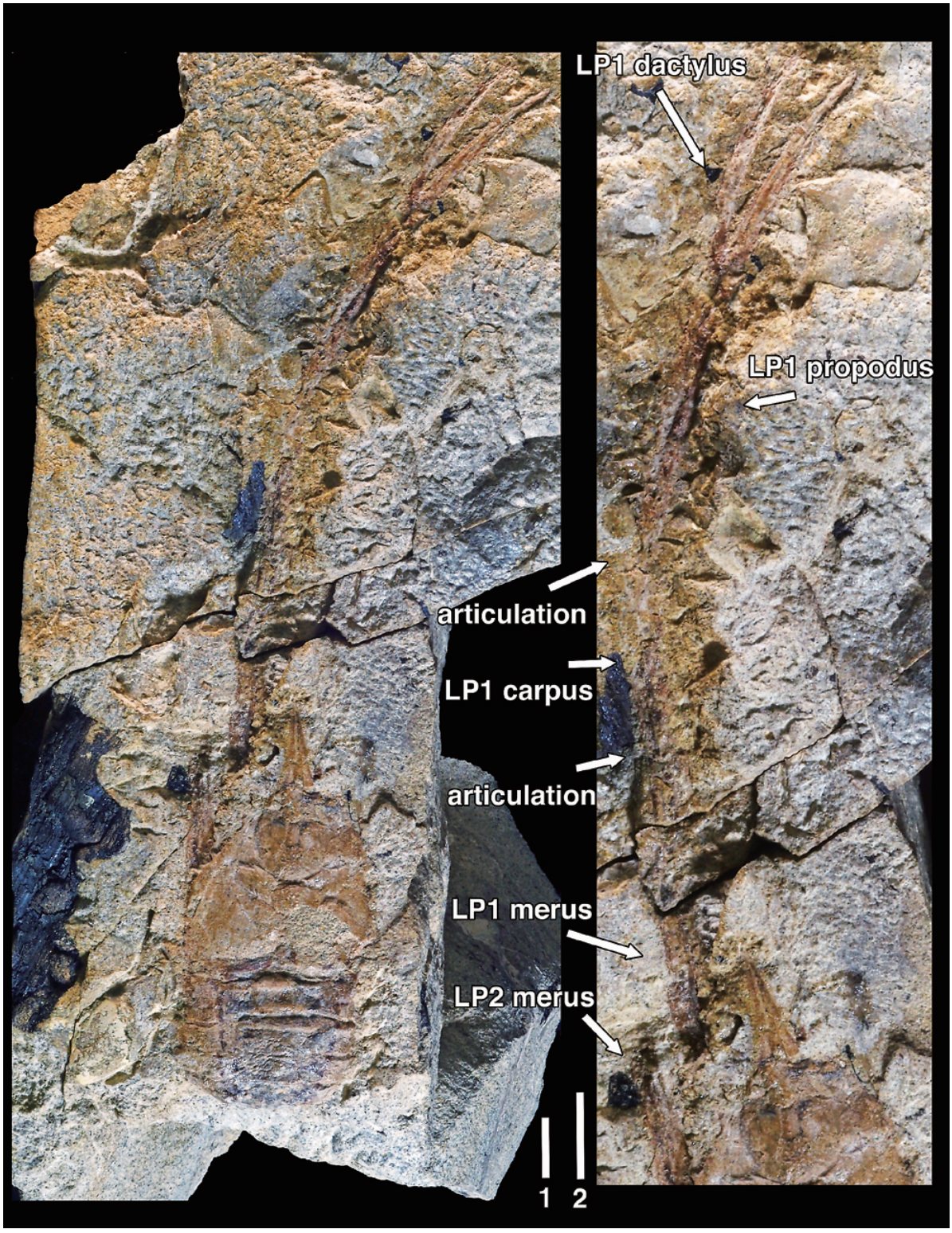
Manuscript accepted on November 5, 2016

Plate 1



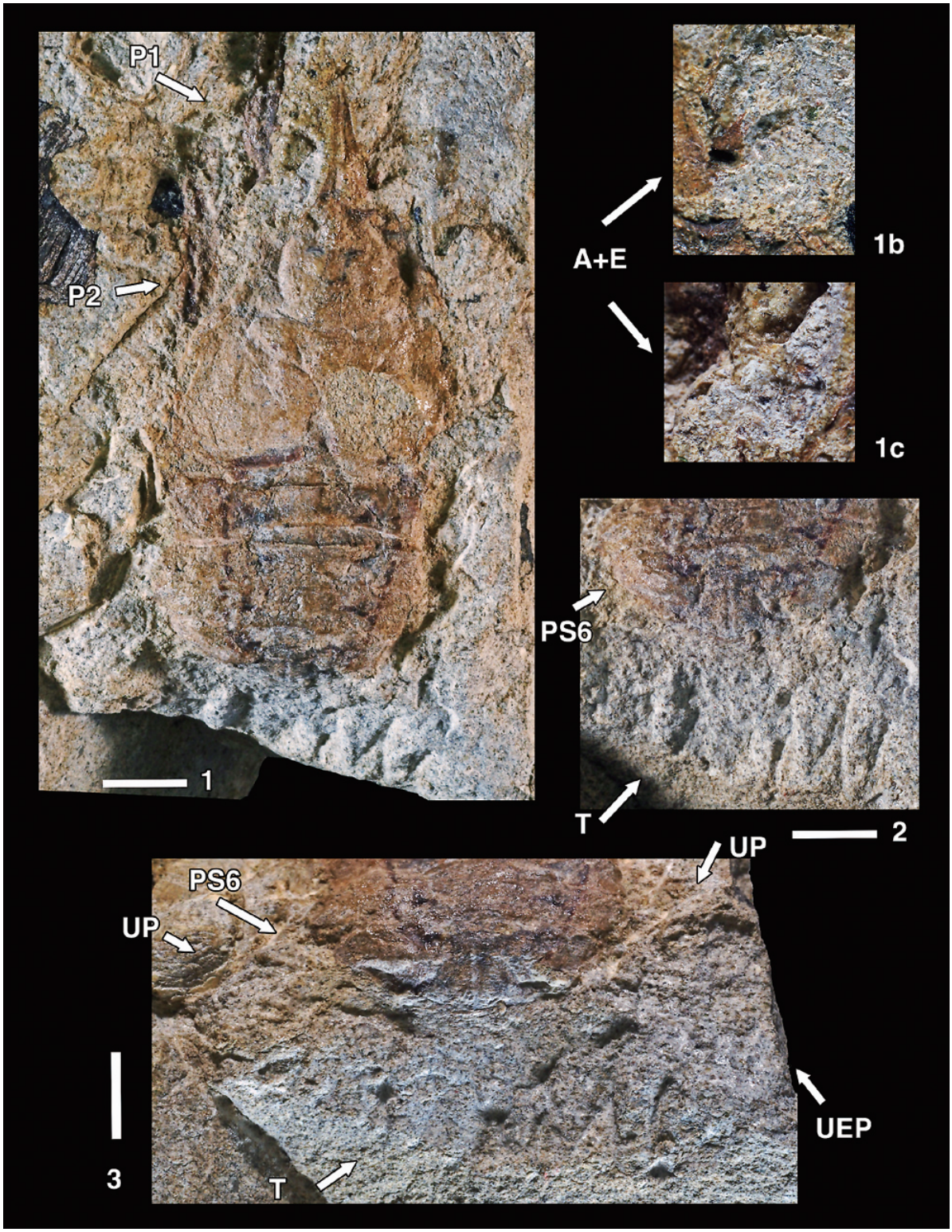
1–3. Munididae. ***1,*** MFM83998, external mold of carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ06; ***2,*** MFM83999, carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ06, dorso-lateral view; ***3,*** MFM84000, external mold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

Plate 2



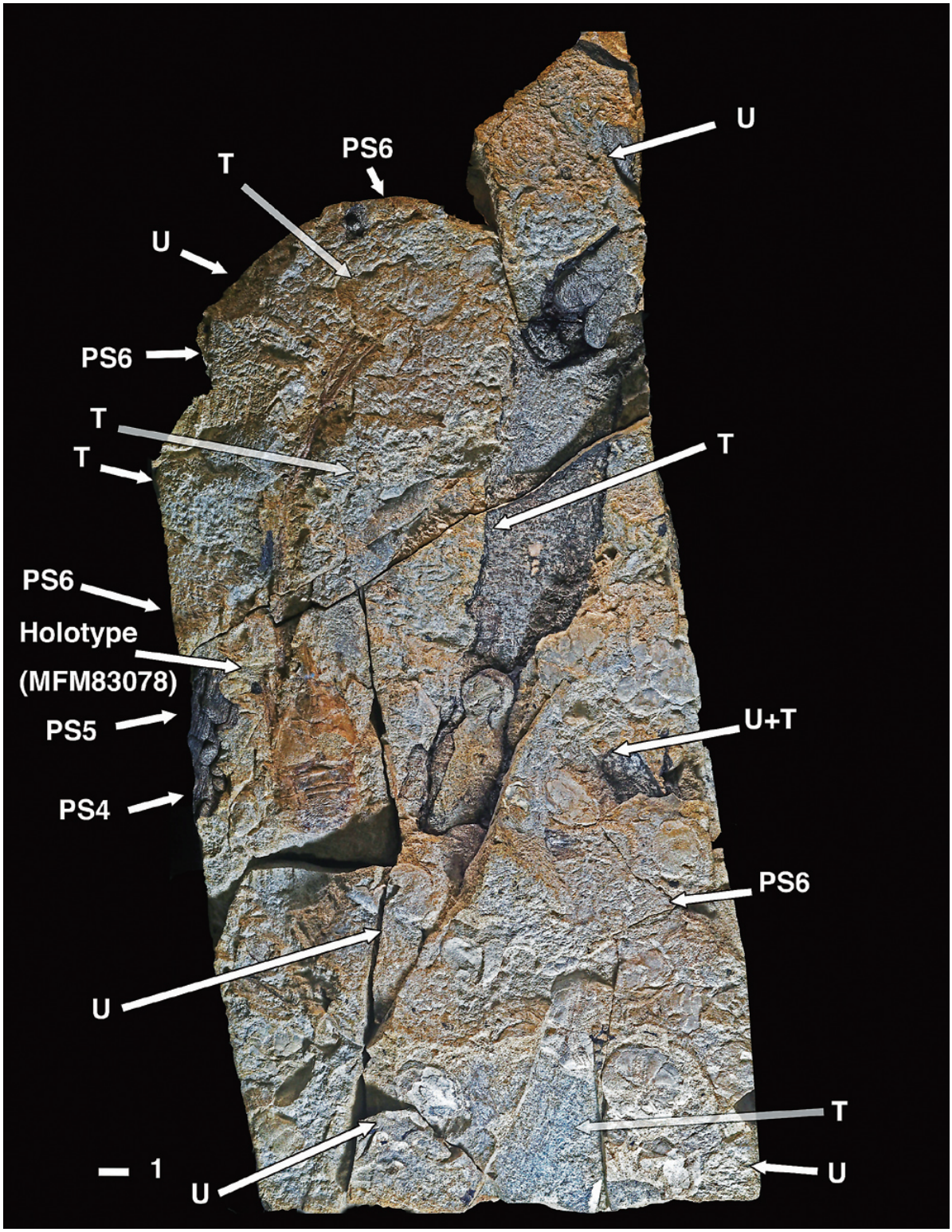
1, 2. *Mizunotengus makiguchimai*, new genus and new species. *1*, holotype, MFM83078, carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view; ***2*,** close-up image of pereiopods 1 of holotype (MFM83078), dorsal view. **Abbreviations**: LP1, left pereiopod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

Plate 3



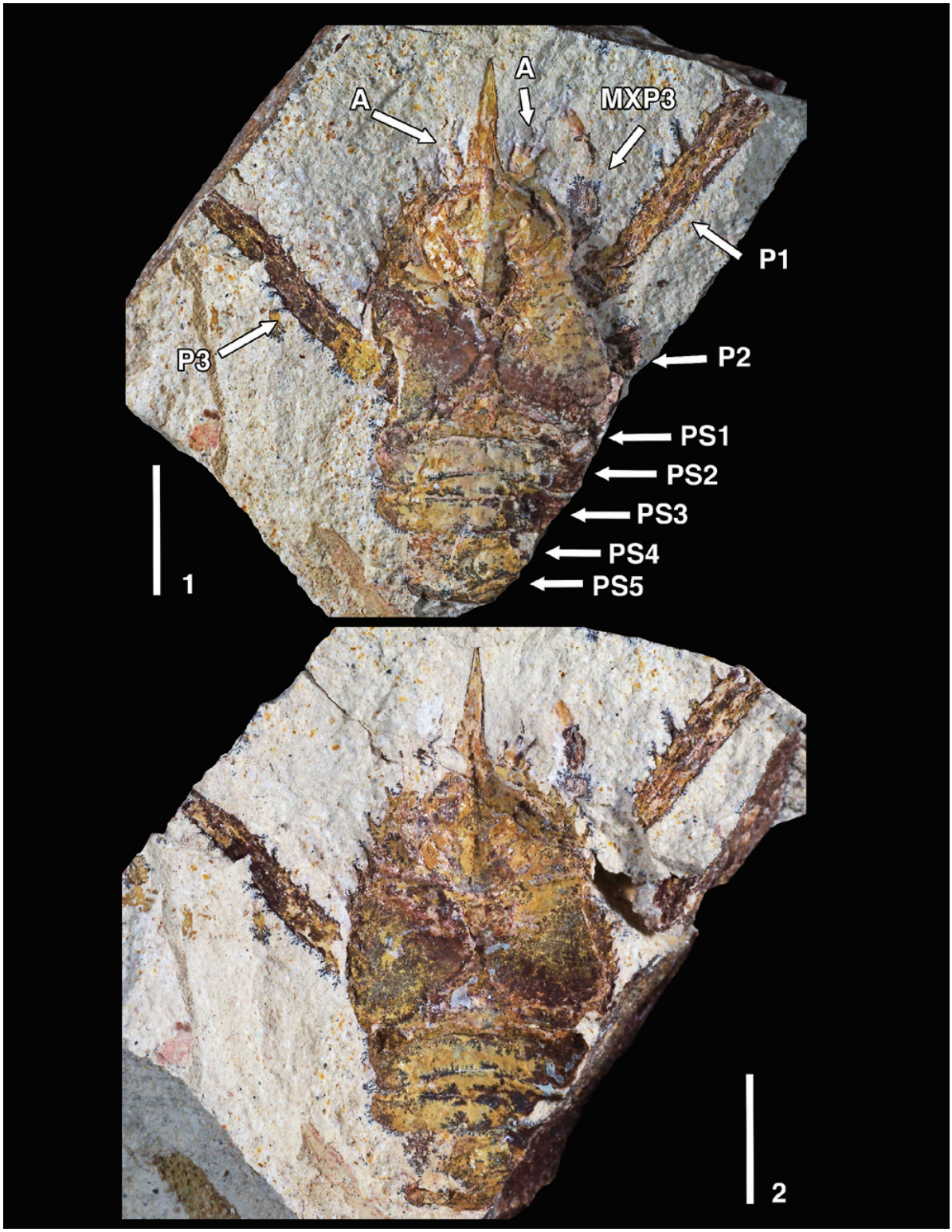
1–3. *Mizunotengus makiguchimai*, new genus and new species. *1*, holotype (MFM83078), carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view; ***1b*,** close-up image of right orbital area of holotype (MFM83078); ***1c*,** close-up image of left orbital 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



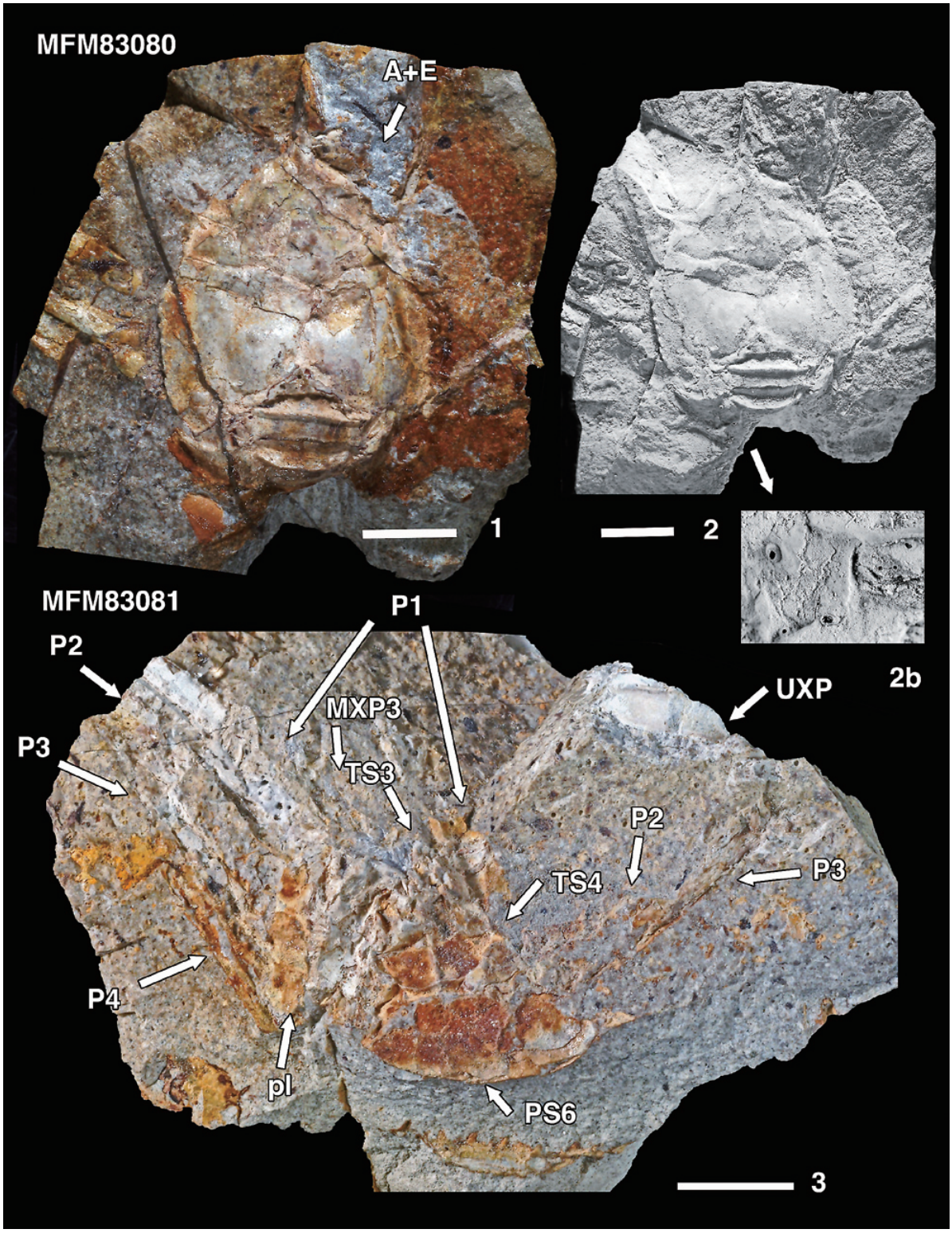
1. *Mizunotengus makiguchimai*, new genus and new species. *1*, occurrence of holotype (MFM83078), surrounded by some individuals (no number) with pleonal somites (PS), telson (T), and uropods (U). Scale bar = 1.0 cm.

Plate 5



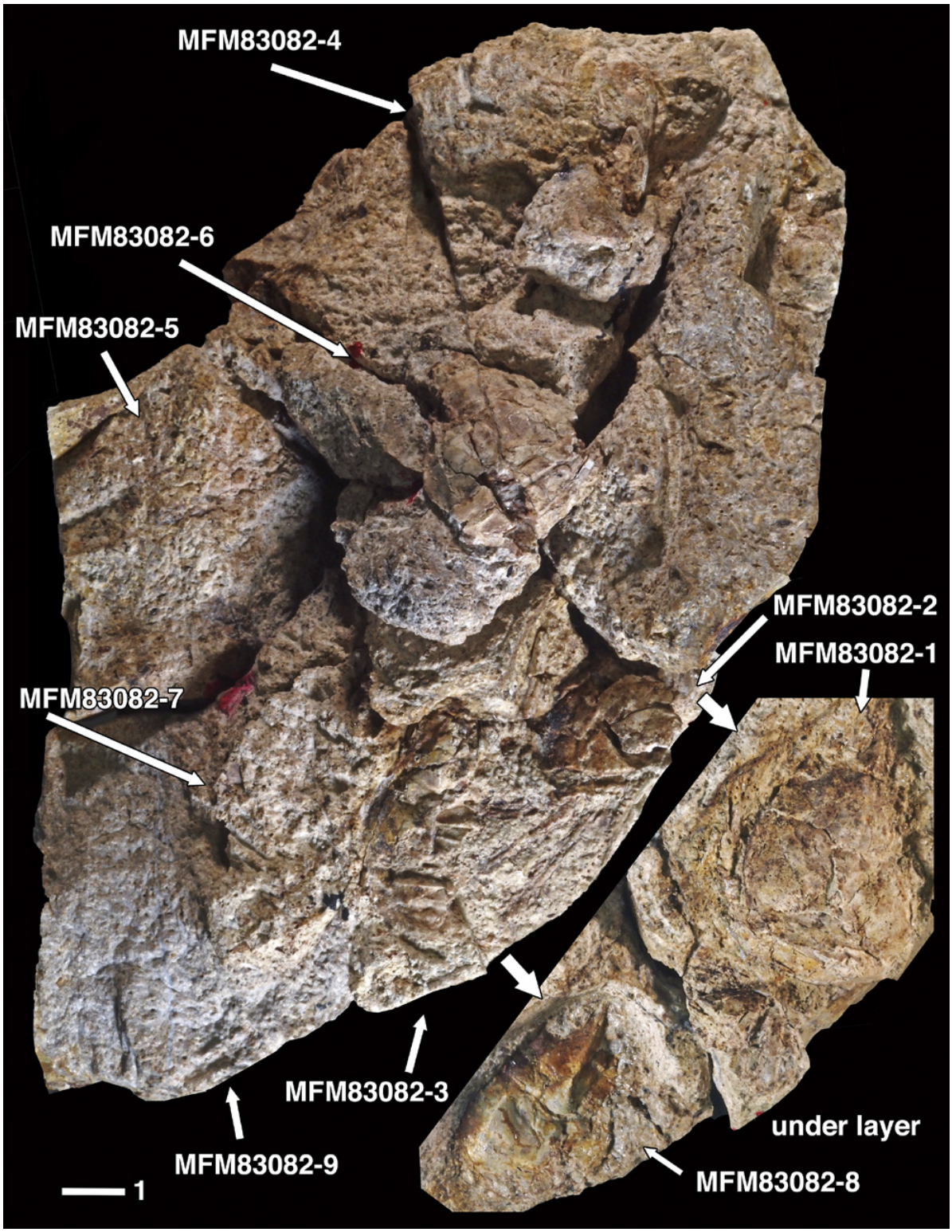
1, 2. *Mizunotengus makiguchimai*, new genus and new species. *1*, paratype (MFM83079), carapace, pleon, and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ07, dorsal view; ***2*,** reversed image of external mold of paratype (MFM83079). **Abbreviations**: A, antennule; MXP3, maxilliped 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



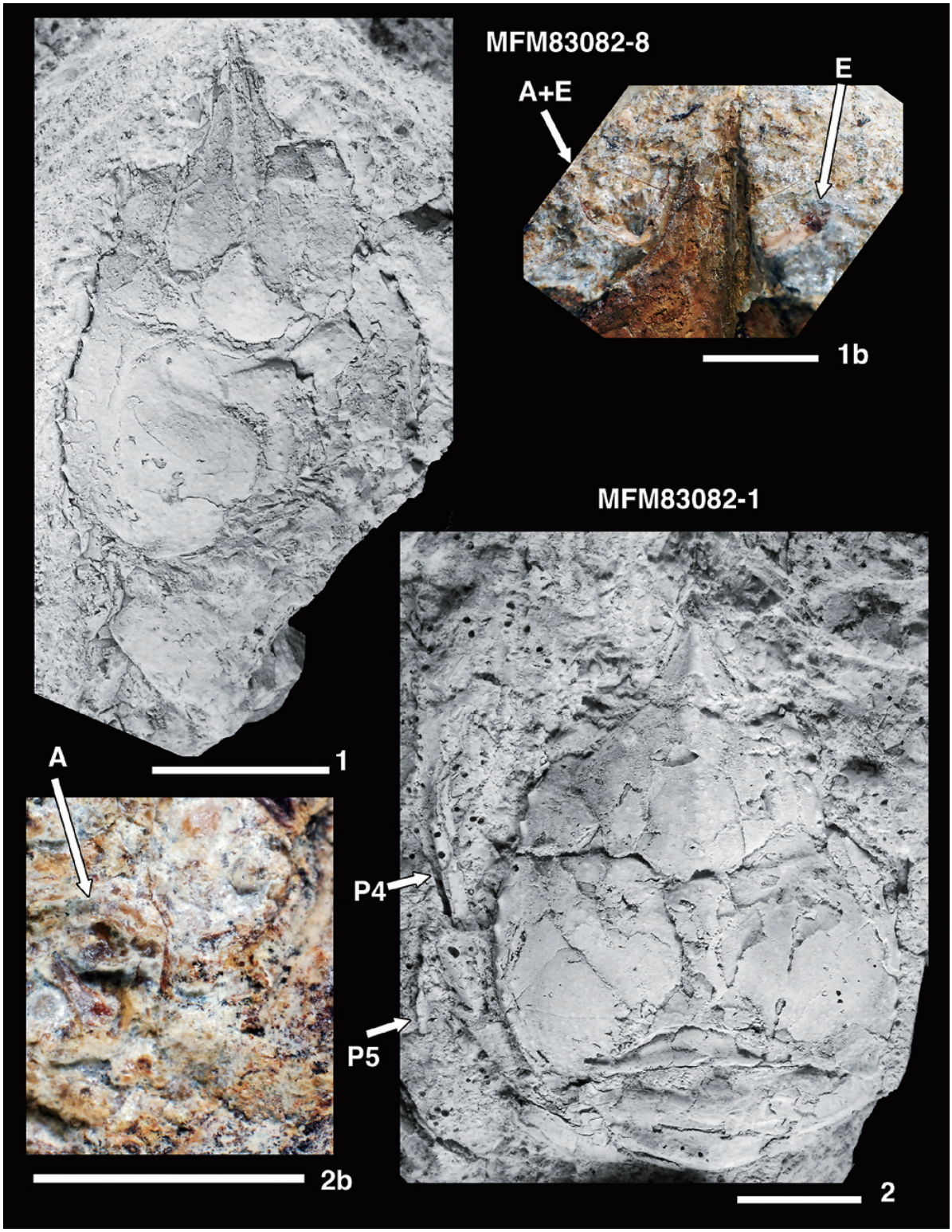
1–3. *Mizunotengus makiguchimai*, new genus and new species. *1*, paratype (MFM83080), carapace, pleon, and pereiopods from the Yamami Formation (lower Miocene), at Loc. MRZ08, dorsal view; ***2*,** paratype (MFM83080), coated with ammonium chloride sublimate, dorsal view ***2b*,** close-up image of 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



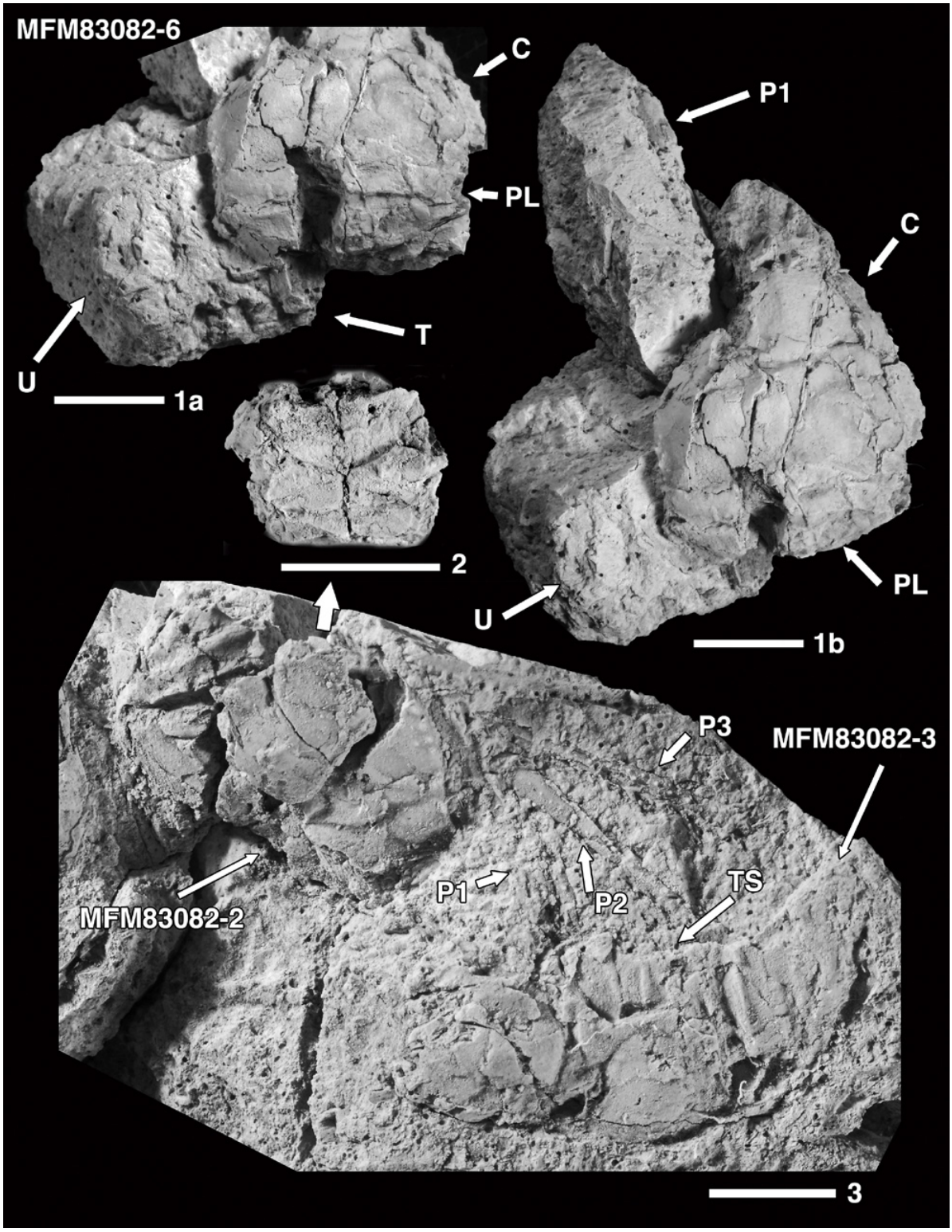
1. *Mizunotengus makiguchimai*, new genus and new species. Occurrences of paratype specimens (MFM83082-1–9) preserved within the matrix from the Yamami Formation (lower Miocene), at Loc. MRZ08. Scale bar = 1.0 cm. Note: Pleon, telson and uropods are indistinguishably preserved within MFM83082-5, MFM83082-7,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

Plate 8



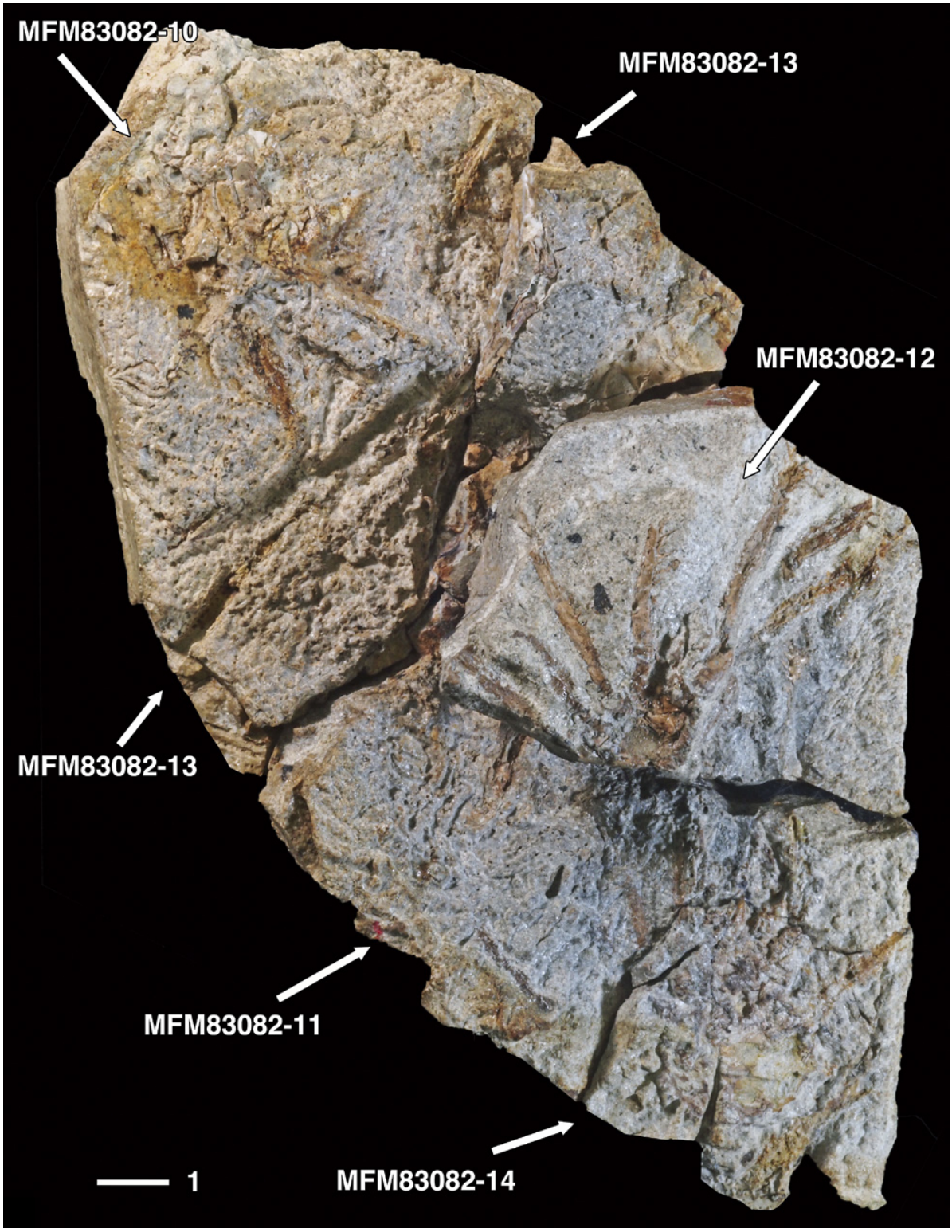
1–2b. ***Mizunotengus makiguchimai*****, new genus and new species.** ***1*****,** paratype (MFM83082-8), carapace and pleon, coated with ammonium chloride sublimate, from the Yamami Formation (lower Miocene), at Loc. MRZ08, dorsal view; ***1b*****,** close-up image of right eye (E) and left eye and 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



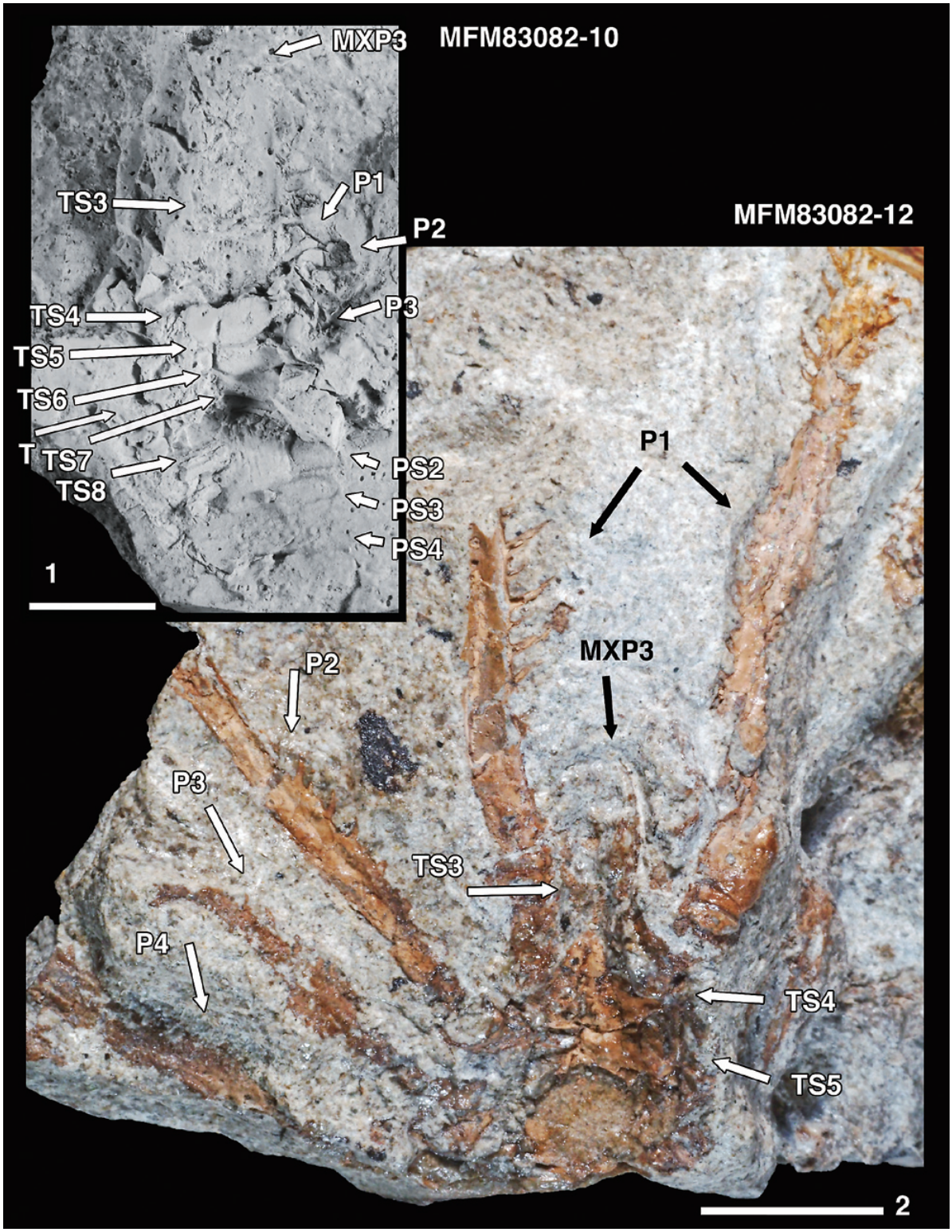
1a–3. ***Mizunotengus makiguchimai*****, new genus and new species.** ***1a***, ***b*****,** paratype (MFM83082-6), carapace, pleon, uropods, and pereiopod 1, from the Yamami Formation (lower Miocene), at Loc. MRZ07, a (dorso-posterior view), b (dorsal view); ***2*****,** thoracic sternum of paratype (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



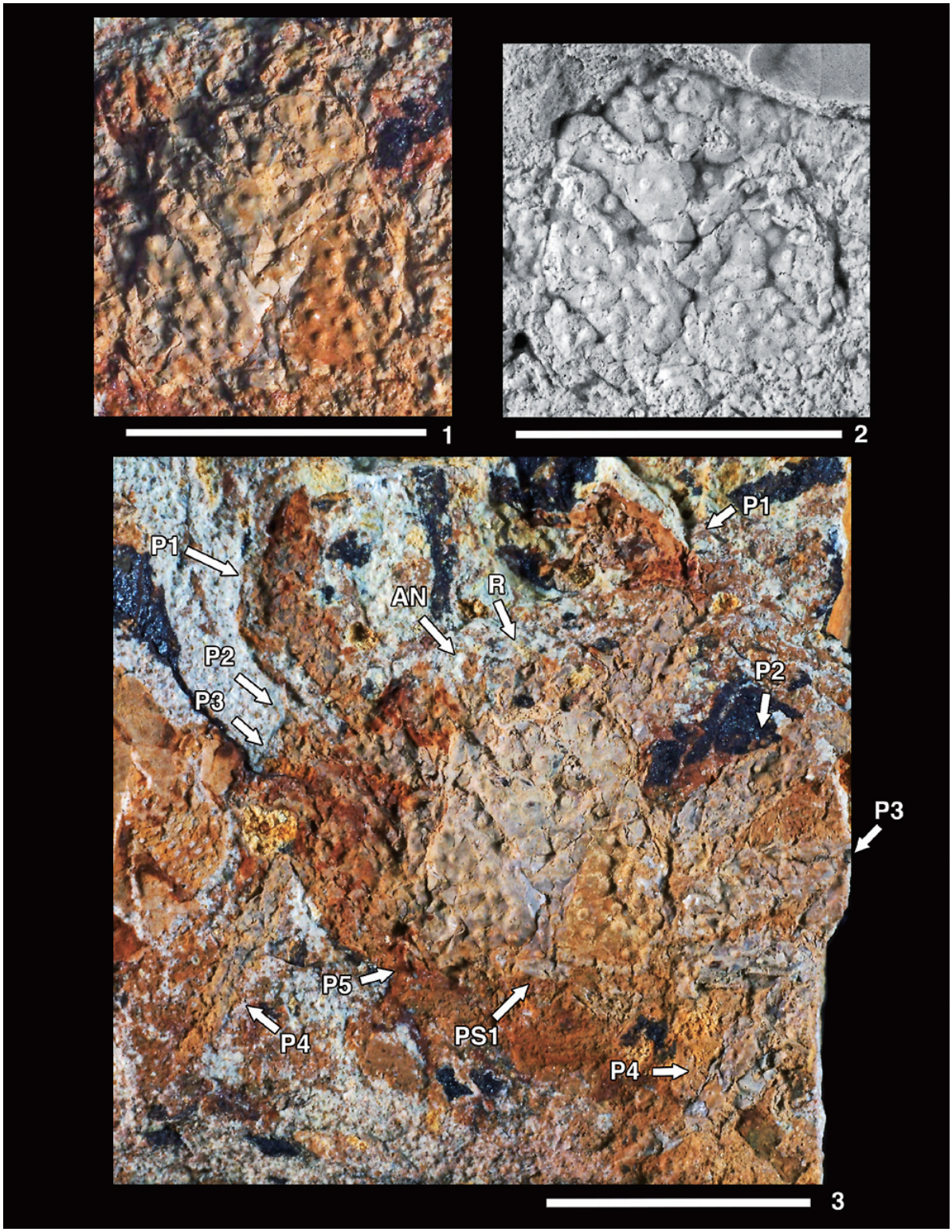
1. *Mizunotengus makiguchimai*, new genus and new species. Occurrences of the paratypes (MFM83082-10–14), preserved within the matrix from the Yamami Formation (lower Miocene), at Loc. MRZ08. Scale bar = 1.0 cm. Note: Pleon, telson and uropods are indistinguishably preserved within MFM83082-11, MFM83082-13,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

Plate 11



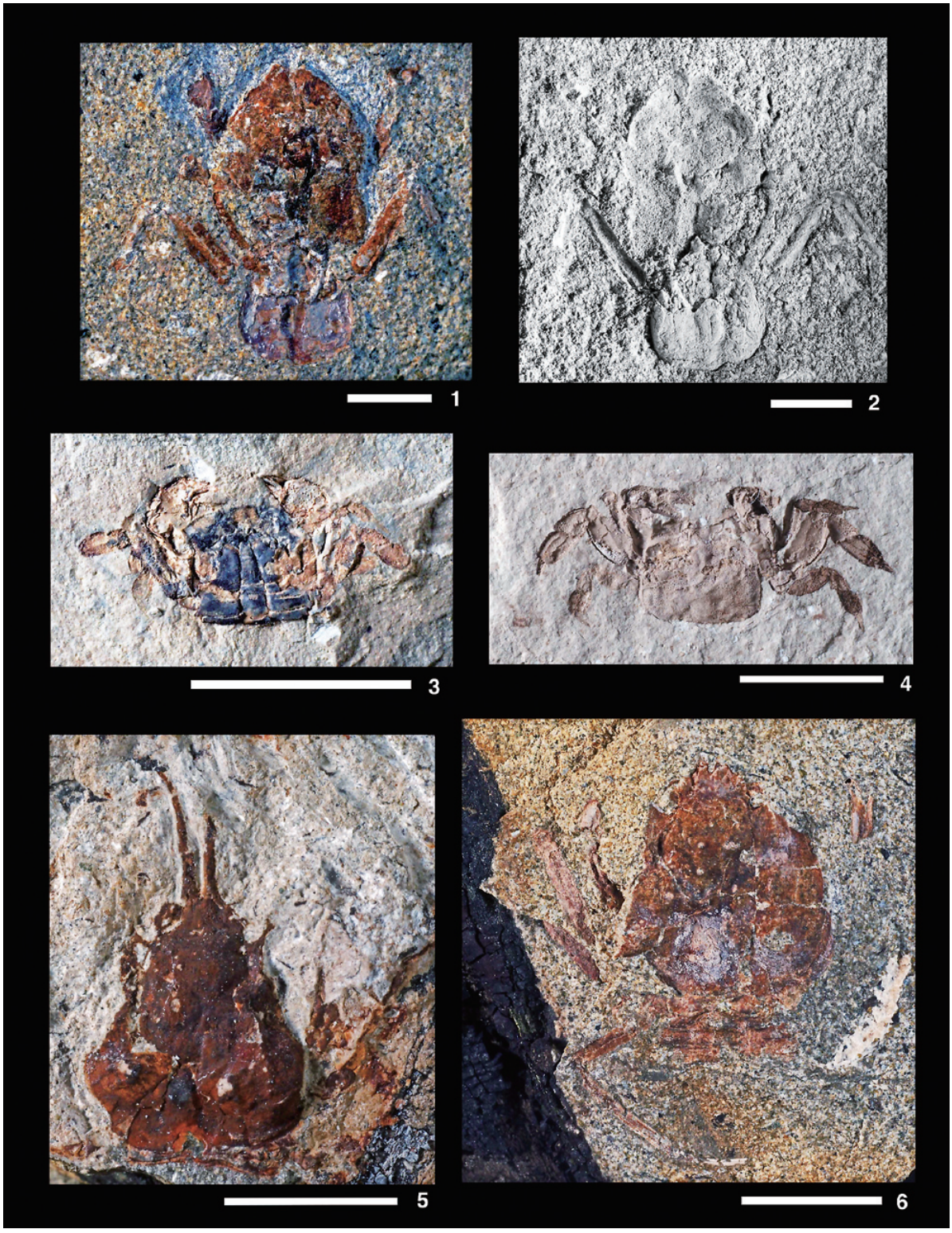
1, 2. *Mizunotengus makiguchimai*, new genus and new species. Paratypes (MFM83082-10 and MFM83082-12), thoracic sternum and pereiopods, from the Yamami Formation (lower Miocene), at Loc. MRZ08, ventral view. **Abbreviations**: MXP3, maxilliped 3; P1, pereiopod 1; P2, pereiopod 2; P3, pereiopod 3; P4, 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.