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Late Cretaceous Decapoda from the Izumi Group of Japan, with descriptions of two new genera and one new species of Axiidea and one new family of Brachyura

Hiroaki Karasawa*, Shingo Kishimoto, Masaaki Ohara***, and Yusuke Ando***

*Mizunami Fossil Museum, Yamanouchi, Akeyo, Mizunami, Gifu 509-6132, Japan
<GHA06103@nifty.com>
**Hyogo Paleontology Research Group, Komatsu 3-65-3, Hirohata, Himeji, Hyogo 671-1152, Japan
***Wakayama Prefectural Museum of Natural History, Funo, Kainan, Wakayama 642-0001, Japan

Abstract

Seven species of decapods are described from the Izumi Group (Upper Cretaceous: Campanian–Maastrichtian) of Hyogo and Osaka Prefectures, central Japan. Archaeopidae, a new family of Retroplumoidea embraces the monotypic Late Cretaceous genus *Archaeopus*. *Hinecaris simplex*, a new genus and species is the first record for the axiidean family Axiidae from the Cretaceous rocks of Japan. "*Callianassa*" (s.l.) *masanorii* Karasawa, 1998, is re-described and is moved from Callianassidae to Gourretiidae. A re-description is given for *Linuparus japonicus* Nagao, 1931, and *Archaeopus ezoensis* (Nagao, 1941). The lectotype for *Linuparus japonicus* Nagao, 1931, is herein designated.

Key words: Decapoda, Achelata, Axiidea, Brachyura, Izumi Group, Cretaceous, Japan

Introduction

Decapods have been recorded from the Upper Cretaceous (Campanian–Maastrichtian) Izumi Group of central Honshu, Japan. Collins, Kanie, and Karasawa (1993) reported a brachyuran, *Archaeopus ezoensis* (Nagao, 1941). Karasawa (1998) described two new species, *Hoploparia miyamotoi* Karasawa, 1998 (Nephropidae) and "*Callianassa*" (s.l.) *masanorii* Karasawa, 1998 (Callianassidae). Kishimoto (2002) discussed the morphology of a palinurid, *Linuparus japonicus* Nagao, 1931, from the Izumi Group. Kishimoto (2012) summarized occurrences of decapods from the group and figured representatives of these taxa. Examination of newly and previously known specimens reveals several new taxa and systematic problems that remain to be addressed. Thus, the purpose of this paper is to describe the previously unrecorded species, to re-describe the hitherto known species, and to update the taxonomic status of two taxa.

Institutional abbreviations

D: Museum of Nature and Human Activities, Hyogo (01-), 6 Yayoigaoka, Sanda, Hyogo 669-1546, Japan

WMNH-Ge: Wakayama Prefectural Museum of Natural History, Funo, Kainan, Wakayama 642-0001, Japan

MFM: Mizunami Fossil Museum, Yamanouchi, Akeyo, Mizunami, Gifu 509-6132, Japan

Systematics

Infraorder Achelata Scholtz and Richter, 1995
Superfamily Palinuroidea Latreille, 1802
Family Palinuridae Latreille, 1802

Genus *Astacodes* Bell, 1863

Type species: *Astacodes falcifer* Bell, 1863, by monotypy.

Species included: see Schweitzer *et al*. (2010, p. 45).

Remarks: Although Frațescu (2013) synonymized *Astacodes* with *Palinurus* Weber, 1795, we treat *Astacodes* as a valid genus, followed Karasawa *et al*. (2013) and Schweitzer *et al*. (2015).

Astacodes sp.

(Pl. 2, figs. 2a, b)

Description: Carapace poorly preserved and deformed, its posterior half not preserved. Surface of carapace

densely ornamented with anteriorly directed, pointed tubercles which varying in size. Frontal margin gently concave, rimmed. Supraorbital horns triangular, directed anterolaterally. Orbital margin broken. Gastric region with weak subdorsal carinae. Cervical groove well marked, V-shaped. Postcervical carinae absent. Antennal carina weakly developed. Left pereiopod 1 poorly preserved, the detailed characters unknown.

Discussion: The carapace of the present specimen resembles that of *Astacodes falcifer* Bell, 1863, from the Early Cretaceous of eastern United Kingdom and Argentina (Aguirre-Urreta, 2012), but differs in having a V-shaped cervical groove of the carapace. However, we cannot make sufficient comparison because the specimen is represented by a single incomplete carapace.

The hitherto known species of *Astacodes* has been known from the Early Jurassic of Czech Republic, the Early Cretaceous of Switzerland, United Kingdom, Questionably Australia, and Argentina, and the Late Cretaceous of Czech Republic and U.S.A (Aguirre-Urreta *et al*., 2012; Schweitzer *et al*., 2015). The occurrence of *Astacodes* sp. from the lower Maastrichtian Izumi Group represents the youngest record for the genus.

Material examined: WMNH-Ge-1141220001 from Nadayamamoto (=Loc. Aw16 of Morozumi, 1985), Minamiawaji City, Hyogo Prefecture; nodule of the Shimonada Formation of the Izumi Group (early Maastrichtian; *Pachydiscus* sp. aff. *P. subcompressus* Zone of Morozumi, 1985).

Genus *Linuparus* White, 1847

Type species: *Palinurus trigonus* von Siebold, 1824, by monotypy.

Species included: see Kornecki *et al*. (2017, p. 284).

***Linuparus japonicus* Nagao, 1931**

(Pl. 1; Pl. 2, figs. 1a–1c; Pl. 3–Pl. 6; Pl. 7, fig. 1)

Linuparus japonicus Nagao, 1931, p. 212, pl. XIV, figs. 1–3.

Linuparus japonicus Nagao; Imaizumi, 1978, p. 21, pl. 3, figs. 1–3; Kishimoto, 2002, p. 45, figs. 1–25 (non fig. 24); Kishimoto, 2012, p. 32, with unnumbered 7 figs.

Types: Nagao (1931), who described his new species, *Linuparus japonicus*, based upon four specimens, did not indicate a holotype so that all these specimens are syntypes. Among these, two specimens (Pl. XIV, Figs. 1, 1a, and Pl. XIV, Figs. 2, 2a) occurred from "*Scaphites* Bed of the Upper Ammonites Beds (Senonian) exposed along the Pombets, a tributary of the Ikushumbets, Province of Ishikari, Hokkaidô" (=Upper Yezo Group (Turonian–Maastrichtian, Late Cretaceous) of Ikushunbetsu, Mikasa City, Hokkaido, by Karasawa and Kato, 2001) and two specimens (Pl. XIV, Fig. 3 and one unfigured specimen) were collected from "Kunitan Beds (Senonian) of the Kuji Cretaceous developed along the railway cutting at Kunitan near Kuji, Province of Rikuchû" (=Kunitan Formation (Santonian–Campanian, Late Cretaceous) of the Kuji Group of a railway cutting at Kunitan near Kuji, Kuji City, Iwate Prefecture, by Karasawa and Kato, 2001). His illustrated specimen (Pl. XIV, Figs. 1, 1a) consisting of the carapace, pleon, thoracic sternum, and pereiopods is designated here as the lectotype of *Linuparus japonicus* Nagao, 1931, and the other specimens thus becomes paralectotypes. The four specimens described by Nagao (1931) are now deposited in the Hokkaido University Museum collection (UHR). Y. Kobayashi (Research Division of the Hokkaido University Museum) kindly sent one of the authors (HK) photographs of each specimen attached with the original label. Examination of these photographs and original description and figures of Nagao (1931) show that UHR 3188 is the lectotype (Nagao, 1931, Pl. XIV, Figs. 1, 1a) and UHR3185 is the paralectotype (=Nagao, 1931, Pl. XIV, Fig. 3). Additionally, UHR 4510 was the latex cast of the paralectotype (Nagao, 1931, Pl. XIV, Figs. 2, 2a) and UHR 3187 is the paralectotype of an unfigured specimen by Nagao (1931, p. 213).

Type locality and stratigraphic horizon: *Scaphites* Bed of the Upper Ammonites Beds (Senonian) exposed along the Pombets, a tributary of the Ikushumbets, Province of Ishikari, Hokkaidô (Nagao, 1931, p. 214) (=Upper Yezo Group (Turonian–Maastrichtian, Late Cretaceous) of Ikushunbetsu, Mikasa City, Hokkaido, by Karasawa and Kato, 2001) by the lectotype herein designated.

Diagnosis: Moderate to large-sized *Linuparus*. Carapace subrectangular, about 0.45 times as wide as long. Rostrum narrow, rimmed, flattened dorsally, concave medially, consists of two triangular, supraorbital horns directed anteriorly. Upper orbital margin concave, rimmed, with triangular outer orbital spine directed anteriorly. Cephalic region sparsely granular; lateral margins moderately convex, weakly dentate; dorsolateral margins keeled, convex outward, granular, with four short forward-directed spines; longitudinal postorbital carinae low, finely granular, extending from pointed, forwardly directed postorbital spines posterior to supraorbital horns, to level of low, granular, medial node directed anteriorly; gastric region weakly concave axially, much narrower than long, defined by granular, convex ridge arising anteriorly as a pair of low, granular nodes. Cervical groove broad, deep, smooth,

forming concave-forward arc; medial element straight or weakly convex, situated at posterior half of carapace. Postcervical groove shallow, nearly parallel to cervical groove on branchial regions; dorsal areas defined by cervical and postcervical grooves weakly convex. Thoracic region sparsely granular; cardiac region raised longitudinally, defined laterally by sinuous depressions, with well inflated anterior margin; medial keel well-marked, granulated; lateral margins keeled, finely granular, nearly straight; lateral regions with stridulatory apparatus, situated just posterior to cervical groove; posterior margin gently concave with broad, deep marginal groove and prominent ridge. Pleon elongate, punctate; tergite and pleuron of each somite bounded by shallow, oblique groove; pleuron of somites 2–5 subtriangular, directed posteriorly, with pointed tip and two spines on posterior margin. Antennules long, slender. Antennae very long; peduncles robust, composed of three segments; basal segments stout, bearing longitudinal ridge on dorsal surface, with anteromesial and laterodistal spines; intermediate and distal segments with two longitudinal ridges dorsally; flagellum rigid, dorso-ventrally compressed, extremely long, multiarticulate, grooved dorsally and ventrally. Pereiopods 5 apparently shorter and slender than other pereiopods. Epistome longitudinally inflated with median suture; anterior margin with median projection directed anteroventrally.

Description: Moderate to large-sized *Linuparus*. Carapace subrectangular, about 0.45 times as wide as long, dorso-ventrally compressed. Rostrum about 30% carapace width, flattened dorsally, rimmed, concave medially, composed of two triangular, supraorbital horns directed anteriorly. Upper orbital margin concave, rimmed, with triangular outer orbital spine directed anteriorly. Cephalic region sparsely granular; lateral margins moderately convex, weakly dentate; dorsolateral margins keeled, convex outward, granular, with four short spines directed forward; longitudinal postorbital keels low, finely granular, extending from pointed, forwardly directed postorbital spines posterior to supraorbital horns, to level of low, granular, medial node directed anteriorly; gastric region weakly concave axially, much narrower than long, defined by irregularly dentate, convex ridge arising anteriorly as a pair of low, granular nodes. Cervical groove broad, deep, forming concave-forward arc; medial element straight or weakly convex, situated at posterior half of carapace; lateral elements steeply inclined anteroventrally across dorsolateral margins. Postcervical groove shallow, nearly parallel to cervical groove on branchial regions; dorsal areas defined by cervical and postcervical grooves weakly convex. Thoracic region sparsely granular; cardiac region raised longitudinally, defined laterally by sinuous depressions, with well inflated anterior margin; medial keel well-developed, granulated; lateral margins keeled, finely granular, nearly straight; lateral regions with stridulatory apparatus, situated just posterior to cervical groove; posterior margin gently concave with broad, deep marginal groove and prominent ridge.

Pleon elongate with punctate surface; tergite and pleuron of each somite bounded by shallow, oblique groove. Somites 1–5 much narrower than wide, subrectangular in outline. Somites 1–4 medially keeled; each tergite bearing articulated ring posteriorly; Somite 1 with reduced pleuron; somite 2 widest of all somites; somite 3 about as long as somite 2, slightly narrower than somite 2; somite 4 about as long as somite 3, slightly narrower than somite 3; somite 5 slightly longer than somite 4, narrower than somite 4; somite 6 trapezoidal, longest of all somites, narrower than somite 5, with reduced pleura. Pleuron of somites 2–5 subtriangular, directed posteriorly, with pointed tip and two spines on posterior margin. Telson subrectangular, much longer than wide, converged distally; calcified anterior part on anterior one-third of telson bearing shallow median groove with forwardly concave distal margin; flexible posterior area striate with gently convex distal margin. Flexible posterior area of uropods striate; endopod and exopod with gently arched lateral margin and slightly convex distal margin.

Thoracic sternum triangular, longer than wide, widest at sternite 7, smooth, concave axially. All sternites fused. Sternites 1–3 completely fused, small, triangular, separated laterally from sternite 4 by shallow insertion. Sternite 4 diverged posteriorly; lateral margins concave; lateral elements raised, separated from those of sternite 5 by deep insertion, with narrow, posterolaterally directed episternal projections. Sternite 5 diverged posteriorly, wider than sternite 4; lateral margins concave; lateral elements raised, separated from those of sternite 4 by deep insertion, with posterolaterally directed episternal projections. Sternite 6 diverged posteriorly, wider than sternite 5, with median sulcus; lateral margins concave; lateral elements raised, separated from those of sternite 5 by deep insertion, with posterolaterally directed episternal projections. Sternite 7 diverged posteriorly, wider than sternite 6; lateral margins concave; lateral elements raised, separated from those of sternite 6 by deep insertion, with posterolaterally directed episternal projections. Sternite 8 narrower than sternite 7; lateral margins slightly concave; axial element separated from that of sternite 7 by shallow, concave groove; lateral

elements raised, separated from those of sternite 7 by deep insertion, with posteriorly directed episternal projections. Gonopore of male not preserved, but that of female located on coxa of pereiopods 3.

Antennules long, slender. Antennular peduncles composed of three segments; basal segments shorter than intermediate one, much longer than wide, distal segment about as long as intermediate one.

Antennae very long. Antennal peduncles robust, composed of three segments; basal segments stout, bearing longitudinal ridge on dorsal surface, with anteromesial and laterodistal spines; intermediate segment narrower than basal segment, bearing two longitudinal ridges on dorsal surface, with unarmed lateral and mesial margins; distal segment narrower than intermediate segment, bearing two longitudinal ridges on dorsal surface, with unarmed lateral and mesial margins. Antennal flagellum rigid, dorsoventrally compressed, extremely long, multiarticulate, grooved dorsally and ventrally.

Maxillipeds 3 elongate, extending beyond epistome. Basis short. Ischium much longer than wide, dentate on mesial margin. Merus longer than ischium, much longer than wide, dentate on mesial margin. Carpus, propodus, and dactylus shorter than merus; margins unarmed; dactylus subcylindrical with pointed tip. Maxillipeds 2 flattened dorsoventrally; meus elongate.

Pereiopods 1–5 flattened laterally, ovate in cross section, without chelae, but detailed characters indistinct by preservation. Propodi, carpi, and meri of pereiopods 1–4 punctuated, tuberculated. Pereiopods 5 apparently shorter and slender than other pereiopods.

Epistome longitudinally inflated with median suture; anterior margin with median projection directed anteroventrally.

Remarks: The above diagnosis and description are given examination of the type specimens described by Nagao (1931) and the present specimens. *Linuparus japonicus* has been recorded from the Upper Yezo Group (Turonian-Maastrichtian, Late Cretaceous) of Hokkaido (Nagao, 1931), the Kunitan Formation (Santonian–Campanian, Late Cretaceous) of Iwate Prefecture (Nagao, 1931), the Izumi Group (Campanian–Maastrichtian, Late Cretaceous) of Osaka and Hyogo Prefectures (Imaizumi, 1978; Kishimoto, 2002; Kishimoto, 2012; present work), and the Furushiroyama Formation (Coniacian, Late Cretaceous) of Ehime Prefecture (Mizuno, 1974).

Material examined: D1048485, D1048486, D1048491, and D1048497 from Yura (=Loc. Aw16 of Morozumi, 1985), , Sumoto City, Hyogo Prefecture, mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985). D1048487 and MFM247119 from Nadachino (=Loc. IZM-1 of Collins *et al*., 1993), Minamiawaji City, Hyogo Prefecture; mudstone of the Shimonada Formation of the Izumi Group (early Maastrichtian; *Pachydiscus* sp. aff. *P. subcompressus* Zone of Morozumi, 1985). D10848487–D1048489 and D1048492–D1048495, from Nadanigoro (=southwest Loc. IZM-1 of Collins *et al*., 1993), Minamiawaji City, Hyogo Prefecture; mudstone of the Shimonada Formation of the Izumi Group (early Maastrichtian; *Pachydiscus* sp. aff. *P. subcompressus* Zone of Morozumi, 1985). D1048491 from Hirota (=Loc. Aw7 of Morozumi, 1985), Minamiawaji City, Hyogo Prefecture; sandy siltstone of the Seidan Formation of the Izumi Group (late Campanian; *Pachydiscus awajiense* Zone of Morozumi, 1985).

Infraorder Astacidea Latreille, 1802
Section Homarida Scholtz and Richter, 1995
Superfamily Nephropoidea Dana, 1852
Family Nephropidae Dana, 1852

Genus *Hoploparia* McCoy, 1849

Type species: *Astacus longimanus* Sowerby, 1826, by subsequent designation of Rathbun (1926).

Species included: see Kornecki *et al*. (2017, p. 277–278).

***Hoploparia miyamotoi* Karasawa, 1998**

(Pl. 7, figs. 2a–Pl. 8)

Hoploparia miyamotoi Karasawa, 1998, p. 217, figs. 1.1–1.4, 2.1–2.4.

Hoploparia miyamotoi Karasawa; Kishimoto, 2012, p. 33, with two unnumbed figures.

Diagnosis: Rostrum with small dorsolateral spines on distal half; one supraorbital, one metaorbital and one postantennal spine present, all small; pleonal somites with well-developed lateral carina, somites 3–5 bearing two marginal spines on pleura (slightly modified from Karasawa, 1998, p. 217).

Remarks: Karasawa (1998) erected this species based upon four type specimens. The specimens figured herein are more well preserved. Within the original description he did not refer characters to the pereiopod 1; however, among newly obtained specimens, chelae of the pereiopod 1 are poorly preserved. A short palm is slightly longer than high and is finely punctuated laterally, and unarmed dorsal and ventral margins are gently diverged distally.

We have to notice that two paratypes, MFM247004 and MFM247006, have been lost and not deposited in the Mizunami Fossil Museum.

Material examined: D1048498–D1048500 from Yura (=Loc. Aw16 of Morozumi, 1985), Sumoto City, Hyogo Prefecture; mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985).

Infraorder Axiidea de Saint Laurent, 1979

Families included: Anacalliacidae Manning and Felder, 1991; Axiidae Huxley, 1879; Bathycalliacidae Sakai and Türkay, 1999; Callianassidae Dana, 1852; Callianideidae Kossmann, 1880; Callianopsidae Manning and Felder, 1991; Coralaxiidae Sakai and de Saint Laurent, 1989; Ctenochelidae Manning and Felder, 1991; Eucalliacidae Manning and Felder, 1991; Gourretiidae Sakai, 1999; Lipkecallianassidae Sakai, 2005; Micheleidae Sakai, 1992; Paracalliacidae Sakai, 2005; Strahlaxiidae Poore, 1994.

Remarks: In his major revision of Axioidea and Callianassoidea, Sakai (2011) classified nine families under Axioidea and 11 families under Callianassoidea. However, the recent molecular phylogenetic analyses (Bracken *et al*., 2009; Robles *et al*., 2009) showed that both superfamilies are polyphyletic. Therefore, the superfamilial classification for Axiidea has not been used (*i.e*., Dworschak *et al*., 2012; Poore *et al*., 2014). We concur. After Sakai (2011)'s work, Poore (2015a) synonymised Thomassiniidae de Saint Laurent, 1979, with Callianideidae Kossmann, 1880, Ctenocheloidae Sakai, 2011, was synonymous with Ctenochelidae Manning and Felder, 1991 (Poore, 2015b), and Poore and Collins (2015) showed that Meticonaxiidae Sakai, 1992, was the junior synonym of Micheleidae Sakai, 1992. Sakai (2016) added a new family, Tosacallianassidae Sakai, 2016, to axiidean families; however, Poore and Dworschak (2017) synonymised Tosacallianassidae with Ctenochelidae Manning and Felder, 1991. Sakai (2017a) erected the new monotypic family Neoaxiidae Sakai, 2017a, but the family was the junior synonym of Axiidae (Dworschak and Poore, 2018). Poore (2017) added three families, Calocarididae Ortmann, 1891, Eiconaxiidae Sakai and Ohta, 2005, and Eiconaxiopsididae Sakai, 2011, to the junior synonym of Axiidae. Additionally, Dworschak and Poore (2018) synonymised Pseudogourretiidae Sakai, 2011, with Gourretiidae and gave Paracalliacinae a full family status. Thus, Axiidea consists of 14 families.

Family Axiidae Huxley, 1879

Genus *Hinecaris*, new genus

Type species: *Hinecaris simplex*, new genus and species, by monotypy; feminine gender.

Etymology: A combination derived from Hine, name of country in modern history age, and *karis* (Greek), a shrimp.

Discussion: *Hinecaris* is similar to the Cretaceous forms of *Axiopsis* Borradaile, 1903, described by Franțescu (2014), but differs in that a weakly rugose carapace lacks the median gastric and submedian gastric carinae. Besides *Axiopsis*, *Acanthaxius* Sakai and de Saint Laurent, 1989, *Axius* Leach, 1816, *Cretaxiopsis* Charbonnier, Audo, Garassino, and Hyžný, 2017, *Huxleycaris* Bravi and Garassino, 1998, *Libanoaxius* Charbonnier, Audo, Garassino, and Hyžný, 2017, *Paraxiopsis* de Man, 1905, *Protaxius* Beurlen, 1930, and *Schlueteria* Fritsch and Kafka, 1887, have been known from the Cretaceous deposits. The new genus is clearly distinguished from *Acanthaxius*, *Axius*, *Huxleycaris*, *Paraxiopsis*, and *Schlueteria*, by presence of weakly developed gastric carinae and absence of a median postcervical carina. *Hinecaris* differs from *Cretaxiopsis*, *Libanoaxius*, and *Protaxius* by having rounded ventral margins of the pleon.

The axiids from Japan have been sparsely recorded as fossils. The previously known records were *Axius* (s.l.) sp. from the Oligocene Kishima Group (Karasawa and Fudouji, 2000) and *Protaxius* sp. from the Late Jurassic Somanakamuma Group (Kato *et al*., 2010). Therefore, the present new genus and species represents the third fossil record for the family from Japan.

***Hinecaris simplex*, new species**

(Pl. 9, figs. 1a–3c)

Etymology: The trivial name is derived from a simple carapace.

Diagnosis: Moderate-sized axiid. Carapace very weakly rugose. Rostrum acutely triangular, about longer than wide at base, continuous with supraorbital carinae; lateral margins unarmed; dorsal surface with narrow median sulcus extending at about anterior one-third of gastric region. Outerorbital spine short, directed anterolaterally. Gastric region gently convex; median and submedian carinae absent; supraorbital carinae weak with small tubercles; outerorbital carinae nearly straight, finely tuberculate. Antennal region with finely tuberculate, oblique antennal carina. Cervical groove deep, well defined. Postcervical median carina absent. Pleon elongate, finely punctate. Somite 1 much wider than long, trapezoidal in dorsal view, divergent posteriorly, bearing transverse, dorsal groove at anterior fifth, with narrow anterolateral lobes. Somite 2 much longer than somite 1; tergite bearing narrow articulate ring along posterior margin, divided from pleuron by shallow notch and groove. Somites 3–5, slightly shorter than somite 2; each

tergite bearing narrow articulate ring along posterior margin, divided from pleuron by shallow notch and rather deep groove; ventral margin strongly convex. Somite 6 slightly longer than somite 5; pleuron reduced, ventral margin sinuous. Telson trapezoidal, shorter than Somite 6, wider than long, with gently convex lateral margin. Uropod without spine; endopod subtriangular, about 1.2 times as long as wide, bearing median longitudinal and latero-marginal ridges dorsally, with sinuous distal and gently convex lateral margins; exopod obovate, much longer than endopod, 1.5 times as long as wide, bearing strongly convex distal and lateral margins, with two longitudinal median ridges dorsally; diaeresis absent. Pereiopods long, slender.

Description: Moderate-sized axiid. Carapace sclerotized, laterally compressed, with very weakly rugose. Rostrum acutely triangular, weakly downturned anteriorly, about 0.4 times as wide as long at base, continuous with supraorbital carinae; lateral margins smooth, unarmed; dorsal surface concave transversely with narrow median sulcus extending at about anterior one-third of gastric region. Outerorbital spines short, directed anterolaterally. Gastric region gently convex; median and submedian carinae absent; supraorbital carinae weak, ornamented with small, scattered tubercles; outerorbital carinae nearly straight, finely tuberculate. Antennal region with finely tuberculate, oblique antennal carina not reaching lateral carina. Cervical groove deep, well-defined. Cardiac and branchial regions just behind cervical grooves covered with small tubercles; postcervical median carina absent. Posterior margin of carapace not preserved.

Pleon elongate, sclerotized, finely punctate. Somite 1 much wider than long, trapezoidal in dorsal view, divergent posteriorly, bearing transverse dorsal groove at anterior fifth, with narrow anterolateral lobes; pleuron narrow, widened posteriorly, directed posteriorly, with gently convex ventral margin. Somite 2 much longer than somite 1; tergite bearing narrow articulate ring along posterior margin, divided from pleuron by shallow notch and groove. Somites 3–5, slightly shorter than somite 2; each tergite bearing narrow articulate ring along posterior margin, divided from pleuron by shallow notch and rather deep groove; ventral margin strongly convex, directed posteriorly. Somite 6 slightly longer than somite 5; pleuron reduced, ventral margin sinuous. Telson poorly preserved, trapezoidal, shorter than Somite 6, wider than long, with gently convex lateral margin; dorsal ornaments and posterior margin not preserved. Uropodal endopod subtriangular, about 1.2 times as long as wide, without spine; distal margin sinuous and lateral margin gently convex; dorsal surface with median longitudinal and latero-marginal ridges. Uropodal exopod obovate, 1.2 times longer than endopod, 1.5 times as long as wide, without spine; distal and lateral margins strongly convex; dorsal surface with two longitudinal median ridges; inner ridge reaching distal margin and outer one not reaching distal margin, its distal end extending at level of distal margin of endopod. Diaeresis absent.

Pereiopods long, slender. Chela of pereiopod 1 not preserved; carpus short, but longer than high, with dentate dorsal margin; merus long, flattened laterally, with unarmed dorsal and ventral margins and lateral surface. Pereiopod 2 with unarmed margins; carpus much longer than high; merus long, much longer than carpus. Pereiopods 3 and 4 poorly preserved. Pereiopod 5 much shorter than other pereiopods.

Material examined: Holotype, WMNH-Ge-1141120001, and paratype, WMNH-Ge-1141120002, from Hakotsukuri (=IZM-4 by Collins *et al*., 1993), Han-nan City, Osaka Prefecture; Mudstone of the Shindachi Formation of the Izumi Group (Maastrichtian by Kase, 1990). Paratype, WMNH-Ge-1141220002, from Yura (=Loc. Aw16 of Morozumi, 1985), Sumoto City, Hyogo Prefecture; Mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985).

Axiidae genus and species indeterminate

(Pl. 10, figs. 1a–f)

Description: Dactylus and propodus of chela of right pereiopod 1 preserved, with unarmed dorsal and ventral margins. Palm slightly longer than high, strongly converged proximally; dorsal margin strongly convex; ventral margin slightly concave; lateral surface convex, glabrous, unarmed; mesial surface weakly concave longitudinally, with low, minute granules distally. Fixed finger lacking distal part, gently deflexed ventrally to ventral margin of palm; occlusal margin gently concave; ventral margin gently convex, forming thin edge; lateral surface smooth, slightly elevated longitudinally; mesial surface shallowly grooved medially along occlusal margin, with low, minute granules near occlusal and ventral margins. Dactylus lacking distal part, dorsal margin strongly convex; occlusal margin gently concave; lateral surface smooth, slightly elevated longitudinally; mesial surface slightly concave longitudinally, ornamented with low, minute granules, shallowly grooved medially.

Discussion: The present specimen is represented by a single incomplete chela of the pereiopod 1, but it does not seem to confirm to known members from the

Izumi Group under consideration. The one possibility is considered is that it is an axiid like to the extant *Eiconaxius* Bate, 1888, and/or the Cretaceous *Schlueteria* Fritsch and Kafka, 1887, but *Eiconaxius* has a small-sized chela and the chela in *Schlueteria* is ornamented with well-developed spines and tubercles. The certain generic placement of the specimen awaits the discovery of best material.

Material examined: D1048501 from Yura (=Loc. Aw16 of Morozumi, 1985), Sumoto City, Hyogo Prefecture; Mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985).

Family Gourretiidae Sakai, 1999

Genus *Ahazianassa*, new genus

Type species: "*Callianassa*" (s.l.) *masanorii* Karasawa, 1998, by monotypy; feminine gender.

Etymology: The trivial name is derived from "Ahazi", meaning Awaji in an ancient age.

Diagnosis: see species.

Discussion: Within the original description of Karasawa (1998), it was considered best to place the species in *Callianassa* (s.l.) because of absence of the maxilliped 3, telson, and uropods. Re-examination of the type specimens and new specimens collected from the type locality suggests that the species is not a callianassid and represents a new genus, *Ahazianassa*. Members of Callianassidae have the dorsal plate of the uropodal exopod which *Ahazianassa* lacks. The new genus resembles members of Callianopsidae, Gourretiidae, and Paracalliacidae by having ovate uropods without the dorsal plate. However, the new genus differs from the genera of Callianopsidae and Paracalliacidae by absence of the cardiac prominence on the carapace and the lateral projection of the pleonal somite 6. Therefore, the new genus is placed in Gourretiidae.

Sakai (2017b) reviewed the extant taxa of Gourretiidae and recognized eight genera, *Gourretia* de Saint Laurent, 1973, *Heterogourretia* Sakai, 2017b, *Ivorygourretia* Sakai, 2017b, *Laurentgourretia* Sakai, 2004, *Ruiyuliugourretia* Sakai, 2017b, *Paracalliax* de Saint Laurent, 1979, *Plantesgourretia* Sakai, 2017b, and *Tuerkaygourretia* Sakai, 2017b, based upon characters of the maxilliped 3, pleonal somite 6, uropodal exopod, and male pleopods 1 and 2. Among these genera, Dworschak and Poore (2018) removed *Paracalliax* to Paracalliacidae. We agree with their opinion. The new genus is related to *Gourretia*, *Ivorygourretia*, and *Plantesgourretia* by lacking the lateral projection of the pleonal somite 6 and lacking of a notch of the uropodal exopod; however, *Ahazianassa* differs in that the carapace has the dorsal oval and pereiopods 1 are subequal without the meral hook. Interestingly, most of extant gourretiids lack the dorsal oval of the carapace, but the dorsal oval in *Gourretia biffari* Blanco Rambla and Liñero Arana, 1994, is weakly developed.

Karasawa (1998) suggested that in the carapace character the species has a close affinity with *Protocallianassa archiaci* (A. Milne Edwards, 1860) from the early Senonian of United Kingdom. However, *Ahazianassa masanorii* is distinguished from *Protocallianassa archiaci* in that the pereiopods 1 are subequal and the telson has a smooth dorsal surface. Within the latter species the pereiopods 1 are unequal and the telson is carinate dorsally. Most extant callianassids have the cervical groove of the carapace extending far back medially (Glaessner, 1969; Karasawa, 1998) and have the dorsal plate on uropodal exopods (Manning and Felder, 1991; Sakai, 2011; and so on). Therefore, *Protocallianassa archiaci* is not a member of Callianassidae and might be moved to other axiidean families bearing *linea thalassinica*. However, evaluation of the family placement of it is beyond the scope of this paper.

The hitherto known gourretiid has been only one, *Gourretia* sp. from the Miocene of Austria (Hyžný *et al*., 2015). The occurrence of *Ahazianassa* extends the known geological range for the family back to the late Cretaceous.

***Ahazianassa masanorii* (Karasawa, 1998), new combination**

(Pl. 10, fig. 2–Pl. 17)

"*Callianassa*" (s.l.) *masanorii* Karasawa, 1998, p. 220, figs. 3.1–3.7.

Callianassa masanorii Karasawa; Kishimoto, 2012, p. 33, with a unnumbed figure.

Callianassa sp., Kishimoto, 2012, p. 33, with three unnumbed figures.

Diagnosis: Large-sized gourretiid. Carapace sclerotized; frontal margin with short, broadly triangular, downturned rostral spine and without lateral spine; *linea thalassinica* well defined; dorsal oval convex, about half of dorsal length; cervical groove deep, joining *linea thalassinica* at posterior third of oval; hepatic boss well defined; cardiac prominence absent. Pleon sclerotized, elongate, with smooth surface; somite 1 short, trapezoidal; somite 2 longest, bearing arcuate groove separating pleuron from tergite at posterior third, with gently convex ventral margin and rounded posterior margin; somites 3–5 bearing arcuate, posterior groove separating pleuron from tergite with gently convex ventral and rounded posterior margins; somite 6 slightly longer

than somite 5, converged posteriorly, without lateral projection. Telson about as long as wide, rectangular, with weak longitudinal median groove; lateral margin nearly straight; distal margin gently convex. Uropodal endopod oval, slightly longer than wide, with median longitudinal carina dorsally; distal margin convex. Uropodal exopod, much larger than endopod, bearing two longitudinal carinae medially, lacking dorsal plate and diaeresis; distal margin convex without notch. Pereiopods 1 chelate, subequal, dissimilar in shape, with unarmed dorsal and ventral margins. Dactylus of major cheliped curved ventrally, slightly longer than fixed finger, with pointed tip strongly hooked ventrally; fixed finger curved dorsally, with pointed tip gently hooked dorsally; palm subrectangular, converged distally, longer than high, bearing gently convex dorsal margin, nearly straight ventral margin, distal margin initially at about 90 degree angle to dorsal margin with shallow indentation just above fixed finger, and proximal margin at about 90 degree angle to ventral margin; carpus subrectangular, short, much higher than long, with nearly straight dorsal and strongly curved ventral margins; merus about equal to carpus length, rhomboidal, bearing strongly vaulted lateral surface with median longitudinal ridge, and strongly convex dorsal and ventral margins. Propodus of minor cheliped slightly smaller than that of major one, more slender in outline; dactylus elongate, nearly straight, slightly shorter than palm, with pointed tip hooked ventrally; its occlusal margin slightly sinuous, forming thin edge, without tooth; fixed finger elongate, nearly straight, slightly shorter than dactylus, with straight occlusal margin; palm subrectangular, slightly narrowed distally, much longer than high, with gently convex dorsal and ventral margins; carpus short, subrectangular. Pereiopod 2 chelate, strongly compressed laterally.

Revised description: Large-sized gourretiid. Carapace sclerotized, laterally compressed, height about half of length. Frontal margin with short, broadly triangular, downturned rostral spine and without lateral spine. *Linea thalassinica* well defined. Dorsal oval convex, about half of dorsal length. Cervical groove deep, joining *linea thalassinica* at posterior third of oval. Hepatic boss well defined. Posterior margin evenly curved without lateral lobe. Cardiac prominence absent.

Pleon sclerotized, elongate, with smooth surface; somite 1 short, trapezoidal in dorsal view, bearing dorsal transverse groove at anterior fourth, with divergent lateral margins. Somite 2 longest, about 1.5 times as long as somite 1, diverged posteriorly, with arcuate groove separating pleuron from tergite at posterior third; pleuron with gently convex ventral margin and rounded posterior margin. Somites 3–5 diminishing in size posteriorly with posterior, arcuate groove separating pleuron from tergite; each pleuron with gently convex ventral margin and rounded posterior margin. Somite 6 slightly longer than somite 5, converged posteriorly; pleuron reduced with sinuous ventral margin. Telson about as long as wide, rectangular in dorsal view, with weak longitudinal median groove; lateral margin nearly straight; distal margin gently convex. Uropodal endopod oval, slightly longer than wide, with median longitudinal carina dorsally; distal margin convex. Uropodal exopod oval, much larger than endopod, bearing two longitudinal carinae medially, without dorsal plate; distal margin convex without notch.

Antennular peduncle and antennal peduncle partly preserved. Maxilliped 3 poorly known.

Pereiopods 1 chelate, subequal, dissimilar in shape. Dactylus of major cheliped curved ventrally, about 1/3 of propodus length, slightly longer than fixed finger, with pointed tip strongly hooked ventrally; dorsal margin unarmed; occlusal margin with median and proximal teeth; mesial surface smooth; lateral surface pitted along occlusal margin. Fixed finger curved dorsally, about 1/4 length of propodus, with pointed tip gently hooked dorsally; occlusal margin smooth, gently concave, with broad median tooth; ventral margin unarmed, gently convex; mesial and lateral margins smooth. Palm subrectangular, about 0.7 times as high as long; dorsal margin gently convex, unarmed; ventral margin nearly straight, unarmed, concave at junction of palm and fixed finger; both margins converged distally; lateral and mesial surfaces smooth; distal margin initially at about 90 degree angle to dorsal margin with shallow indentation just above fixed finger; proximal margin at about 90 degree angle to ventral margin. Carpus subrectangular, short, about 0.3 times as long as propodus, about 0.4 times as high as long, dorsal margin nearly straight, ventral margin strongly curved; mesial and lateral surfaces smooth. Merus about equal to carpus length, rhomboidal in lateral view; dorsal and ventral margins strongly convex, unarmed; lateral surface strongly vaulted with median longitudinal ridge; proximal margin at about 100 degree angle to dorsal margin. Ischium about as long as merus, tapering proximally, with unarmed dorsal and ventral margins.

Propodus of minor cheliped slightly smaller and more slender than that of major one. Dactylus elongate, nearly straight, slightly shorter than palm, with pointed tip hooked ventrally; dorsal margin

unarmed; occlusal margin slightly sinuous, forming thin edge, without tooth; lateral surface with a row of small pits parallel to occlusal margin. Fixed finger elongate, nearly straight, slightly shorter than dactylus, with unarmed occlusal and ventral margins; lateral surface with row of small pits along occlusal and ventral margins; dorsal and ventral margins nearly straight; occlusal margins straight, unarmed. Palm subrectangular, slightly narrowed distally, about 0.6 times as high as long, with smooth lateral and mesial surfaces; dorsal and ventral margins gently convex, unarmed; ventral margin concave at junction of palm and fixed finger. Carpus short, subrectangular, about 1/5 of propodus length, convergent proximally, with smooth lateral and mesial surfaces; dorsal margin gently convex, unarmed; ventral margin strongly curved, unarmed. Merus slightly longer than carpus, slightly convergent proximally without ventral spine; dorsal and ventral margins slightly convex, unarmed; lateral surface gently vaulted.

Pereiopod 2 chelate, strongly compressed laterally, with unarmed margins and surfaces. Chela subtriangular, slightly longer than high. Dactylus curved ventrally, about half of propodus length. Fixed finger subtriangular, about as long as dactylus; occlusal margin gently concave and ventral margin gently convex. Palm about as long as high; dorsal and ventral margins gently arched. Carpus about as long as propodus, tapering proximally; dorsal margin gently convex and ventral margin nearly straight. Merus long, about 2.5 times as long as carpus; dorsal margin nearly straight; ventral margin gently convex. Ischium short.

Pereiopods 3–5 poorly known, compressed laterally, with unarmed margins and smooth surfaces. Dactylus of pereiopod 3 not preserved; propodus much higher than long; carpus longer than propodus, tapering proximally; merus long. Carpi and meri of pereiopods 4 and 5 long, slender.

Pleopods preserved, long, but detailed characters not observed.

Remarks: Most of *Ahazianassa masanorii* are preserved three-dimensionally within nodules. The preservation style of our material is really variable and is correspond to all types summarized by Hyžný and Klompmaker (2015) who discussed the types of the ghost shrimp preservation of Bishop and Williams (2005). The disassociated chelae of the pereiopods 1 are most abundant in nodules, but sometimes are associated with disassociated other pereiopods, the carapace, the pleon, the telson, uropods, and pleopods. It is noteworthy that nearly completed bodies are preserved. Additionally, several individuals are preserved within the same nodule (pl. 17, figs. 1a–4b). Bishop and Williams (2005) and Hyžný and Klompmaker (2015) showed that nearly-completed bodies were preserved within burrows and/or the direct association of burrows; however, our specimens have not yet been associated with burrows. The detailed taphonomic work by Ando *et al.* is now in progress; therefore, exemplars of preservation within our work are herein figured.

Material examined: Holotype, D000495, paratypes, D000506, D000507, MFM247008), and 27 additional specimens, MFM247114, MFM247115, WMNH-Ge-1141220003, WMNH-Ge-1141220005, and D1048502–1048505, and D1048507–D1048521 from Yura (=Loc. Aw16 of Morozumi, 1985), Sumoto City, Hyogo Prefecture, Mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985). 1048506 from Chikusakou (=Loc. Aw12 of Morozumi, 1985), Sumoto City, Hyogo Prefecture, Mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985). WMNH-Ge-1141220006 from Nadayamamoto (=Loc. Aw16 of Morozumi, 1985), Minamiawaji City, Hyogo Prefecture; nodule of the Shimonada Formation of the Izumi Group (early Maastrichtian; *Pachydiscus* sp. aff. *P. subcompressus* Zone of Morozumi, 1985). We have to note that two paratypes, MFM247007 and 247009, have been lost and have not yet been deposited in the Mizunami Fossil Museum.

Infraorder Brachyura Latreille, 1802
Section Eubrachyura de Saint Laurent, 1980
Superfamily Retroplumoidea Gill, 1894

Family Archaeopidae, new family

Type and sole included genus: *Archaeopus* Rathbun, 1908.

Diagnosis: see genus.

Discussion: Retroplumidae contains two extant genera, *Bathypluma* de Saint Laurent, 1989, and *Retropluma* Gill, 1894 (type genus) and nine extinct genera, *Archaeopus* Rathbun, 1908, *Costacopluma* Collins and Morris, 1975, *Cristipluma* Bishop, 1983, *Gaudipluma* Artal, Van Bakel, Fraaije, and Jagt, 2013, *Gonioplacoides* Quayle and Collins, 2012, *Loerenthoplumopsa* Schweitzer, Dworschak, and Martin, 2011 (new name for *Loerentheya* Beurlen in Lőrenthey and Beurlen, 1929), *Loerenthopluma* Beschin, Busulini, De Angeli, and Tessier, 1996, *Retrocypoda* Vía, 1959, *Serrablopluma* Artal, Van Bakel, Fraaije, and Jagt, 2013 (Feldmann and

Schweitzer, 2018).

Among these retroplumid genera, the systematic position of *Archaeopus* have been often discussed. de Saint Laurent (1989), McLay (2006), and Guinot *et al.* (2013) summarized the historical account of the systematic placement of *Archaeopus*. Rathbun (1908) erected the new monotypic genus *Archaeopus* with *Archaeopus antennatus* Rathbun, 1908, and originally placed it in Retroplumidae (Rathbun, 1908), and most subsequent workers followed her opinions (*i.e.*, Collins *et al.*, 1993; De Grave *et al.*, 2009; Schweitzer *et al.*, 2010). Glaessner (1969) moved *Archaeopus* to Palicidae Bouvier, 1898, and McLay (2006) assigned *Archaeopus* together with some species of *Costacopluma* to Palicidae, but noted that the genus should be removed to a new unnamed family. However, the anterior end of the pleon within Palicidae extends to the base of maxillipeds 3 (Guinot *et al.*, 2013), but that in *Archaeopus* reaches the sternal suture 3/4. Additionally, within Palicidae a wide frontal margin of the carapace consists of two or four lobes, upper orbital margins bear two deep fissures, lateral margins bear numerous teeth, chelae of pereiopod 1 are short, pereiopods 2–4 are extremely long, and the well-developed episternite 7 is expanded posteriorly. *Archaeopus* apparently lacks those characters. de Saint Laurent (1989) suggested that *Archaeopus*, *Costacopluma*, *Cristipluma*, and *Retrocypoda* should be excluded from Retroplumidae and should be placed in an another her retroplumoid family Costacoplumidae (an unavailable name under Art. 13.2 of ICZN (1999)). Although Guinot and Breton (2006) and Guinot *et al.* (2013) discussed about the systematic position of *Archaeopus* under Retroplumidae and/or Palicidae, but retained the status of *Archaeopus* within Retroplumidae.

Examination of the original description of the type species, *Archaeopus antennatus*, and newly and previously known material of *A. ezoensis* suggests that *Archaeopus* warrants its own new family. Within most extant and extinct taxa of Retroplumidae a flattened carapace is ornamented with well-developed dorsal ridges, the front is extremely narrow, and the dorsal regions are not well defined (de Saint Laurent, 1989; Guinot *et al.*, 2013). However, *Archaeopus* lacks these carapace characters and have an inflated carapace with well-defined dorsal regions and a wide rostrum rather than those of other retroplumid genera. Although ventral aspects of three extinct genera, *Cristipluma*, *Gonioplacoides*, and *Loerenthoplumopsa*, have not yet known, these characters among remainders have been well documented as in *Costacopluma* (Armstrong *et al.*, 2009; Collins and Ward, 2010; Martínez-Díaz *et al.*, 2016; Vega *et al.*, 2017), *Gaudipluma* (Artal *et al.*, 2013), *Loerenthopluma* (Beschin *et al.*, 1996; Van Bakel *et al.*, 2010), *Retrocypoda* (Vía Boada, 1969; de Saint Laurent, 1989), and *Serrabloplumа* (Artal *et al.*, 2013). Within these extinct and extant genera the anterior end of the sterno-pleonal cavity reaches the thoracic sternite 3, each pleonal somite bears a transverse ridge, the pleonal somite 6 of male is crescent-shaped in outline and the lateral expansions for pleonal locking and the pleon has the fused somites 3–5 (Guinot and Bouchard 1998, Guinot *et al.*, 2013). These characters of the sternum and pleon cannot be seen in *Archaeopus*. Additionally, *Archaeopus* has the median sulcus on the thoracic sternites 6 and 7, which lacks in the extant *Retropluma* and *Bathypluma*.

Archaeopidae is a monotypic family with a sole genus *Archaeopus*. The genus contains eight species from Late Cretaceous to Eocene rocks from the Pacific coast of North America and Japan (Schweitzer *et al.*, 2010; Guinot *et al.*, 2013).

Genus *Archaeopus* Rathbun, 1908

Type species: *Archaeopus antennatus* Rathbun, 1908, by monotypy.

Species included: see Schweitzer *et al.* (2010, p. 99).

Diagnosis: Carapace subquadrate, somewhat wider than long, widest at about posterior third, moderately vaulted longitudinally and transversely; front narrow, produced beyond orbits, downturned, axially sulcate; orbits very wide, sinuous, rimmed, continuing to divergent lateral margin of front, terminating in sharp, anterolaterally directed post-orbital spine, with a shallow notch laterally; infraorbital spines well developed, projected beyond outer-orbital spines; lateral margins weakly convex, diverged posteriorly, bearing short spines at about mid-length; posterolateral angle broadly concave, rimmed; posterior margin about half of maximum carapace width, weakly concave, rimmed. Dorsal surface with well-defined regions; protogastric regions with straight or arcuate ridge; mesogastric regions with transverse ridges; cardiac region sub-pentagonal, much wider than long, ornamented with transverse ridge, fringed with lobate, lateral swellings; hepatic regions with small swelling. epibranchial regions with two ovoid swellings; mesobranchial regions with oblique, discontinuous swellings; sub-hepatic region well-defined, inflated. Thoracic sternum wide, slightly wider than long, widest at sternite 5; sternal suture 2/3 complete; sternite 4 longest, narrowed anteriorly; sternites 5–7 much longer than wide with blunt episternal projections; lateral elements flattened or bearing transverse ridge; sternal sutures 3/4, 4/5, 5/6,

and 6/7 incomplete; sternites 6 and 7 with median sulcus; sternites 8 apparently small; sterno-pleonal cavity of male deep, well-defined; its anterior end rounded, weakly rimmed, reaching sternal suture 3/4. Pleon of male narrow with free somites; telson sub-trapezoidal with convex anterior margin; somite 6 trapezoidal, longest of all somites, with straight lateral margins. Pleon of female wider than that of male with free somites; medial elements inflated, separated from lateral elements by shallow grooves. Pereiopods 1 with sexually dimorphic chelae. Chelae of male subequal, dissimilar in shape; major chela with gaped fingers; propodus of minor chela slightly shorter and more slender than that of major one; both fingers not gaped, elongate. Chelae of female slightly subequal, similar in shape, much slender than those of male; propodus of chela slender, elongate; fingers not gaped. Pereiopods 2–4 slender, elongate, flattened laterally; pereiopod 3 longest. Pereiopod 5 much reduced in size, apparently short, slender, subdorsal; coxa positioned at lateral corner of posterior margin; ischium long, shorter than merus. Eyes elongate, directed laterally with eyestalks tapering distally. Buccal cavern sub-quadrangular. Maxillipeds 3 widely gaped medially.

Archaeopus ezoensis (Nagao, 1941)

(Pl. 18–Pl. 21)

Plagiolophus ezoensis Nagao, 1941, p. 97, pl. 26, figs. 1, 2.
Plagiolophus ezoensis Nagao, 1941; Imaizumi, p. 45.
Archaeopus ezoensis (Nagao, 1941); Collins, Kanie, and Karasawa, 1993 p. 304, figs. 4.3–4.7, 5.1–5.5; Kishimoto, 2012, p. 33, with 6 unnumbered figures.

Diagnosis: *Archaeopus* with weak transverse protogastric ridges (after Collins *et al.*, 1993, p. 34).

Description: Large-sized *Archaeopus*. Carapace trapezoidal in outline, almost as long as wide or slightly wider than long, widest at about posterior third, moderately arched transversely and longitudinally. Carapace of juvenile more longer than that of adult. Fronto-orbital margin about 80% maximum carapace width. Front narrow, about 20% maximum carapace width, projected well beyond orbits, downturned, with deep median sulcus; frontal margin bilobed, composed of gently convex lobes divided by V-shaped median notch. Orbit large; upper orbital margin sinuous, rimmed, bearing shallow notch laterally, continuing to slightly concave, divergent lateral margin of front, with broadly triangular, slightly anterolaterally directed outer-orbital spines; infraorbital spines well developed, projected beyond outer-orbital spines. Lateral margins weakly convex, diverged posteriorly, bearing three short spines directed anterolaterally at about mid-length; cervical notch present, shallow; posterolateral angle broadly concave, rimmed. Posterior margin about half of maximum carapace width, weakly concave, rimmed.

Dorsal surface with well-defined regions. Protogastric regions with prominent, concave-forward granular ridge which extends from mid-line to hepatic regions; short, transverse, granular swelling present behind orbit. Hepatic regions smooth, flattened, with small swelling. Mesogastric region granular posteriorly, widened posteriorly, bearing narrow, elongate anterior process, with convex posterior margin. Urogastric region narrow with concave upper margin and convex lower margin. Cardiac region sub-pentagonal, much wider than long, ornamented with transverse, granular ridge, fringed with lobate, lateral swellings. Intestinal region flattened, narrow. Cervical groove distinct, nearly straight, oblique back from margin to mesogastric region. Epibranchial regions with two ovoid, granular swellings. Mesobranchial regions with oblique, discontinuous, granular swellings. Metabranchial regions swollen. Sub-hepatic region inflated, separated from pterygostomian region by distinct groove.

Thoracic sternum wide, slightly wider than long, widest at sternite 5. Sternites 1 and 2 fused, broadly triangular, axially concave; sternal suture 2/3 nearly straight, complete. Sternite 3 short, narrow, axially depressed, strongly converged anteriorly. Sternite 4 longest, narrowed anteriorly, fused axially and sutured laterally to sternite 3; lateral regions flattened or gently inflated; sternites 4 and 5 fused axially and free laterally. Sternites 5–7 much longer than wide with blunt episternal projections. Sternite 5 narrow axially; lateral regions nearly flat; sternites 5 and 6 fused axially and free laterally. Sternite 6 with median sulcus; sternites 6 and 7 fused axially and free laterally. Sternite 7 narrower than sternite 6, deeply concave posteriorly, with median sulcus; lateral regions flattened directed posterolaterally. Sternite 8 poorly known, small in size. Sterno-pleonal cavity of male deep, well-defined; its anterior end rounded, weakly rimmed, reaching sternal suture 3/4.

Pleon of male narrow, covering sterno-abdominal cavity, with free somites. Telson appears to be sub-trapezoidal, wider than long, with convex anterior margin. Somite 6 subrectangular, longest of all somites, wider than long; lateral margins straight. Somite 5 trapezoidal, much wider than long, narrower and wider than Somite 6; lateral margins straight, converged anteriorly. Somite 4 much narrower and wider than Somite 5, with strongly converged, straight lateral margins. Somites 3 and 2 poorly preserved. Pleon of female wider than that of

male, with free somites; medial elements inflated, separated from lateral elements by shallow grooves. Telson not preserved. Somite 6 sub-trapezoildal, wider than long, with anteriorly diverged lateral margins. Somite 5 subrectangular, wider than long, about half length of Somite 6. Shape of somites 2-4 similar to that of somite 5, decreasing in width anteriorly.

Pereiopods 1 with sexually dimorphic chelae. Chelae of male subequal, dissimilar in shape; propodus of major chela about 2.2 times as long as high; fingers gaped; dactylus about half length of propodus, moderately curved ventrally, with unarmed dorsal margin and roughly serrated occlusal margin; fixed finger about as long as dactylus, deflexed ventrally, bearing longitudinal lateral groove along ventral margin, with roughly serrated occlusal margin and unarmed ventral margin; palm much longer than high, inflated laterally, with unarmed dorsal and ventral margins; carpus short. Propodus of minor chela slightly shorter and more slender than that of major one; fingers not gaped, elongate, bearing finely serrated occlusal margins, with unarmed dorsal and ventral margins. Chelae of female slightly subequal, similar in shape; propodus of chela about 3.5 times as long as high; fingers not gaped; dactylus about half length of propodus, gently curved ventrally, with unarmed dorsal margin and finely serrated occlusal margin; fixed finger about as long as dactylus, deflexed ventrally, laterally bearing longitudinal groove, along ventral margin, with finely serrated occlusal margin and unarmed ventral margin; palm much longer than high, inflated laterally, with unarmed dorsal and ventral margins; carpus short.

Pereiopods 2–4 slender, elongate, flattened laterally; pereiopod 3 longest. Pereiopod 5 apparently short, slender, subdorsal; coxa positioned at lateral corner of posterior margin; ischium long, shorter than merus.

Eyes elongate, directed laterally, with eyestalks tapering distally. Buccal cavern sub-quadrangular. Maxillipeds 3 widely gaped medially. Ischium of endopod much longer than wide, narrowing distally. Merus longer than wide, narrower and shorter than ischium. Articles of palp poorly preserved. exopod narrow, much longer than wide.

Material examined: D1048523–D1048528, D1048530, and MFM247123 from Yura (=Loc. Aw16 of Morozumi, 1985), Sumoto City, Hyogo Prefecture, mudstone of the Kita-ama Formation of the Izumi Group (early Maastrichtian; *Nostoceras hetonaiense* Zone of Morozumi, 1985). D1048522, D1048529, MFM247116, MFM247121, and MFM247122, from Nadaokawa (=Loc. IZM-2 of Collins *et al*., 1993), Minamiawaji City, Hyogo Prefecture; mudstone of the Shimonada Formation of the Izumi Group (early Maastrichtian; *Pachydiscus* sp. aff. *P. subcompressus* Zone of Morozumi, 1985). D1048522, D1048529, MFM247101, MFM247117, and MFM247118 from Nadachino (=Loc. IZM-1 of Collins *et al*., 1993), Minamiawaji City, Hyogo Prefecture; mudstone of the Shimonada Formation of the Izumi Group (early Maastrichtian; *Pachydiscus* sp. aff. *P. subcompressus* Zone of Morozumi, 1985). MFM247120 from Takinoike (=Loc. IZM-4 of Collins *et al*., 1993), Izumisano City, Osaka Prefecture; nodule of the Matsuo Formation of the Izumi Group (Campanian/Maastrichtian by Matsumoto and Morozumi, 1980).

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