A new species of *Princaxelia* from Shinkai Seep Field, Mariana Trench (Crustacea, Amphipoda, Pardaliscidae)

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Abstract

A new pardaliscid amphipod, *Princaxelia marianaensis* sp. nov., is described from a single female captured at the Shinkai Seep Field, Mariana Trench, from a depth of 5,689–5,683 m. A key to species of *Princaxelia* is provided. This is the first species of *Princaxelia* to be described from the Mariana Trench, and the second report of this genus from this region.

Keywords

COI, deep sea, first record, hadal zone, *Princaxelia marianaensis*, systematics
Introduction

The benthic amphipod genus *Princaxelia* Dahl, 1959 occurs in deep waters of the Pacific Ocean (Lörz 2010). To date, four species have been described: *P. abyssalis* Dahl, 1959 from 6,435–9,530 m in the Aleutian, Kurile-Kamchatka, Izu-Ogasawara, Yap, Japan, Philippine, Bougainville, and Kermadec Trenches (Kamenskaya 1981, 1997); *P. jamiesoni* Lörz, 2010 from 7,055–9,583 m in the Kurile-Kamchatka, Japan, and Izu-Ogasawara Trenches (Lörz 2010; Jażdżewska and Mamos 2019); *P. magna* Kamenskaya, 1977 from 7,190–7,250 m in the Yap Trench; and *P. stephensi* Dahl, 1959, the type species of the genus, from 1,505 m off the coast of Iceland. *Princaxelia abyssalis* and *P. jamiesoni* are reported to prey on other amphipods, suggesting that this genus is carnivorous (Jamieson et al. 2012).

The Shinkai Seep Field is a serpentinitized, peridotite-hosted, cold-seep system which hosts an aggregation of chemosynthesis-based communities including *Abyssogena* clam, *Provanna* gastropod, and *Phyllochaetopterus* polychaete species. It is located northeast of the Challenger Deep, the deepest part of the Mariana Trench (Ohara et al. 2012; Okutani et al. 2013, 2016; Chen et al. 2018; Watanabe et al. in press). During one submersible dive on an expedition to this seep by R/V *Yokosuka*, a single specimen of a species referable to *Princaxelia* was collected. This is the first record of an identified *Princaxelia* species from the Mariana Trench. We here describe and illustrate this species as new.

Material and methods

Samples

The single *Princaxelia* specimen was collected from the Mariana Trench during dive 1402 of the deep-submergence vehicle (DSV) *Shinkai 6500* aboard R/V *Yokosuka* (cruise YK14-13, PI: Yasuhiko Ohara) by H. K. Watanabe (Fig. 1). Aboard the ship, the specimen was fixed and preserved in 99.5% ethanol. The specimen was sorted by K. Tanaka in the laboratory.

The holotype of *P. jamiesoni*, which was collected from the Japan Trench, was borrowed from the Tsukuba Collection Center of the National Museum of Nature and Science, Tokyo (NSMT-Cr 21250, female BL 56.2 mm), for comparison.

Morphology

Appendages were dissected in 99% ethanol and mounted using gum chloral medium on glass slides with the aid of a stereomicroscope (Olympus SZX7). Appendages were examined by light microscopy (Nikon Eclipse Ni) and illustrated using a camera lucida. Body length (BL), from the tip of the rostrum to the base of the telson along the dorsal curvature, was measured to the nearest 0.1 mm. The only known specimen, the holotype, has been deposited in the collections of the American Museum of Natural History (AMNH).
PCR and DNA sequencing

Genomic DNA was extracted from pereopod muscle of the holotype following procedures detailed in Tomikawa et al. (2014). The primer set for the cytochrome c oxidase subunit I (COI) gene (LCO1490 and HCO2198; Folmer et al. 1994) was used for the polymerase chain reaction (PCR) and cycle sequencing reactions. PCR and sequencing followed the methods detailed by Tomikawa et al. (2017). The DNA sequence has been deposited with the International Nucleotide Sequence Database Collaboration (INSDC) through the DNA Data Bank of Japan (DDBJ).

Systematics

Family Pardaliscidae Boeck, 1871
Genus Princaxelia Dahl, 1959

Princaxelia marianaensis Tomikawa & Watanabe, sp. nov.
http://zoobank.org/B127A8B4-7BDA-4027-A7DA-8C04F61EA6BA
Figures 2–5

Material examined. Holotype: female (BL 23.9 mm), AMNH_Izc 00361360, the surface of the chimney which was named as “Chim 4” in CH 3 site in the Shinkai Seep Field (Okumura et al. 2016), Mariana Trench (11°39.36′N, 143°2.88′W), 5,689–5,683 m, collected by H. K. Watanabe, 17 July 2014.
Diagnosis. Posterodistal corner of epimeral plate 3 quadrate. Primary flagellum article 1 of female antenna 1 not elongate; accessory flagellum article 1 longer than each of the articles 2–6. Maxilla 1 inner plate with 1 terminal plumose seta; palp article 2 expanded, with 8 or 9 apical robust setae. Dactylus of gnathopods 1 and 2 with three strong projections on posterior margin proximal to base. Dorsal margin of coxa 5 highest at proximal end. Venral margin of coxa 7 weakly concave. Telson lobe uniformly tapering distally.

Description (female). Head (Fig. 2) as long as pereonites 1 and 2 combined; rostrum short, pointed; lateral cephalic corner rounded; eyes absent. Pleon (Fig. 2) with dorsal surfaces of pleonites 1–3 smooth; epimeral plates 1–3 (Fig. 3A–C) with setae on ventral submargin and posterior margin; posterodistal corner of epimeral plates 2 and 3 quadrate. Dorsal margin of urosomites 1 and 2 (Fig. 2) with distally oriented projection.

Antenna 1 (Fig. 3D) length 0.3 times BL (distal part broken off); peduncular articles 1–3 with length ratio 1.0 : 0.7 : 0.3; peduncular article 1 broadened, with anterolateral cluster of setae, some weakly plumose; posterior margin of peduncular articles 2 and 3 with clusters of short setae; primary flagellum article 1 length 1.2 times width, 3.0 times as long as article 2; accessory flagellum 6-articulated, article 1 0.9 times as long as articles 2–6 combined; primary flagellum with at least 47 articles.

Antenna 2 (Fig. 3E) length 0.4 times BL; anterior margin of peduncular article 2 with setae; peduncular articles 4 and 5 with clusters of short setae on anterior margin, article 4 1.1 times longer than article 5; flagellum with 42 articles.
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Upper lip (Fig. 3F) asetose, with asymmetrically incised ventral margin. Mandibles (Fig. 3G–I) slightly asymmetric, incisor margins broad, anteroventral corner with strong tooth; left lacinia mobilis (Fig. 3H) broad, about 0.7 times as long as incisor,
multi-dentate; right incisor (Fig. 3I) with three teeth on proximal to anterodorsal corner; right lacinia weak, with two teeth; accessory setal row of left and right mandibles each with about 20 robust setae; molar absent; mandibular palp 3-articulated with length ratio 1.0 : 1.7 : 1.5; article 1 asetose; article 2 posteriorly reflected, articles 2 and 3 with 18 and 22 setae, respectively. Lower lip (Fig. 3J) with broad outer and distinct inner lobes. Maxilla 1 (Fig. 3K, L) with inner and outer plates and palp; inner plate small with apical plumose seta; outer plate subrectangular, with 9 robust apical setae and strong projection; palp 2-articulate; article 1 with marginal setae; article 2 expanded distally with nine and eight robust setae on apical margin of left and right maxilla 1, respectively, and with apical submargin and medial margin lined with setae. Maxilla 2 (Fig. 3M) with inner plate bearing row of 13 plumose setae along apical to medial margin; outer plate slightly longer than inner plate, with three apical plumose setae. Maxilliped (Fig. 3N) with inner and outer plates and palp; inner plate small, subtriangular, not reaching base of palp, with plumose apical seta and short subapical seta; outer plate oval, reaching base of article 2 of palp, with setae along apical to medial margin; palp 4-articulate, long: article 2 longest with inner marginal rows of setae, article 3 with clusters of setae on dorsal and ventral faces and medial marginal setae, and article 4 slender, with robust setae on medial margin.

**Gnathopod 1** (Fig. 4A, B) coxa subrectangular, length 1.8 times width, ventral margin straight, posterior submargin and medial face with setae; basis arched, with anterior and posterior margins with numerous setae in a row; posterior margin of merus with sparse setae; carpus oval, length 2.5 times width, posterior margin and medial face setose; propodus slender, length 0.6 times that of carpus, posterior margin weakly convex with setae; dactylus slender, slightly curved, posterior margin with three strong projections proximal to base. Gnathopod 2 (Fig. 4C, D) coxa tapering anteriorly, length 1.8 times width, posterior submargin with setae; basis slender and straight, anterior and posterior margins densely setose; carpus widely produced posteriorly with numerous long setae, length 2.3 times width; propodus and dactylus similar to gnathopod 1.

**Pereopod 3** (Fig. 4E, F) coxa weakly rounded ventrally, with submarginal setae; basis long, posterior margin strongly setose; merus, carpus, propodus, and dactylus in length ratio 1.0 : 1.4 : 1.4 : 0.5; posterior margin of propodus lined with short setae. Pereopod 4 (Fig. 4G) similar to pereopod 3, with coxa tapering anteriorly. Pereopod 5 (Fig. 4H, I) coxa subtriangular, dorsal margin highest at proximal end, anterior and ventral submargins with setae; basis length 2.9 times width, with clusters of setae on anterior margin proximal to base, posterodistal corner weakly produced; merus, carpus, propodus, and dactylus in length ratio 1.0 : 0.8 : 1.2: 0.3; carpus and propodus with robust setae on anterior and posterior margins. Pereopod 6 (Fig. 4J) coxa weakly concave; basis length 2.5 times width, posterodistal corner quadrate; merus, carpus, propodus, and dactylus in length ratio 1.0 : 1.0 : 1.2: 0.3. Pereopod 7 (Fig. 4K) coxa weakly concave; basis length 1.9 times width, weakly expanded anteriorly, posterodistal corner quadrate.

**Coxal gills** (Fig. 2) on gnathopod 2, pereopods 3–6; coxal gills 2–4 elongate, coxal gill 2 longest, its length exceeding the distal part of basis of gnathopod 2, coxal gill 6 shortest.
Figure 4. *Princaxelia marianaensis* Tomikawa & Watanabe, sp. nov., holotype female (BL 23.9 mm)
A gnathopod 1, lateral view  B dactylus of gnathopod 1, lateral view  C gnathopod 2, lateral view
D dactylus of gnathopod 2, lateral view  E pereopod 3, lateral view  F dactylus of pereopod 3, lateral view
G pereopod 4, lateral view  H pereopod 5, lateral view  I dactylus of pereopod 5  J pereopod 6, lateral view
K pereopod 7, lateral view.
**Pleopods 1–3** (Fig. 5A–C) each with paired retinacula (Fig. 5B) on inner distal margin of peduncle, and bifid (clothespin) setae (Fig. 5C) on inner basal margin of inner ramus; rami articles wide and flattened.

**Uropod 1** (Fig. 5D) peduncle longer than rami, with 14 basofacial setae, distomedial peduncular projection very strong; inner ramus length 0.8 times that of peduncle, outer ramus distally damaged, rami with setal row along medial and lateral margins. Uropod 2 (Fig. 5E) peduncle slightly longer than rami, with four basofacial setae, distomedial peduncular spine shorter than that of uropod 1; inner ramus length 1.2 times that of outer ramus, rami with setal row along medial and lateral margins. Uropod 3 missing (damaged).

**Telson** (Fig. 5F) length 2.3 times width, with cleft extending 80% its length; lobes tapering distally with facial setae; apex of each lobe shallowly incised with small robust seta.

**Etymology.** The specific name is an adjective derived from the type locality, the Mariana Trench.

**DNA sequence.** A single nucleotide sequence of COI was obtained from the holotype (AMNH_IJC 00361360; 658 bp).

**Remarks.** The morphologies of *P. marianaensis* sp. nov. and congeners are summarized in Table 1. *Princaxelia marianaensis* sp. nov. is most similar to *P. abyssalis* Dahl, 1959 in having a short first flagellar article of the female antenna 1, a weakly setose maxilla 1, coxa 5 with its dorsal margin highest at the proximal end and its distal margin rounded, and a uniformly tapering telson. However, *P. marianaensis* sp. nov. differs from the description of *P. abyssalis* in having the posterodistal corner of epimeral plate 3 quadrate in *P. marianaensis* sp. nov. but rounded in *P. abyssalis*; the

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**Table 1.** Morphological comparison of *Princaxelia* species.

|                      | *P. marianaensis* Tomikawa & Watanabe, sp. nov. | *P. abyssalis* Dahl, 1959 | *P. jamiesoni* Lörz, 2010 | *P. magna* Kamenskaya, 1977 | *P. stephenseni* Dahl, 1959 |
|----------------------|-------------------------------------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|
| Maximum body size    | female 23.9 mm                                 | male 21 mm, female 32 mm  | male 57 mm, female 61 mm  | male 32 mm                  | male 10 mm, female 11 mm    |
| Epimeral plate 3     | rounded                                        | quadrant                   | quadrant                   | quadrant                    | weakly rounded              |
| Postero-distal corner|                                                |                           |                           |                             |                             |
| Dorsal projections   | pointing toward distal end                     | unknown                    | pointing toward           | pointing upright            | pointing toward distal end  |
| on urosomites 1 and 2|                                                |                           | distal end                |                             |                             |
| Upper lip            | strongly asymmetrical                          | unknown                    | slightly asymmetrical     | strongly asymmetrical       | nearly asymmetrical          |
| Maxilla 1 palp article 2 | expanded                                | expanded                  | expanded                  | expanded                    | not expanded                |
| Maxilla 1 palp article 2 | 9 apical robust setae           | less than 14 apical robust setae | 25 apical robust setae   | approx. 10 apical robust setae | 7 apical robust setae       |
| Maxilla 1 inner plate | 1 plumose seta                              | 1 plumose seta            | 1 plumose seta            | 6 plumose setae             | 1 plumose seta              |
| Female antenna 1 primary flagellum article 1 | not elongated                       | not elongated              | elongated                  | unknown                     | elongated                    |
| Female antenna 1 accessory flagellum article 1 | longer than each of the rest         | equal to length of        | longer than each of the   | unknown                     | unknown                     |
| Gnatopods 1 and 2 dactyli | 3 strong projections near the base        | unknown                    | 8–9 strong projections    | 4 strong projections        | unknown (absent?)           |
| Coxa 5 dorsal margin | highest at proximal end                      | highest at proximal end   | straight                   | convex                      | straight / convex           |
| Coxa 5 distal margin | rounded                                      | rounded                   | rounded                   | slightly pointed            | straight                     |
| Coxa 7 ventral margin | shallowly concave                           | straight                   | slightly concave           | straight                    | straight                     |
| Telson lobe          | uniformly tapering distally                 | uniformly tapering distally| tapering from distal      | weakly tapering distally    | unknown                     |
| References           | This study                                   | Dahl (1959)               | Lörz (2010); this study   | Kamenskaya (1977)           | Dahl (1959); Lörz (2010)    |
accessory flagellum article 1 of the female antenna 1 longer than each of the articles 2–6 in *P. marianaensis* sp. nov. but equal to the length of the remaining segments in *P. abyssalis*; and the ventral margin of the coxa 7 weakly concave in *P. marianaensis* sp. nov. but straight in *P. abyssalis*. 
Princaxelia jamiesoni Lörz, 2010 was described from 7,703 m and 9,316 m in the Japan and Izu-Ogasawara trenches, respectively (Lörz 2010), and subsequently from 7,055–9,583 m in the Kurile-Kamchatka Trench (Jażdżewska and Mamos 2019). Examination of the holotype of *P. jamiesoni* reveals new features not originally described which facilitate differentiation of this species from *P. marianaensis* sp. nov.: the palp article 2 of the maxilla 1 bears eight or nine robust apical setae in *P. marianaensis* sp. nov. but 25 robust apical setae in *P. jamiesoni* (Fig. 5G); the dactylus of gnathopods 1 and 2 has three strong projections proximal to its base in *P. marianaensis* sp. nov., but eight or nine strong projections proximal to the base of the dactylus in *P. jamiesoni* (Fig. 5H, I); and the telson lobe uniformly tapers distally in *P. marianaensis* sp. nov. but tapers from the distal 1/3 in *P. jamiesoni* (Fig. 5J). While two projections on the dactylus of the left gnathopod 2 were originally described for *P. jamiesoni*, we report nine projections on the right gnathopod 2 of the holotype; we believe that Lörz (2010) described the damaged left gnathopod 2.

The morphology of Princaxelia is consistent with an animal that swims in that its body is streamlined, flat, and has well-developed pleopods (Lörz 2010). Analyses of the locomotion of *Princaxelia* species demonstrate they have a high swimming ability – a trait useful for preying on other amphipods in hadal trenches (Jamieson et al. 2012). Amphipods lack a planktonic larval stage and generally have low dispersal ability (Chapman 2007). Judging from known habitat depths of Princaxelia, with the exception of the bathypelagic *P. stephenseni*, the distributions of species might be expected to be restricted to individual trenches. However, *P. abyssalis*, and especially

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**Figure 6.** Geographical distributions of the species of Princaxelia (map data from GEBCO Compilation Group [2020]). The exact location of the distribution of *P. abyssalis* in the Aleutian Trench is uncertain.
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New Princaxelia from Mariana Trench (Fig. 6) (Kamenskaya 1981, 1997; Lörz 2010; Jazdzewska and Mamos 2019). Deep-sea amphipod species previously regarded as widely distributed have since been found to contain cryptic species (e.g., Narahara-Nakano et al. 2018). Lörz (2010) also considered that P. abyssalis, as reported from multiple trenches by Kamenskaya (1981), may contain other or undescribed species. It is possible that P. abyssalis and P. jamiesoni represent species complexes, but a greater understanding of species diversity of this hadal-dwelling genus will require additional genetic and morphological analyses.

Key to species of Princaxelia modified from Lörz (2010)

We added P. marianaensis sp. nov. to the key by Lörz (2010) and modified the key to include the characteristics of the telson, which was not considered by Lörz (2010).

1 Palp article 2 of maxilla 1 expanded ............................................................
  – Palp article 2 of maxilla 1 not expanded .......... P. stephenseni Dahl, 1959
2 Inner plate of maxilla 1 with 1 terminal plumose seta ................................
  – Inner plate of maxilla 1 with several plumose setae ......................... P. magna Kamenskaya, 1977
3 Primary flagellum article 1 of female antenna 1 not elongate; dorsal margin of coxa 5 highest at proximal end; telson lobe uniformly tapering distally... P. jamiesoni Lörz, 2010
  – Primary flagellum article 1 of female antenna 1 elongate; dorsal margin of coxa 5 straight; telson lobe tapering from distal 1/3 ........ P. abyssalis Dahl, 1959
4 Posterodistal corner of epimeral plate 3 rounded; accessory flagellum article 1 of female antenna 1 equal to length of remaining articles; ventral margin of coxa 7 straight ................................................. P. marianaensis Tomikawa & Watanabe, sp. nov.
  – Posterodistal corner of epimeral plate 3 quadrate; accessory flagellum article 1 of female antenna 1 longer than each of remaining articles; ventral margin of coxa 7 weakly concave ....... P. abyssalis Dahl, 1959

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