

## Two new *Rhynchothorax* sea spiders from Japan

(Pycnogonida, Rhynchothoracidae)

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We describe two new sea-spider species, *Rhynchothorax nopperabo* sp. nov. and *Rhynchothorax monoceros* sp. nov., from Japan. *Rhynchothorax nopperabo*, collected from intertidal gravel at Shiriuchi, Hokkaido, resembles *R. vallatus* Child but differs from the latter in the number and shape of spines on the oviger, number of posterior tubercles on the first lateral process, and length of the auxiliary claws. An 18S rRNA sequence was determined for *R. nopperabo* for future DNA barcoding. *Rhynchothorax monoceros* sp. nov., collected from dead corals on Amami-Oshima Island, Kagoshima, resembles *R. mediterraneus* Costa but differs from the latter in the lack of dorsal tubercles on the third lateral process, lack of mid-ventral spines on the oviger seventh segment, and presence of dorsal tubercle on first coxa of fourth leg. A key to species in *Rhynchothorax* is provided.

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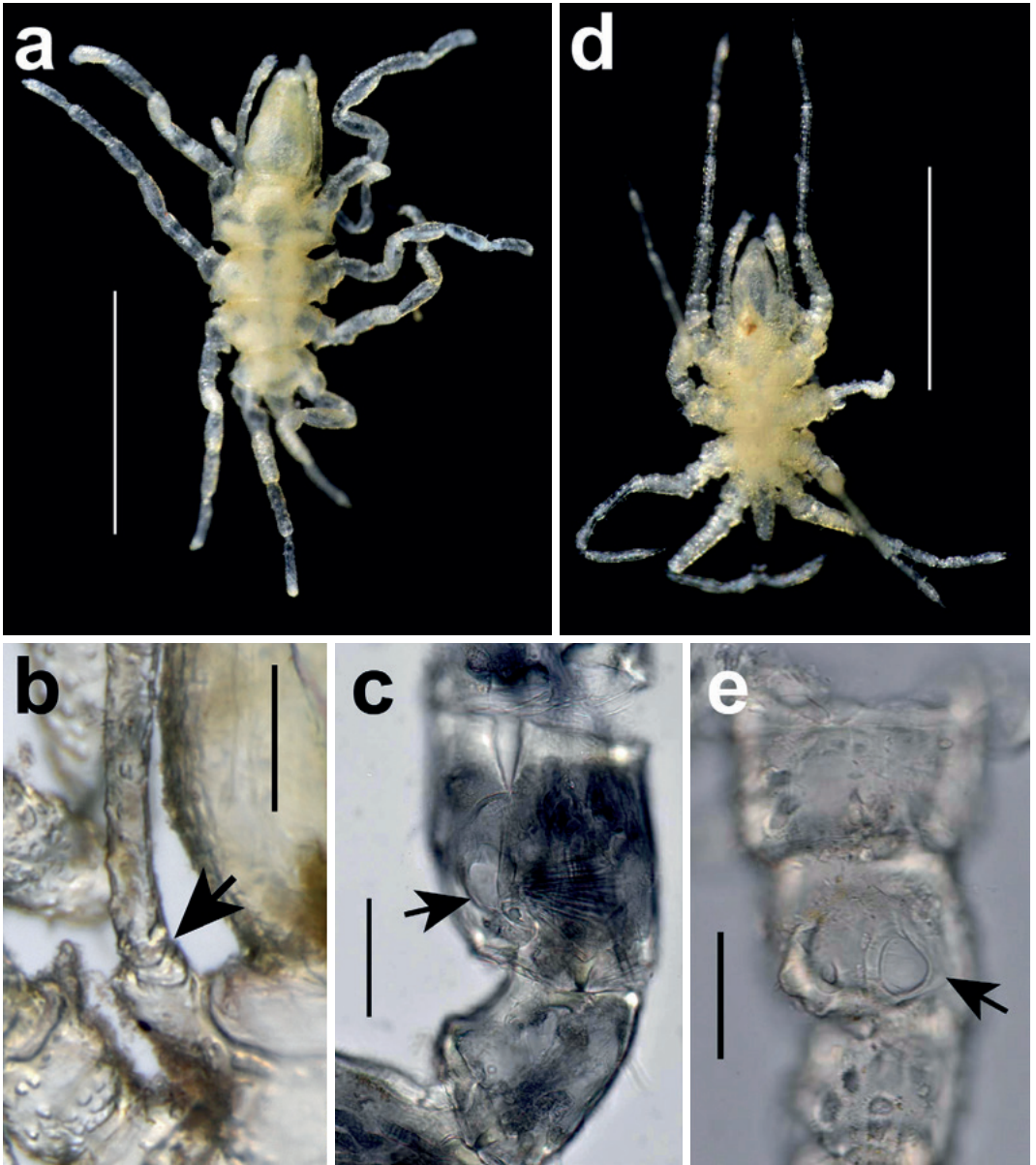
### Introduction

*Rhynchothorax* Costa, 1861, the sole genus in the family Rhynchothoracidae, is characterized by (1) a small body, less than 2.5 mm in total length, (2) three or four segmented trunk, (3) very short legs compared to the total length, (4) chelifores lacking in adults, and (5) nine or 10 oviger segments (Arnaud & Krapp 1990). Arnaud & Krapp (1990) included the number of palp segments as a diagnostic character, but Staples (2019) pointed out that the number may have been incorrectly counted in several species. *Rhynchothorax* ranges from the tropics to the polar regions, with most species recorded interstitially. Currently, 22 species are included in the genus. Molecular phylogenetic

analyses (Arabi et al. 2010, Ballesteros et al. 2021) have indicated that Rhynchothoracidae is closely related to Pycnogonidae.

Two *Rhynchothorax* species have previously been reported from Japan. One is nominal *R. mediterraneus* Costa, 1861, collected subtidally (depth unknown) in Wakayama Prefecture (Miyazaki & Stock 1995) and possibly misidentified; the other is *R. orientalis* Child, 1988, reported from 42.7 m depth in Okinawa Prefecture (Child 1996).

Here we describe two new *Rhynchothorax* species, one from Hokkaido Prefecture and the other from Kagoshima Prefecture, Japan. In addition to descriptions, we provide a partial 18S rRNA gene sequence for the Hokkaido species and present a revised key to the species in *Rhynchothorax*.



**Fig. 1.** New *Rhynchothorax* species described herein, fixed specimens; *Rhynchothorax nopperabo* sp. nov., female, holotype, ICHUM 8636 (a, c), and paratype ICHUM 8637 (b, after soft tissues dissolved for DNA extraction); *Rhynchothorax monoceros* sp. nov., female, holotype (d, e), ICHUM 8640. a, d. Habitus, dorsal view; b. palp first segment (arrow), ventral view; c, e. sexual pore (arrows) on second coxa of fourth leg (c, intentionally stained with black oil-based paint). Scale bars: 1 mm (a, d); 100  $\mu$ m (b); 50  $\mu$ m (c, e).

#### Material and methods

*Rhynchothorax* individuals were collected among intertidal gravel at Ikari-kai, Shiriuchi Town, Hokkaido Prefecture, Japan (41°32'08.8"N, 140°25'46.9"E), on 27

June 2021, and among dead coral obtained by SCUBA diving at 15–30 m depth, Nishikomi, Setouchi Town, Amami-Oshima Island, Kagoshima Prefecture, Japan (28°13'14.0"N, 129°10'35.0"E), on 5 November 2015. The sea spiders were fixed in 70% ethanol and preserved in

99% ethanol. Appendages were detached from the trunk by using chemically sharpened tungsten needles and mounted on glass slides in glycerin. The habitus was observed with a Nikon SMZ 1500 microscope, and slides of appendages were observed with an Olympus BX51 microscope. Illustrations were prepared with Adobe Illustrator 2021 from draft line drawings. Digital images were taken with a D5600 Nikon digital camera. Morphological terminology follows Child (1979). The specimens studied were deposited in the Invertebrate Collection of the Hokkaido University Museum (ICHUM), Japan.

Length measurements of the proboscis, abdomen, trunk, legs (from second coxa to claw), palp, oviger, and apical extension of the ocular tubercle were made laterally; each leg and oviger segment was measured between the midpoints of the proximal and distal segmental borders; claws and terminal claws were measured curvilinearly from proximal joint to distal tip. Trunk length was measured as the length from the frontal margin of the cephalic segment to the anterior border of the abdomen; total length was the combined lengths of proboscis, trunk, and abdomen. Trunk width was measured as the distance across the lateral processes at the attachment points of the first coxae. Trunk height was measured at the border between the cephalic segment and second trunk segment. The lengths of the dorsal tubercle on the fourth palp segment in the Hokkaido species and second palp segment in the Kagoshima species were measured from the base to the distal end. The lengths of apical extensions of the ocular tubercle were measured from the anterior margin of the ocular tubercle to the distal tip of the extension. Measurements in the text are in millimeters.

For morphological comparisons with *R. mediterraneus*, we considered only the description by Dohrn (1881) based on Mediterranean individuals. *Rhynchothorax mediterraneus* was originally described from the Mediterranean and later reported from Brazil (Zilberberg 1963, Zago 1970, Stock 1992), Madagascar (Stock 1974), Seychelles (Child 1988), Mozambique (Stock 1994), New Guinea (Stock 1994), and Japan (Miyazaki & Stock 1995). Several morphological differences, such as the presence/absence of tubercles on the lateral process, were observed in specimens from regions other than the Mediterranean, suggesting they might not have been *R. mediterraneus*.

Total DNA was extracted from whole body (ICHUM 8637, 8639), two legs (ICHUM 8638), or four legs (ICHUM 8639) from Hokkaido individuals, and from the whole body (ICHUM 8642) or three legs (ICHUM 8641) from Kagoshima individuals, by using a NucleoSpin Tissue XS Kit (Macherey-Nagel, Germany). For 18S, primers 18SU (Nakamura et al. 2007) and R9 (Giribet et al. 1996) were used for PCR amplification, and 18S-b3F, 18S-b4R, 18S-b5F, 18S-a6R, and 18S-b8F for cycle sequencing (Kakui et al. 2011, 2021, Kakui & Shimada 2017). Amplification conditions with KOD One polymerase (Toyobo, Japan) were 45 cycles of 98°C for 10 s, 52°C for 5 s, and 68°C for 10 s. Nucleotide sequences were determined by direct sequencing with a

Big Dye Terminator Kit ver. 3.1 and a 3730 DNA Analyzer (Life Technologies, USA). Sequence fragments were concatenated by using MEGA7 (Kumar et al. 2016). Our final sequence was deposited in the International Nucleotide Sequence Database (INSD) through the DNA Data Bank of Japan.

## Taxonomy

### *Rhynchothorax nopperabo* sp. nov.

Figs 1a–c, 2, 3

[New Japanese name: ノッペライボウミグモ (Noppera-ibo-umigumo)]

**Etymology.** The specific name is for the mythical Japanese faceless ghost “Noppera-bo”, referring to the lack of eyes.

**Material examined.** Holotype: Female (ICHUM 8636), three slides and one vial; Ikari-kai, Shiriuchi Town, Hokkaido Prefecture, Japan (41°32'08.8" N, 140°25'46.9" E), intertidal zone, among gravel, 27 June 2021, coll. by Aoi Tsuyuki and Yuki Oya. Paratypes: Three females (ICHUM 8637, three slides and one vial; ICHUM 8638, one vial; ICHUM 8639, one vial); same collection information as for holotype.

**Diagnosis (female).** Anterolateral border of cephalic segment not produced into horns; no dorsal setae on lateral processes; one posterior tubercle on first lateral process; two posterior tubercles on second lateral process not reaching anterior margin of third lateral process; proboscis with nearly smooth dorsal surface; eyes lacking; cephalic segment with antero-dorsal extensions; terminal palp segment unilobed; seventh to ninth segments of oviger with four ventral (one middle and three distal), three ventro-subdistal, three ventro-subdistal terminally-digitiform spines, respectively; auxiliary claws present, longer than half claw length.

### Descriptions of holotype female

Trunk (Figs 1a, 2a, b) four segmented, decreasing in size anterior to posterior, without dorsal tubercles; total length about three times trunk width at second lateral process. Anterolateral border of cephalic segment lacking horns. Fourth trunk segment fan shaped. Lateral processes all separated by less than half their diameter at base, without dorsal setae. First lateral process directed anterolaterally, with large posterior tubercle; second lateral process directed slightly anteriorly, with two large posterior (not reaching anterior margin of third lateral process) and one small anterior tubercles; third lateral process directed slightly posteriorly, with one small

anterior and one small posterior tubercles; fourth lateral process directed posterolaterally, with small anterior tubercle.

Proboscis (Fig. 2a,b) egg shaped with two pairs of slight dorsolateral swellings; mouth triradiate. Anterior tip of proboscis not reaching distal tip of palp in lateral view.

Ocular tubercle and eyes (Fig. 2a,b) lacking.

Abdomen (Fig. 2a,b) conical, not reaching distal margin of second coxa of fourth leg; ventral surface flat; tip slightly trifurcate.

Chelifores (Fig. 2a,b) lacking; cephalic segment with flat triangular anterodorsal extensions.

Palp (Figs 1b,2c) with five segments. First segment tiny, without setae. Second segment cylindrical, with dorsodistal seta. Third segment cylindrical, without setae. Fourth segment cylindrical, with large dorsal tubercle at two-thirds of length from proximal end, several ventrodorsal, one mid-dorsal, and one lateroproximal tiny setae, and laterodistal seta; dorsal tubercle cylindrical, length about half that of fourth segment, with two latero-subdistal and one distal setae. Fifth segment arched dorsally, unlobed, semicircular in shape, with many setae.

Oviger (Fig. 2d,e) with 10 segments. First to third segments cylindrical, without setae; first segment originating from flat ventral surface of trunk. Fourth and sixth segments cylindrical. Fifth segment arched ventrally. Fourth to sixth segments without setae. Seventh segment cylindrical, with one mid-ventral and three ventrodorsal spines. Eighth and ninth segments oval, each with three ventro-subdistal spines. All spines on seventh to ninth segments terminally digitiform. Tenth segment oval, with large terminal claw, distal seta, medial terminally-digitiform spine, two ventroproximal conical spines, and serrated lamellar projection between terminal claw and proximal-most conical spine.

Legs (Fig. 3a–d) slender. First coxa cylindrical, with anterodistal tubercle on first and second legs (Fig. 3a,b), and posterior tubercle on third leg (Fig. 2b). Second coxa cylindrical, with sexual pore on posterior surface of fourth leg (Fig. 1c). Third coxa cylindrical. Femur and first and second tibiae cylindrical, each with long dorsodistal seta and several tiny setae as illustrated; three ventrodorsal setae on second tibia. Tarsus with ventral seta. Propodus cylindrical, slightly arched ventrally, with many setae. Claw short, broad. Two auxiliary claws, narrow, longer than half claw length.

**Measurements.** Primarily based on holotype; in parentheses are corresponding measurements for paratype ICHUM 8637; nd, no data.

Proboscis length 0.51 (0.51), trunk length 0.90 (0.90), abdomen length 0.22 (0.21), total length

1.62 (1.62), proboscis width 0.27 (0.29), trunk widths at first and second lateral processes 0.53 (0.48), 0.50 (0.51).

Lengths for palp: second to fifth segments 0.26 (0.25), 0.06 (0.06), 0.13 (0.15), 0.08 (0.07) [total length 0.53 (0.53)]; dorsal tubercle on fourth segment 0.07 (0.07).

Lengths for oviger: second to tenth segments 0.06 (nd), 0.08 (0.08), 0.13 (0.12), 0.09 (0.09), 0.13 (0.13), 0.08 (0.07), 0.06 (0.06), 0.05 (0.04), 0.06 (0.06), terminal claw 0.04 (0.04) [total length from second segment to terminal claw 0.78 (nd)].

Lengths for first leg: first coxa 0.14 (nd), second coxa 0.17 (0.18), third coxa 0.12 (0.08), femur 0.28 (0.27), first tibia 0.26 (0.26), second tibia 0.26 (0.26), tarsus 0.03 (0.03), propodus 0.20 (0.20), claw 0.07 (0.06) [total length 1.52 (nd)]; auxiliary claw 0.05 (0.05).

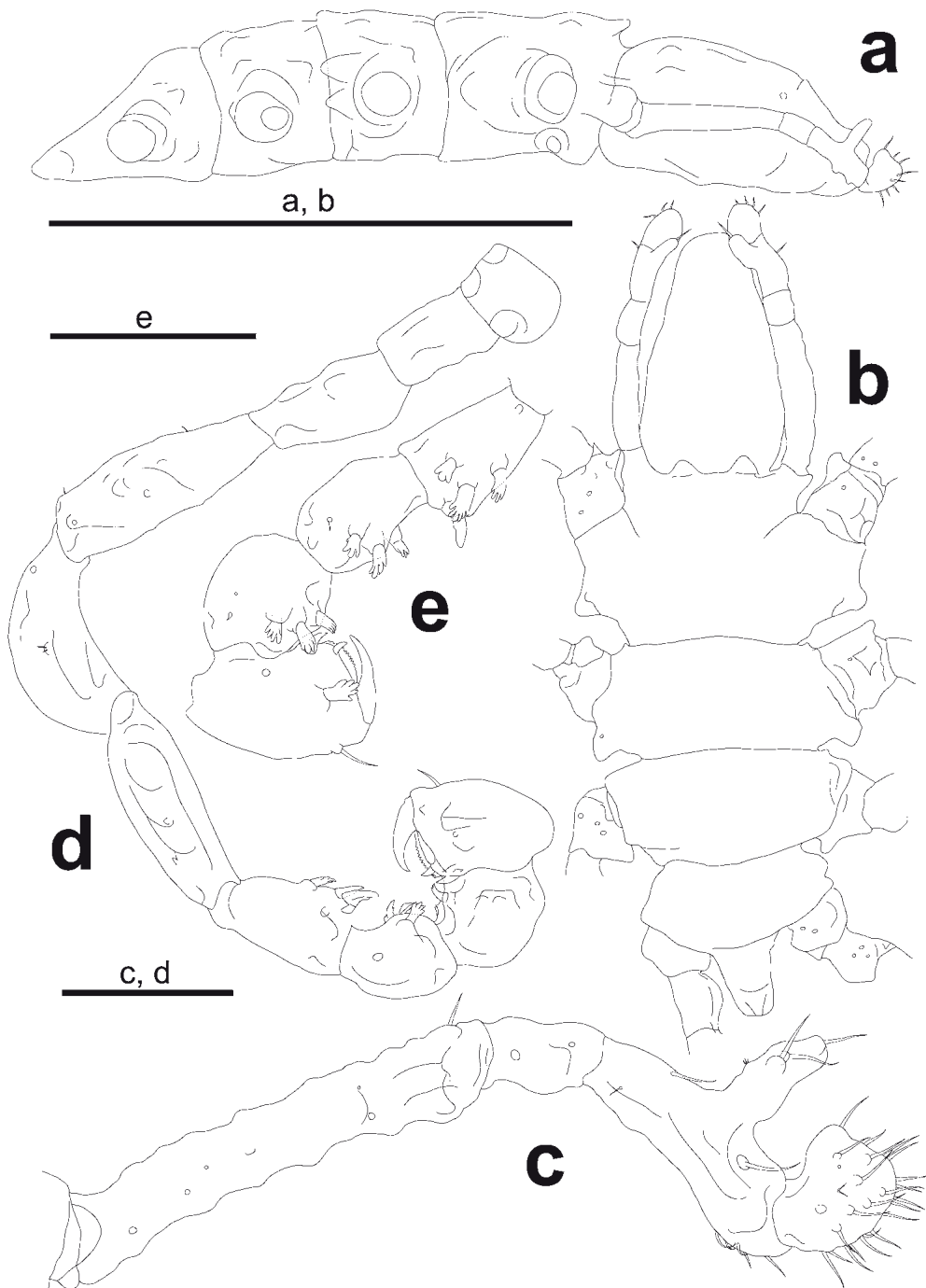
Lengths for second leg: first coxa 0.10 (nd), second coxa 0.12 (0.14), third coxa 0.10 (0.10), femur 0.21 (0.20), first tibia 0.22 (0.18), second tibia 0.20 (0.22), tarsus 0.03 (0.03), propodus 0.18 (0.18) claw 0.06 (0.06) [total length 1.22 (nd)]; auxiliary claw 0.05 (0.05).

Lengths for third leg: first coxa 0.07 (nd), second coxa 0.11 (0.12), third coxa 0.09 (0.09), femur 0.22 (0.22), first tibia 0.20 (0.21), second tibia 0.21 (0.21), tarsus 0.03 (0.03), propodus 0.20 (0.19) claw 0.07 (0.06) [total length 1.19 (nd)]; auxiliary claw 0.04 (0.05).

Lengths for fourth leg: first coxa 0.08 (nd), second coxa 0.13 (0.13), third coxa 0.09 (0.09), femur 0.25 (0.23), first tibia 0.24 (0.24), second tibia 0.24 (0.22), tarsus 0.03 (0.05), propodus 0.24 (nd, broken) claw 0.07 (nd, broken) [total length 1.37 (nd)]; auxiliary claw 0.04 (nd, broken).

**Genetic information.** A partial 18S sequence was determined from one paratype (ICHUM 8639, 1695 bp, LC795945). The sequence in the INSD most similar to our 18S sequence, as determined by BLAST searches (Altschul et al. 1990), was from the pycnogonid *Pycnogonum tuberculatum* Clark, 1963 (KX536444; identity score 96.36%, query cover 100%; Sabroux et al. 2017). A single congeneric 18S sequence had previously been deposited in INSD, from nominal *R. mediterraneus* collected from Japan (AB292215; Nakamura et al. 2007); this sequence appeared in ninth place in our BLAST results (identity score 96.21%, query cover 99%). One *Hedgpethia* (Colossendeidae) and six *Pycnogonum* sequences appeared in the second to eighth places, with 96.02–96.53% identity scores and 100% query cover.

**Remarks.** *Rhynchothorax nopperabo* sp. nov. is similar to the six congeners in the *philopsannum*-group sensu Krapp (1973) (*R. alcornis* Krapp, 1973; *R. anophthalmus*, Arnaud, 1972; *R. architectus* Child, 1979; *R. areni-*



**Fig. 2.** *Rhynchothorax nopperabo* sp. nov., female, holotype, ICHUM 8636. **a, b.** Body, lateral (**a**) and dorsal (**b**) views; **c.** right palp; **d.** left oviger; **e.** distal part of right oviger. Scale bars: 1 mm (**a, b**); 100  $\mu$ m (**c-e**).

*colus* Stock, 1989; *R. philopsammum* Hedgpeth, 1951; and *R. vallatus* Child, 1990) in lacking eyes, having auxiliary claws, and having anterodorsal extensions on the cephalic segment. It differs from all of them except *R. vallatus* in having a unilobed terminal segment of the palp, the anterolateral border of the cephalic segment not produced into horns, and the two small posterior tubercles on the second lateral process not reaching the anterior margin of the third lateral process, and in lacking mid-dorsal tubercles on the proboscis.

*Rhynchothorax nopperabo* differs from *R. vallatus* as follows (character states of *R. vallatus* in parentheses; Child 1990): the oviger has a mid-ventral and three ventrodistal spines on the seventh segment, three ventro-subdistal spines on each of the eighth and ninth segments, two ventroproximal conical spines and a medial spine on the tenth segment (one mid-ventral and one ventrodistal spine on the seventh; one mid-ventral spine on each of the eighth and ninth; one ventroproximal spine on the tenth); the spines on the seventh to ninth segments of the oviger are terminally digitiform (conical); each lateral process lacks dorsal setae (one); the first lateral process has one posterior tubercle (two); the auxiliary claws are 0.63–0.81 times as long as the claw (less than half the claw length).

The 18S sequence in the INSD most similar to that from *R. nopperabo*, as determined by BLAST searches, was not from a confamilial species but from the pycnogonid *Pycnogonum tuberculatum*. All of the top nine sequences determined by BLAST searches (one from Rhynchothoracidae, seven from Pycnogonidae, and one from Colossendeidae) showed approximately 96% similarity to our sequence, i.e., our sequence differed from one confamilial and eight non-confamilial sequences to the same extent. This suggests that the 18S data alone may be insufficient to distinguish these three families.

*Rhynchothorax monoceros* sp. nov.

Figs 1d, e, 4, 5, 6

[New Japanese name: イツカクイボウミグモ (Ikkaku-ibo-umigumo)]

**Etymology.** The specific name is the Latin noun (nominative case) for unicorn, referring to the long, anteriorly directed apical extension of the ocular tubercle.

**Material examined.** Holotype: Female (ICHUM 8640), six slides and one vial; Nishikomi, Setouchi Town, Amami-Oshima Island, Kagoshima Prefecture, Japan (28°13'14.0"N, 129°10'35.0"E), 15–30 m

depth, among dead coral collected by SCUBA diving, 5 November 2015, coll. by Keiichi Kakui. Paratypes: Two females (ICHUM 8641, one vial; ICHUM 8642, seven slides); same collection information as for holotype.

**Diagnosis (female).** Trunk three segmented, with third and fourth trunk segments fused; trunk less than four times as long as proboscis; dorsal tubercles lacking on third lateral process; eyes present; ocular tubercle with long, anteriorly directed apical extension overhanging approximately proximal half of proboscis; anterodorsal extensions of cephalic segment lacking, seventh segment of oviger without mid-ventral spines, first coxa of fourth leg with dorsal tubercle; auxiliary claws absent.

**Descriptions of holotype female**

Trunk (Figs 1d, 4a–d) three segmented, decreasing in size anterior to posterior. Dorsomedian tubercle present on cephalic, second trunk, and third trunk segments, respectively; all tubercles conical, about half as tall as trunk height, with rounded apex. Total length about three times trunk width at second lateral process. Anterolateral border of cephalic segment not produced into horns. Third and fourth trunk segments fused; fourth trunk segment fan shaped. Lateral processes all separated by less than half their diameter at base. First, second, and fourth lateral processes each with large dorsal tubercle. First lateral process directed anterolaterally; second lateral process directed slightly anteriorly; third lateral process directed slightly posteriorly; fourth lateral process directed posterolaterally. Two dorsal conical tubercles present posterior to ocular tubercle, about half as tall as dorsomedian tubercles on trunk.

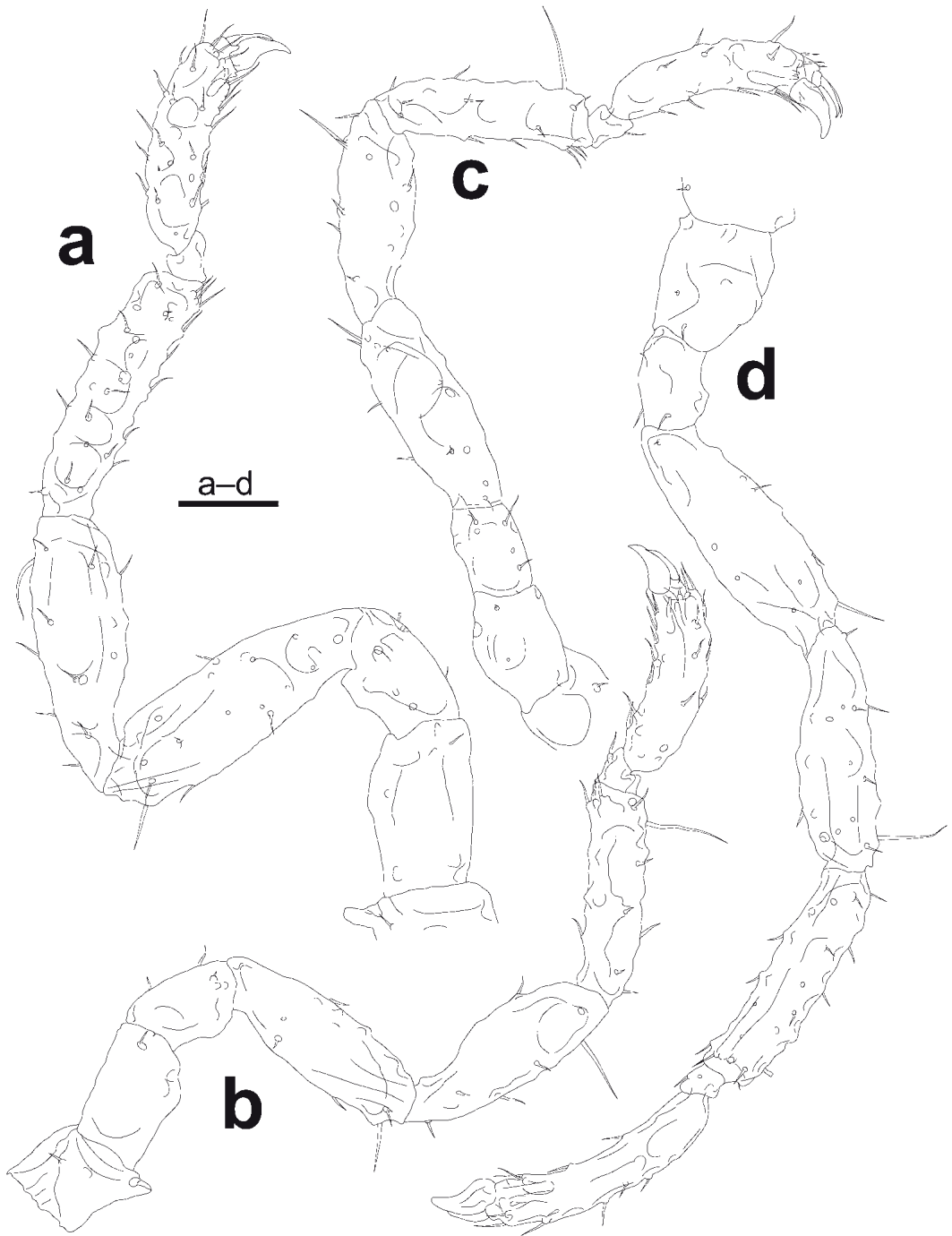
Proboscis (Fig. 4a–d) egg shaped, slightly bent down, with vertical mouth, gentle mid-dorsal bulge, and two ventroproximal bulges. Anterior tip of proboscis not reaching distal tip of palp in lateral view.

Ocular tubercle (Fig. 4a–d) present on anterodorsal surface of cephalic segment, as tall as dorsomedian tubercles on trunk, with eyes. Long, anteriorly directed apical extension of ocular tubercle overhanging approximately proximal half of proboscis.

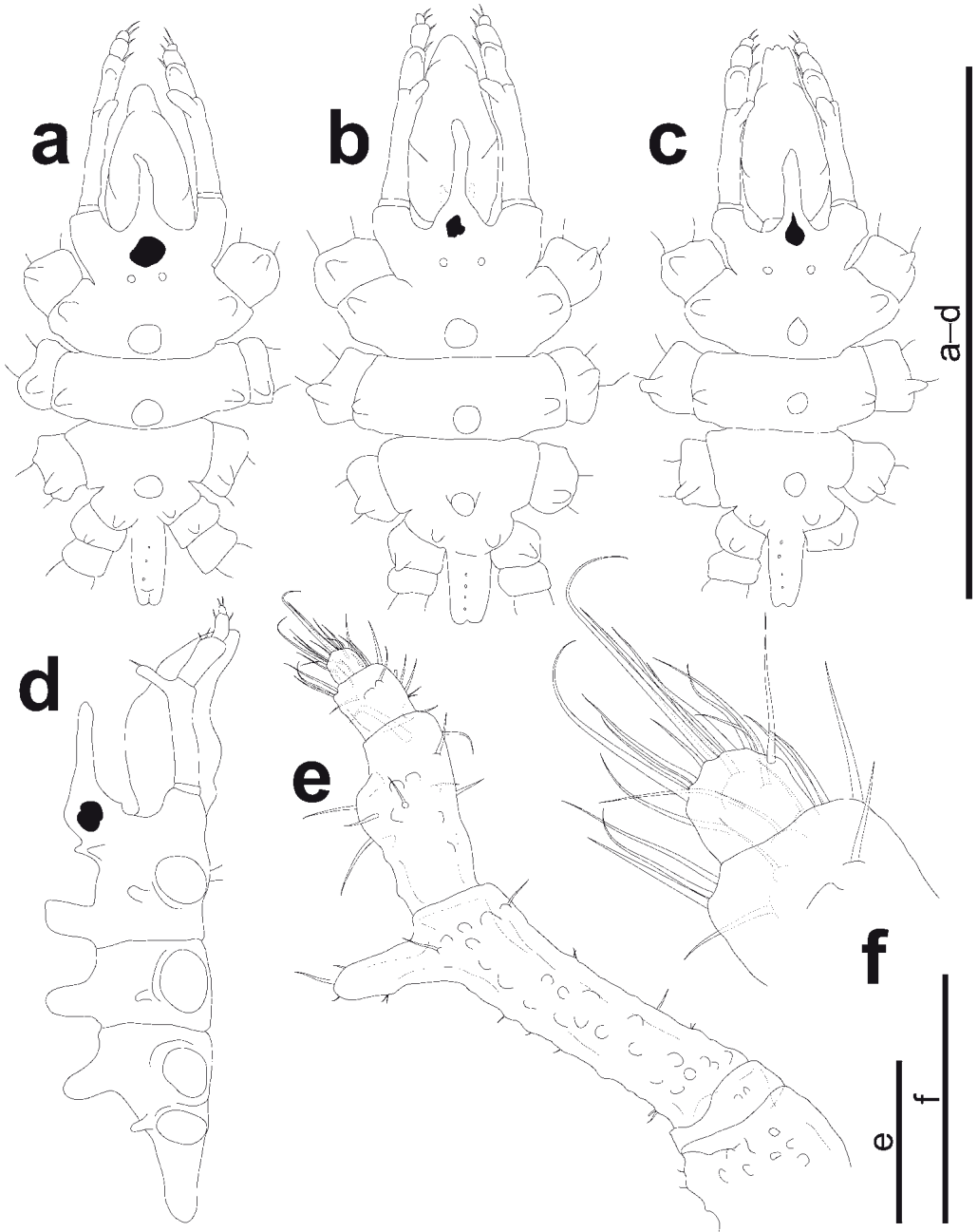
Abdomen (Fig. 4a–d) tapering-cylindrical, reaching beyond distal margin of second coxa of fourth leg; ventral surface flat; tip slightly bifurcate.

Cephalic segment lacking chelifore and anterodorsal extensions.

Palp (Fig. 4e, f) with five segments. First segment short, without setae. Second segment cylindrical, with many tiny setae, one dorsodistal, one ventro-subproximal, and one ventrodistal setae, and large dorsodistal tubercle; dorsodistal tubercle cylindrical



**Fig. 3.** *Rhynchothorax nopperabo* sp. nov., female, holotype, ICHUM 8636. **a.** Right first leg; **b.** right second leg; **c.** right third leg; **d.** right fourth leg. Scale bar: 100  $\mu$ m (a-d).



**Fig. 4.** *Rhynchothorax monoceros* sp. nov., female, holotype, ICHUM 8640 (a, e, f) and paratypes ICHUM 8641 (b, d) and ICHUM 8642 (c). a–c. Body, dorsal view; d. body, lateral view; e. right palp; f. distal part of right palp. Scale bars: 1 mm (a–d); 100  $\mu$ m (e); 50  $\mu$ m (f).

cal, length equal to second-segment width, with distal seta. Third segment cylindrical, with mid-dorsal bulge, mediolateral robust seta, four ventral setae

(two median, two distal), and one mid-lateral seta; mid-dorsal bulge with three setae. Fourth and fifth segments cylindrical, with many setae.



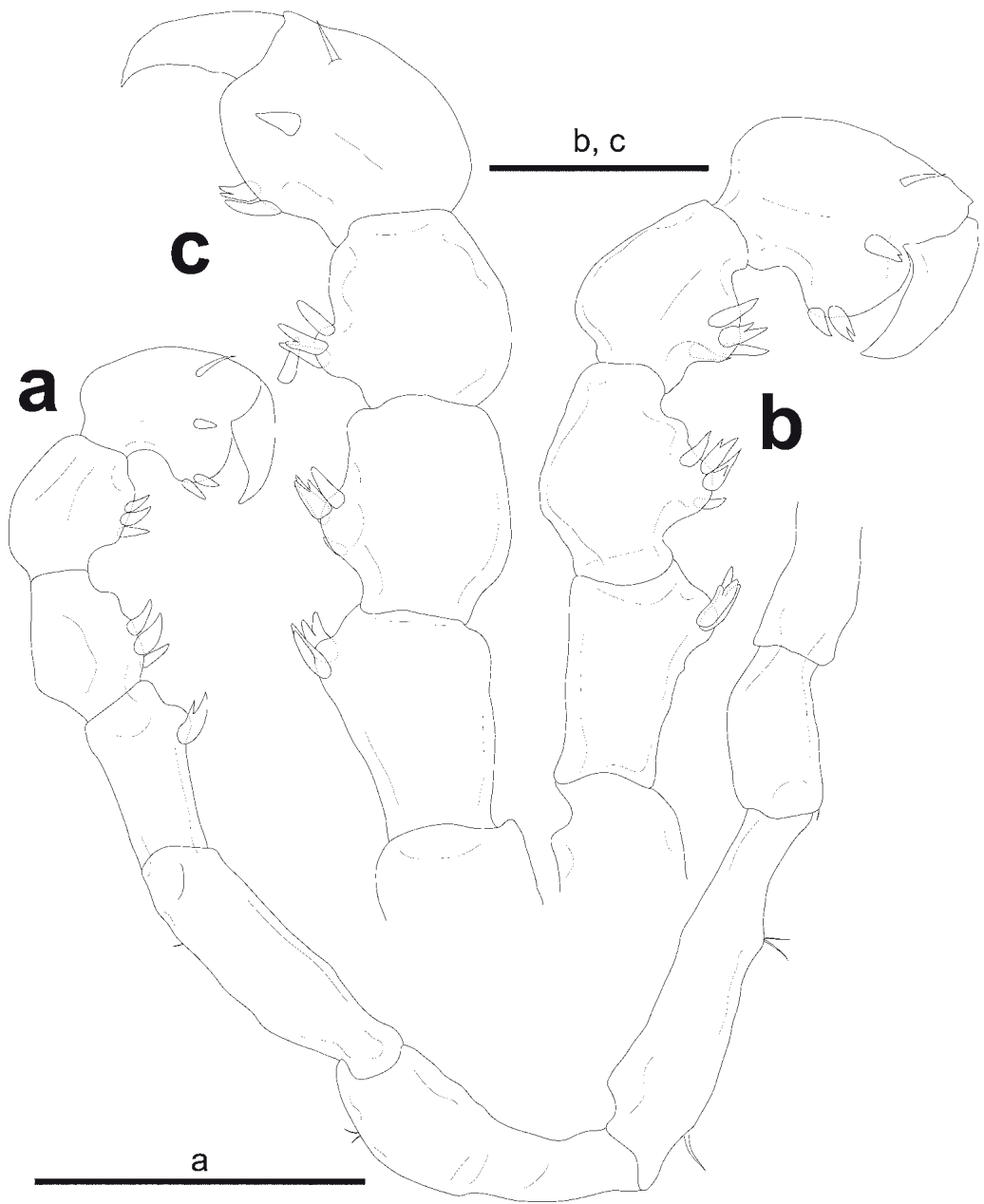


Fig. 5. *Rhynchothorax monoceros* sp. nov., female, holotype, ICHUM 8640. a. Left oviger; b. distal part of left oviger; c. distal part of right oviger. Scale bars: 100  $\mu\text{m}$  (a); 50  $\mu\text{m}$  (b,c).

Oviger (Fig. 5a–c) with 10 segments. First segment (not illustrated) cylindrical, originating from shallow ventral concavity of trunk. Second and third segments cylindrical. Fourth to sixth segments cylindrical; fourth segment with one dorsodistal and

two mid-dorsal setae. Seventh segment cylindrical, with thick tip and two ventrodistal bifurcate spines. Eighth and ninth segments oval, with four mid-ventral spines; spine shapes on eighth segment (from medial to lateral) conical, bifurcate, bifurcate,

conical; spine shapes on ninth segment (from medial to lateral) conical, bifurcate, conical, conical. Tenth segment oval, with large terminal claw, distal seta, medial conical spine, and one mid-ventral conical and one mid-ventral bifurcate spines.

Legs (Fig. 6a–d) slender; first leg longest. First to third coxae cylindrical, with several tiny setae; first coxa of each leg with dorsal tubercle taller than dorsal tubercle on lateral tubercle (Figs 4a–c, 6b, c); second coxa with sexual pore on posterior surface of fourth leg (Figs 1e, 6b). Femur and first and second tibiae cylindrical, each with long dorsodistal seta (detached in holotype) and several tiny setae as illustrated; femur thicker than tibiae, with mid-dorsal seta; second tibia with three ventrodistal setae. Tarsus with two ventral setae. Propodus cylindrical, slightly arched ventrally, with many setae. Claw long and broad. Auxiliary claws absent.

**Measurements.** Primarily based on holotype; in parentheses are corresponding measurements for paratypes ICHUM 8641 (left) and ICHUM 8642 (right); nd, no data

Proboscis length 0.37 (0.37, 0.33), trunk length 0.65 (0.62, 0.58), abdomen length 0.15 (0.15, 0.14), total length 1.17 (1.14, 1.05), proboscis width 0.16 (0.18, 0.16), trunk widths at first and second lateral processes 0.33 (0.40, 0.34), 0.37 (0.40, 0.35), length of anteriorly directed apical extension of ocular tubercle 0.19 (0.19, 0.14).

Lengths for right palp: first to fifth segments 0.02 (nd, 0.02), 0.20 (nd, 0.17), 0.11 (nd, 0.10), 0.04 (nd, 0.04), 0.02 (nd, 0.02) [total length 0.40 (nd, 0.36)]; dorsal tubercle on second segment 0.07 (nd, 0.08). Lengths for left palp: first to fifth segments nd (nd, 0.02), nd (nd, 0.17), nd (nd, 0.11), nd (nd, 0.04), nd (nd, 0.02) [total length nd (nd, 0.36)]; dorsal tubercle on second segment nd (nd, 0.08).

Lengths for right oviger: second to tenth segments nd (nd, 0.05), nd (nd, 0.05), nd (nd, 0.11), nd (nd, 0.07), nd (nd, 0.08), 0.05 (nd, 0.05), 0.05 (nd, 0.05), 0.04 (nd, 0.05), 0.05 (nd, 0.05); terminal claw 0.04 (nd, 0.04) [total length for second to tenth segments nd (nd, 0.59)]. Lengths for left oviger: first to tenth segments nd (nd, 0.05), nd (nd, 0.05), nd (nd, 0.04), 0.11 (nd, 0.11), 0.08 (nd, 0.06), 0.09 (nd, 0.09), 0.05 (nd, 0.05), 0.04 (nd, 0.05), 0.04 (nd, 0.05), 0.05 (nd, 0.05), terminal claw 0.03 (nd, 0.04) [total length nd (nd, 0.62)].

Lengths for right first leg: first coxa 0.10 (nd, nd), second coxa 0.08 (nd, 0.07), third coxa 0.06 (nd, 0.07), femur 0.28 (nd, 0.26), first tibia 0.27 (nd, 0.27), second tibia 0.22 (nd, 0.21), tarsus 0.04 (nd, 0.04), propodus 0.20 (nd, 0.20), claw 0.09 (nd, 0.09) [total length 1.33 (nd, nd)]. Lengths for left first leg: first coxa nd (nd, 0.07), second coxa nd (nd, 0.07), third coxa nd (nd, 0.07), femur nd (nd, 0.25), first tibia

nd (nd, 0.26), second tibia nd (nd, 0.21), tarsus nd (nd, 0.04), propodus nd (nd, 0.19), claw nd (nd, 0.09) [total length nd (nd, 1.25)].

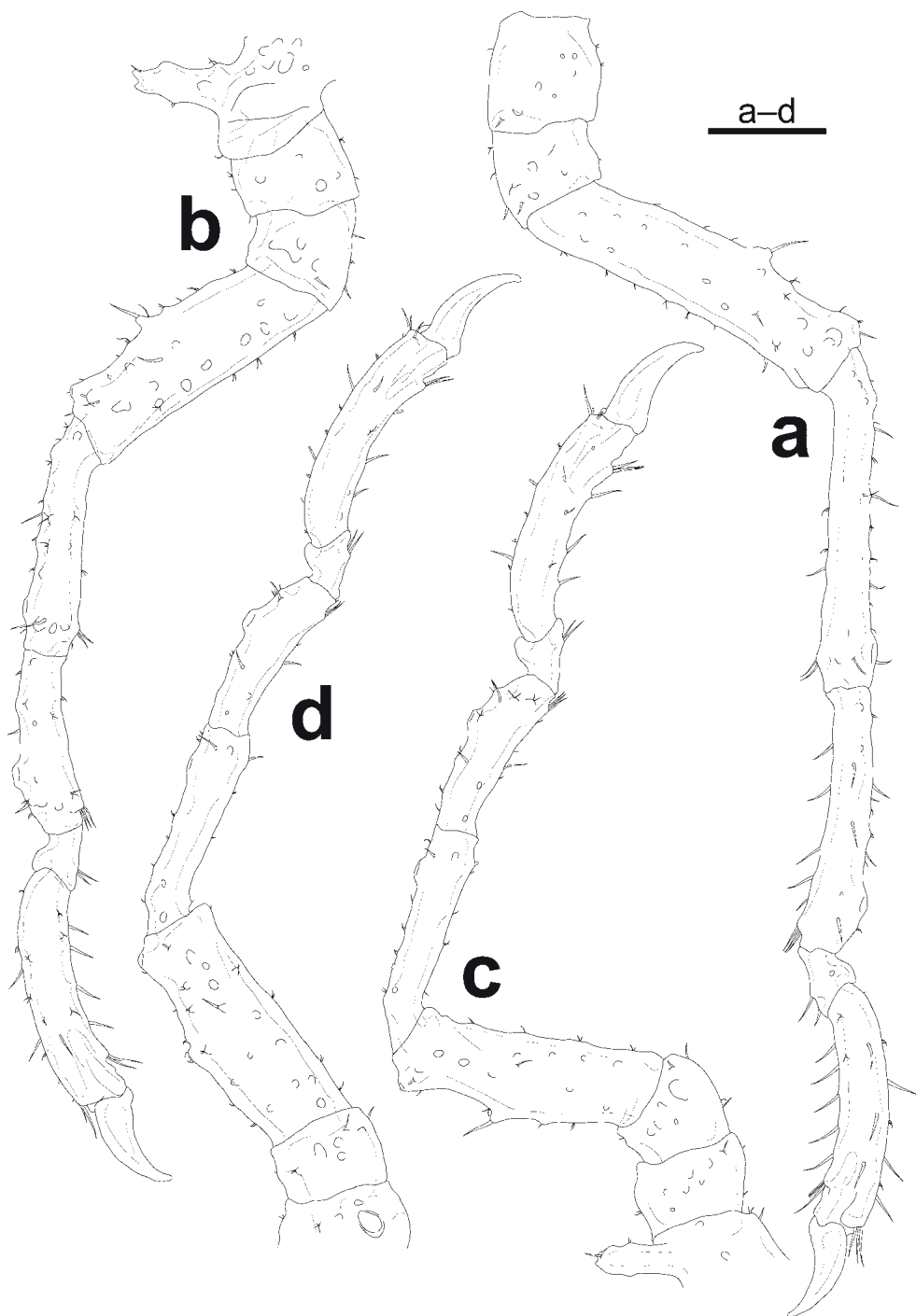
Lengths for right second leg: first coxa nd (nd, 0.07), second coxa nd (nd, 0.06), third coxa nd (nd, 0.07), femur nd (nd, 0.22), first tibia nd (nd, 0.18), second tibia nd (nd, 0.14), tarsus nd (nd, 0.03), propodus nd (nd, 0.19), claw nd (nd, 0.09) [total length nd (nd, 1.06)]. Lengths for left second leg: first coxa 0.05 (nd, nd), second coxa 0.06 (nd, 0.06), third coxa 0.06 (nd, 0.06), femur 0.21 (nd, 0.21), first tibia 0.19 (nd, 0.18), second tibia 0.15 (nd, 0.14), tarsus 0.04 (nd, 0.04), propodus 0.20 (nd, 0.18), claw 0.09 (nd, 0.10) [total length 1.05 (nd, nd)].

Lengths for right third leg: first coxa 0.06 (nd, 0.06), second coxa 0.06 (nd, 0.06), third coxa 0.05 (nd, 0.06), femur 0.21 (nd, 0.20), first tibia 0.18 (nd, 0.17), second tibia 0.14 (nd, 0.14), tarsus 0.04 (nd, 0.03), propodus 0.19 (nd, 0.19), claw 0.10 (nd, 0.10) [total length 1.03 (nd, 1.02)]. Lengths for left third leg: second coxa nd (nd, 0.07), third coxa nd (nd, 0.05), femur nd (nd, 0.20), first tibia nd (nd, 0.17), second tibia nd (nd, 0.14), tarsus nd (nd, 0.04), propodus nd (nd, 0.19), claw nd (nd, 0.10) [total length nd (nd, nd)].

Lengths for right fourth leg: first coxa 0.05, second coxa nd, third coxa 0.06, femur 0.20, first tibia 0.17, second tibia 0.15, tarsus 0.04, propodus 0.19, claw 0.10 [total length nd (nd, nd)]. Lengths for left fourth leg: first coxa (nd, 0.05), second coxa (nd, 0.06), third coxa 0.05 (nd, 0.05), femur 0.20 (nd, 0.19), first tibia 0.17 (nd, 0.17), second tibia 0.14 (nd, 0.14), tarsus 0.03 (nd, 0.03), propodus 0.20 (nd, 0.19), claw 0.10 (nd, 0.10) [total length nd (nd, 0.99)].

**Remarks.** *Rhynchothorax monoceros* sp. nov. is similar to 10 species in the *malaccensis*- and *mediterraneus*-groups sensu Krapp (1973) (*R. barnardi* Child & Hedgpeth, 1971; *R. crenatus* Child, 1982; *R. malaccensis* Stock, 1968; *R. mediterraneus* Costa, 1861; *R. monnioti* Arnaud, 1974; *R. oblongus* (Pushkin, 1977); *R. orientalis* Child, 1988; *R. sidereus* Sabroux, Hassanin & Corbari, 2022; *R. tiahurensis* Müller, 1989; *R. unicornis* Fage & Stock, 1966) in having eyes, and in lacking auxiliary claws and anterodorsal extensions of the cephalic segment. It differs from all of them except *R. mediterraneus* in having the ocular tubercle with a long, anteriorly directed apical extension that overhangs approximately the proximal half of the proboscis, and a dorsal tubercle on the first coxa of the third leg. Additional characters distinguishing *R. monoceros* sp. nov. from the above nine species and *R. mediterraneus* are listed in electronic Supplementary material: Table S1.

*Rhynchothorax monoceros* differs from *R. mediterraneus* as follows (character states of *R. mediterraneus* in parentheses; Dohrn 1881): no dorsal tubercles on



**Fig. 6.** *Rhynchothorax monoceros* sp. nov., female, holotype, ICHUM 8640. **a.** Right first leg; **b.** left second leg; **c.** right third leg; **d.** right fourth leg. Scale bar: 100  $\mu$ m (a-d).

the third lateral process (one); first coxa of the fourth leg with a dorsal tubercle (tubercle lacking); seventh segment of the oviger with two ventrodiscal spines (one mid-ventral and two ventrodiscal spines); tenth segment of the oviger with a median conical spine (spine lacking).

Miyazaki & Stock (1995) reported sea spiders from Tanabe Bay, Shirahama, Wakayama Prefecture, Japan, as *R. mediterraneus*, but their species lacked dorsal tubercles on the third and fourth lateral processes, which distinguishes it from *R. mediterraneus* sensu Dohrn (1881) and from *R. monoceros*.

### Key to species in *Rhynchothorax*

The number of segments in the palp was not used in the key, as Staples (2019) suggested that this number was unclear for several species.

- 1 Auxiliary claws present, cephalic segment with anterodorsal extensions, eyes lacking..... 2
- Auxiliary claws present, cephalic segment lacking anterodorsal extensions, eyes present..... 8
- Auxiliary claws lacking, cephalic segment lacking anterodorsal extensions, eyes present..... 13
- 2 Terminal palp segment unilobed ..... 3
- Terminal palp segment bilobed..... 7
- 3 Anterolateral border of cephalic segment with two horns.....*R. philopsammum*  
Hedgpath, 1951
- Anterolateral border of cephalic segment lacking horns..... 4
- 4 Proboscis with several dorsal tubercles.....  
.....*R. architectus*  
Child, 1979
- Dorsal surface of proboscis nearly smooth.... 5
- 5 Second lateral process with single posterior tubercle, reaching beyond anterior margin of third lateral process .....*R. anophthalmus*  
Arnaud, 1972
- Second lateral process with two posterior tubercles, not reaching anterior margin of third lateral process ..... 6
- 6 Auxiliary claws shorter than half claw length, first lateral process with two posterior tubercles, seventh to ninth segments of oviger respectively with two ventral (one middle and one distal), one mid-ventral, and one mid-ventral spines .....*R. vallatus*  
Child, 1990
- Auxiliary claws longer than half claw length, first lateral process with one posterior tubercle, seventh to ninth segments of oviger respectively with four ventral (one middle and three distal), three ventro-subdistal, and three ventro-subdistal spines .....*R. nopperabo* sp. nov.
- 7 Several conical tubercles on lateral processes .  
.....*R. alcornis*  
Krapp, 1973
- Conical tubercles lacking on lateral processes  
.....*R. arenicolus*  
Stock, 1989
- 8 Ocular tubercle length two or more times width ..... 9
- Ocular tubercle less than or equal to 1.5 times width ..... 11
- 9 Mouth triradiate, trunk four segmented .....  
.....*R. articulatus*  
Stock, 1968
- Mouth vertical slit, trunk three segmented .. 10
- 10 Ocular tubercle with long, anteriorly directed apical extension overhanging approximately proximal half of proboscis.....*R. percivali*  
Clark, 1976
- Ocular tubercle with short apical extension not reaching to middle of proboscis .....*R. swir*  
Staples, 2019
- 11 All lateral processes with long tubercles, proboscis with dorsal tubercle one-third of way from proximal end.....*R. voxorinus*  
Stock, 1966
- Lateral process with or without short tubercles, proboscis without dorsal tubercles ..... 12
- 12 Lateral processes all with dorsal tubercles, dorsodistal tubercle on fourth palp segment from distal end not greater than segment width.....*R. coralensis*  
Staples, 2019
- Lateral process lacking dorsal tubercles, dorsodistal tubercle on fourth palp segment from distal end greater than segment width.....  
.....*R. australis*  
Hodgson, 1907
- 13 Trunk four segmented.....*R. oblongus*  
(Pushkin, 1977)
- Trunk three segmented ..... 14

- 14 Ocular tubercle with long, anteriorly directed apical extension overhanging approximately proximal half of proboscis.....15
- Ocular tubercle with short apical extension not reaching to middle of proboscis .....17
- 15 First coxa of third leg with dorsal tubercle...16
- First coxa of third leg lacking dorsal tubercle. ....*R. orientalis*  
Child, 1988
- 16 Third lateral process with dorsal tubercle, seventh segment of oviger with one mid-ventral and two ventrodistal spines....*R. mediterraneus*  
Costa, 1861
- Third lateral process lacking dorsal tubercle, seventh segment of oviger with two ventrodistal spines..... *R. monoceros* sp. nov.
- 17 Proboscis with dorsal tubercles .....18
- Proboscis lacking dorsal tubercle .....20
- 18 More-proximal of two dorsal tubercles on palp longer than more-distal one ..... *R. unicornis*  
Fage & Stock, 1966
- More-proximal of two dorsal tubercles on palp as long as more-distal one .....19
- 19 Ocular tubercle and dorsal tubercles on trunk as tall as dorsal tubercle on proboscis .....  
..... *R. monnioti*  
Arnaud, 1974
- Ocular tubercle and dorsal tubercles on trunk taller than dorsal tubercle on proboscis .....  
.....*R. crenatus*  
Child, 1982
- 20 Two dorsal conical tubercles posterior to ocular tubercle .....21
- No dorsal conical tubercles posterior to ocular tubercle .....22
- 21 Dorsal tubercles on trunk spiniform, longer than tubercle width, length of dorsal tubercle on third palp segment from distal end not greater than segment width.....*R. sidereus*  
Sabroux, Hassanin & Corbari, 2022
- Dorsal tubercles on trunk dome shaped, not longer than tubercle width, length of dorsal tubercle on third palp segment from distal end greater than segment width .....*R. tiahurensis*  
Müller, 1989

- 22 Dorsal tubercle on fourth palp segment from distal end longer than segment width, three dorsal tubercles on trunk.....*R. barnardi*  
Child & Hedgpath, 1971
- Dorsal tubercle on fourth palp segment from distal end not longer than segment width, four dorsal tubercles on trunk.....*R. malaccensis*  
Stock, 1968

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