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Notes on freshwater shrimp (Crustacea, Decapoda, Caridea) from Belitung, Indonesia

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Abstract

Background

As part of the Oriental Biogeographical Region, Indonesia has recorded the presence of freshwater shrimp in various areas, taking into consideration that these animals are beneficial both ecologically and economically. Even so, the fact is that data on the existence of freshwater shrimp in Indonesia still need to be included in some areas, as well as in Belitung Island. Information recording of a species is necessary so that its existence is easier to protect. This study describes the freshwater shrimp species found in Belitung Island.

New information

Here, we present new distribution records of eight species of freshwater shrimp (Crustacea, Decapoda, Palaemonidae) from Belitung Island, Indonesia. In addition to the morphological description, each species is also provided with the nucleotide sequence of the CO1 gene. All species belong to the genus *Macrobrachium*.

Keywords

Macrobrachium, meristic, morphometric, new record

Introduction

Freshwater shrimp (Caridea) are dominated by the families of Atyidae and Palaemonidae, which account for 97.4% of freshwater shrimp species (De Grave et al. 2015). The *Caridina* dominate the Atyidae, while the Palaemonidae are dominated by the

Macrobrachium (De Grave et al. 2008). Shrimp play a role in maintaining the balance of freshwater ecosystems as part of the food web (Crowl et al. 2001) and determining the benthic community's composition (March et al. 2002). In addition, many species of shrimp are widely used by humans as a source of food (Holthuis 1980) and even commercialised in the aquarium trade (De Grave et al. 2015).

The diversity of freshwater shrimp species in the Oriental Biogeographical Region, which includes Indonesia, is three times greater than in other biogeographical realms (De Grave et al. 2008). The most occupied habitats of freshwater shrimp are rivers, lakes or swamps, from fast-flowing waters to sluggish currents and oligohaline waters (Cai et al. 2007, De Grave et al. 2015). However, the distribution of freshwater shrimps in their habitat can also be limited as they are highly vulnerable to human disturbance and development, either downstream or upstream (Wowor et al. 2004).

Lists and taxonomy of freshwater shrimp are needed to provide scientific support for further research and protection of the species' existence, especially when there are intense human activities and rapid global changes around their habitat. Despite several studies about freshwater shrimp in Indonesia (Daryanto et al. 2015, Purnamasari et al. 2016, Tantri et al. 2016, Bando et al. 2018, Dwiyanto et al. 2018, Oktavia 2018, Susilo et al. 2020), information about freshwater shrimp in Belitung Island is still scarce and, in some cases, not even available. Thus, the main objective of this study is to present a detailed inventory of freshwater shrimp diversity in Belitung Island.

Materials and methods

Field sampling method

Sampling was conducted intensively in January on Belitung Island, Bangka Belitung Province, Indonesia. Three hundred and twenty-seven samples were collected from seven locations: Peramun, Badau, Bantan, Membalong Kundur, Kembiri and Tebat Rasau (Fig. 1). We collected samples using a hand net or by hand-catching the shrimp directly. The samples were preserved in 96% ethanol before being analysed at the Laboratory of Function and Animal Behavior, Department of Biology, Faculty of Mathematics and Natural Sciences, IPB University.

Morphometric and meristic character measurement

All characters were measured to the nearest 0.05 mm using a Vernier caliper. The dimensions of both legs of the second pair of pereiopods and their joints were taken along the external lateral line. The numbers 1 and 2 correspond to the major and minor legs, respectively, for shrimps in which chelipeds were of unequal size. When pereiopods were equal, number 1 was attributed to the right leg and number 2 to the left leg (Table 1). The widths, taken to the distal margin of various articles, were defined as the distance between lateral lines (Konan et al. 2008). Carapace length was used as a reference dimension due

to its simplicity, rapidity and reliability in length measurement (Mariappan and Balasundaram 2004).

Morphology identification

We used the literature to identify specimens collected during fieldwork (Wowor and Choy 2001, Wowor et al. 2004, Wowor and Ng 2010), with the characters used in the identification relating to morphometric and meristic measurements, such as rostrum length, rostrum teeth, carapace features and the appearance of the first and second pereiopods. We also use data from the http://www.marinespecies.org, http://www.gbif.org and http://eol.org websites to confirm the taxonomy status and distribution of the samples we identified.

Molecular analysis

We analysed DNA barcoding for at least two individuals per species using the Genomic DNA Mini Kit for tissue provided by Geneaid (https://www.geneaid.com). The COI gene segment of the mitochondrial genome was amplified using forward primer AF286 (5'-TCTACAAAYCATAAAGAYATYGG 3') and reverse primer AF287 (3'-GTGGCRGANGTRAARTARGCTCG 5'). The methodology for DNA extraction, PCR and sequencing followed the manufacturer's protocol. We included data from GenBank (http://www.ncbi.nlm.nih.gov) in the analysis of DNA barcodes as a reference. We also uploaded our data in GenBank.

Inventory of the freshwater shrimp of the Belitung Island

Macrobrachium cf. equidens (Dana, 1852)

- GenBank OR510092
- GenBank OR510093
- GenBank OR510094

Material

a. scientificName: *Macrobrachium* cf. *equidens*; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. equidens; scientificNameAuthorship: Dana, 1852; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Badau; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 8; recordedBy: Achmad Farajallah; occurrenceStatus: Present; identifiedBy: Lora Purnamasari, Riska Rismawati; identificationReferences: Wowor et al., 2004; occurrenceID: D35A5530-1E1B-5CC7-B25B-2F47C95B490D

Diagnosis: Number of teeth in rostrum 8-10 (often 8), 2-3 postorbital spines, 4-6 ventral teeth, long rostrum beyond scaphocerite and curved at the tip, chela in second pereiopod has soft dense pubescence (Fig. 2).

Conservation status: Least Concern

Distribution: Solomon Islands, Fiji, Taiwan, Australia, China, India, Thailand, Vietnam, Indonesia, Singapore Strait.

Notes: *Macrobrachium* cf. *equidens* is easily distinguished from other species, based on the elevated rostrum.

Macrobrachium cf. lopopodus (Wowor & Choy, 2001)

- GenBank OR510087
- GenBank OR510088
- GenBank OR510089
- GenBank OR510090
- GenBank OR510091

Material

a. scientificName: *Macrobrachium* cf. *lopopodus*; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. lopopodus; scientificNameAuthorship: Wowor & Choy, 2001; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Tebat Rasau; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 13; recordedBy: Achmad Farajallah; occurrenceStatus: Present; identificationReferences: Wowor & Choy, 2001; occurrenceID: A4F96B98-9FB6-59F2-803F-F6ED4DCC0948

Diagnosis: Rostrum curving upwards, ventral margin with less than seven teeth, second pereiopods covered by appressed scales and carpus longer than palm and merus, similar in form, unequal in size, pre-anal carina present (Fig. 3).

Conservation status: Least Concern

Distribution: Kota Marudu District, Sabah down to Temburong District, Brunei Darussalam.

Macrobrachium cf. leucodactylus (Wowor & Choy, 2002)

- GenBank OR510083
- GenBank OR510084
- GenBank OR510085
- GenBank OR510086

Material

a. scientificName: *Macrobrachium* cf. *leucodactylus*; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. leucodactylus; scientificNameAuthorship: Wowor & Choy, 2002; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Linsum Kawai; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 7 ;

recordedBy: Achmad Farajallah; occurrenceStatus: Present; identificationReferences: Wowor & Choy, 2001; occurrenceID: 8905BF9C-67EB-5DE4-86AF-C6018BD2D8F8

Diagnosis: A relatively small-sized species with subcylindrical body form. Rostrum short, reaching to or slightly beyond second segment of antennular peduncle, rostrum with 9-10 teeth in dorsal and 3-4 teeth in ventral, second pereiopods with carpus shorter than merus and carpus conical-shaped, covered by setae, pre-anal carina absent (Fig. 4).

Conservation status: Least Concern

Distribution: Sg. Temburong-Machang in Temburong District, Brunei.

Notes: This species shares similarities with *Macrobrachium leucodactylus* in rostrum moderately slender and tip of rostrum reaching mid-point of third segment of antennular peducle or reaching the scaphocerite.

Macrobrachium cf. malayanum (J. Roux, 1935)

- GenBank OR510076
- GenBank OR510077
- GenBank OR510078
- GenBank OR510079
- GenBank OR510080
- GenBank OR510081
- GenBank OR510082

Material

a. scientificName: *Macrobrachium* cf. *malayanum*; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. malayanum; scientificNameAuthorship: J. Roux, 1935; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Membalong; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 12; recordedBy: Achmad Farajallah, Deny Ariansyah; occurrenceStatus: Present; identificationReferences: Wowor et al., 2004; occurrenceID: 9F00B4E4-6507-56B8-AFB7-972A49966134

Diagnosis: Rostrum armed dorsally with at least with 10-12 teeth, 3-4 postorbital spines, ventral carina with 3 or 4 teeth. Second pereiopods with pubescence; carpus conical. Pre-anal carina absent (Fig. 5).

Conservation status: Least Concern

Distribution: Sumatra, Thailand, Malay Peninsula, Malaysia, Borneo, Singapore.

Notes: This species shares similarities with *M. malayanum*, as the chela in the second pereiopod is covered with velvety setae and there is no pre-anal carina.

Macrobrachium cf. neglectum (De Man, 1905)

- GenBank OR510072
- GenBank OR510073
- GenBank OR510074
- GenBank OR510075

Material

a. scientificName: Macrobrachium cf. neglectum; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. neglectum; scientificNameAuthorship: De Man, 1905; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Bukit Peramun; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 16 ; recordedBy: Achmad Farajallah; occurrenceStatus: Present; identificationReferences: Wowor & Ng, 2010; occurrenceID: D48E700E-84AF-559C-A66A-BCBB175513DC

Diagnosis: Rostrum short, reaching or slightly behind distal end of scaphocerite; moderately slender, dorsal carina straight above orbit, armed with 9–12 teeth, 2–4 teeth completely postorbital, ventral carina with 3 or 4 teeth. Second pereiopods with carpus conical-shaped with setae; carpus shorter than palm (Fig. 6).

Conservation status: Least Concern

Distribution: Myanmar, Thailand, Mergui Archipelago, Peninsular Malaysia, Singapore, north and east coast of Sumatra, southern Sarawak on the west coast of Borneo.

Notes: *Macrobrachium* cf. *neglectum* is easlily distinguished from other species, based on the rostrum being more than half of carapace length and chela in major second pereiopod subcylindrical.

Macrobrachium cf. nipponense (De Haan, 1849)

- GenBank OR510068
- GenBank OR510069
- GenBank OR510070
- GenBank OR510071

Material

a. scientificName: Macrobrachium cf. nipponense; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. nipponense; scientificNameAuthorship: De Haan, 1849; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Bantan; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 23; recordedBy: Achmad Farajallah; occurrenceStatus: Present; identificationReferences: Wowor et al., 2004; occurrenceID: 53AAD7B1-B68D-579C-8320-05ACC18529AC

Diagnosis: Rostrum nearly straight, barely reaching or falling slightly short of anterior end of antennal scale, armed dorsally with 10 – 13 teeth including 2 or 3 placed posterior to orbital margin, ventrally with 2 or 3 teeth. Second pereiopods sub-equal in length and similar in shape, covered with small spinules on almost entire length, palm slightly longer than carpus and chela, the former covered with short setae along its cutting edges (Fig. 7).

Conservation status: Least Concern

Distribution: China, Japan, Korea, Vietnam and Singapore.

Notes: This species shares similarities with *Macrobrachium nipponense*, as the second pereiopod is shorter than carpus.

Macrobrachium pilimanus (De Man, 1879)

- GenBank OR506202
- GenBank OR506205
- GenBank OR506206

Material

a. scientificName: *Macrobrachium pilimanus*; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: pilimanus; scientificNameAuthorship: De Man, 1879; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Membalong; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 21; recordedBy: Achmad Farajallah; occurrenceStatus: Present; identificationReferences: Wowor et al., 2004; occurrenceID: 54B78E81-30EB-59BF-BD19-2E4449471699

Diagnosis: Rostrum short, does not reach the end of the third segment of antennular peduncle, with 12 teeth and 4 postorbital teeth. Post attenular rounded. Second pereiopod unequal in size; carpus cup-shaped and much shorter than the merus; half proximal part of the fingers are covered lightly with pubescence, while the rest of the fingers are glabrous with few scattered setae. The palm is provided with some scattered stiff setae with few spinules on its upper and lower margins. Pre-anal carina present (Fig. 8).

Conservation status: Least Concern

Distribution: Sunda Shelf, from northern Vietnam and southern Yunan to Java and Borneo and Brunei.

Notes: This species is characterised by a cup-shaped carpus in the second pereiopod.

Macrobrachium cf. scabriculum (Heller, 1862)

- GenBank OR510059
- GenBank OR510060

- GenBank OR510061
- GenBank OR510062
- GenBank OR510063
- GenBank OR510064
- GenBank OR510065
- GenBank OR510066
- GenBank OR510067

Material

a. scientificName: *Macrobrachium* cf. *scabriculum*; kingdom: Animalia; phylum: Arthropoda; class: Malacostraca; order: Decapoda; family: Palaemonidae; genus: Macrobrachium; specificEpithet: cf. scabriculum; scientificNameAuthorship: Heller, 1862; island: Belitung; country: Indonesia; stateProvince: Bangka Belitung; locality: Tebat Rasau; year: 2023; month: 1 (January); habitat: Freshwater; individualCount: 45; recordedBy: Achmad Farajallah; occurrenceStatus: Present; identificationReferences: Wowor et al., 2004; occurrenceID: 68A076E3-F232-5B8B-AC81-CB61C16131EC

Diagnosis: Tip of rostrum extending beyond end of third segment of antennular peducle. Rostrum with four teeth on carapace. Major second pereiopods with palm or fingers covered with soft, dense pubescence (in mature males). Major second pepereiopods with carpus and fingers shorter than palm, palm covered in dense pubescence. Pre-anal carina absent (Fig. 9).

Conservation status: Least Concern

Distribution: Indo-West Pacific Region (Sri Lanka, southern India, Peninsular Malaysia, Tioman Island, Singapore and Indian Ocean coast of Sumatra up to Sarawak in Borneo).

Notes: This species shares similarities with *Macrobrachium scabriculum*, as the rostrum is short, with a very low basal crest.

Discussion

Recording of a species is essential as basic information on its distribution before it is lost due to human activities or development. Bangka Belitung Province itself is known for tin mining (Sukarman et al. 2020). Tin mining is one of the contributors to habitat degradation, posing a significant threat to global freshwater biodiversity (Dudgeon et al. 2006). This study presents the first record of freshwater shrimp on Belitung Island. Of the total of 361 individuals that we identified, we found eight species that all belong to the genus Macrobrachium. However, we have yet to come to a definite species conclusion. We compared the species we found with the Macrobrachium species as listed below: *M. cf. equidens, M. cf. lopopodus*, *M. cf. leucodactylus*, *M. cf. malayanum*, *M. cf. neglectum*, *M. cf. nipponense*, *M. pilimanus* and *M. cf. scabriculum*. All the species we found were known to be widely distributed (http://www.gbif.org and http://eol.org). The only species we could identify down to the species was *M. pilimanus*. For other species, conclusions have yet to

be drawn. Furthermore, some species are synonymous with other species, such as *M. equidens,* a species that has similarities with other species, known as the "equidens complex" (Castelin et al. 2017).

The *M. malayanum*, *M. neglectum, M. pilimanus* and *M. scabriculum* are common species in Indonesia (some are recorded as distributed in Sumatra and Kalimantan). Very little information about *M. lopopodus* and *M. leucodactylus* exists, but both have been recorded in Sabah and Brunei (Wowor and Choy 2001). In Indonesia, *M. lopopodus* was recorded in Kalimantan (unpublished thesis, 2016). While *M. nipponense* has been widely recorded in East Asia (Japan, Korea, China), its existence cannot be ascertained in Indonesia. However, *M. nipponense* has been introduced from China or Japan to Singapore (De Grave and Ghane 2006).

The spread of freshwater shrimp can occur because they are carried by other animals (e.g. fish) or because of the life cycle of freshwater shrimp, some of which need brackish or marine water to develop their larvae (amphidromous species) (March et al. 2002, Hamasaki et al. 2021). This amphidromous life cycle allows freshwater shrimp to spread widely (Irving et al. 2017). Therefore, the species we found in this study may also have entered Belitung Island through these two possibilities. However, it is also possible that the species we found did originate from Belitung Island from the start and there may be new or endemic species if investigated further.

Furthermore, several species of freshwater shrimp are known to adapt well to changing climatic conditions and their environment (Chen et al. 2009, De Grave and Fransen 2013). The adaptation makes it easier for freshwater shrimp to move and live in different environments. In this regard, some of the samples in this study were found in habitats with an acidic water (pH < 5).

All data regarding the species we present in this paper come from samples we found at the study site and we found the same characteristics as the *Macrobrachium* species as previously mentioned. However, our molecular results differ as our samples were different from the comparison species. We suspect this is because shrimp have varying morphological or plasticity characters in each species. In addition, there are many cryptic cases in *Macrobrachium* and this creates confusion in the identification. The differences that arise are probably due to differences in environmental conditions (De Melo and Masunari 2017) or because the characters observed have not yet fully developed (Short 2004).

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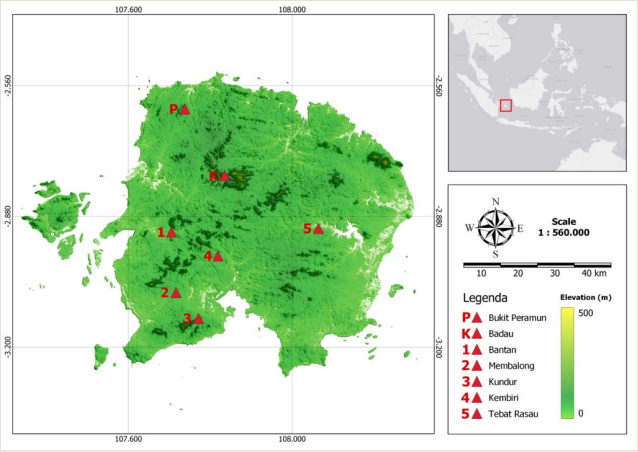

Figure 1.

Sampling location of freshwater shrimp in Belitung Island (http://www.qgis.org).

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Figure 2.

Macrobrachium cf. equidens (TL: 41.4 mm, CL: 10.1 mm, R: 13.9 mm, H: 19.1 mm, CH: 6.8 mm, L1 & L2: 23.4 & 22.2 mm, C1 & C2: 6.5 mm, P1 & P2: 4.4 mm, D1 & D2: 4.2 & 1.1 mm, Pw1 & Pw2: 1.5 mm, dr: 10, vr: 5, po: 3).

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Figure 3.

Macrobrachium cf. lopopodus (TL: 68.4 mm, CL: 18.1 mm, R: 23.2 mm, H: 32.6 mm, CH: 12.9 mm, L1 & L2: 66.6 & 51.6 mm, C1 & C2: 18.5 & 12.9 mm, P1 & P2: 18 & 10.1 mm, D1 & D2: 12 & 9.4 mm, Pw1 & Pw2: 3.4 & 5.5 mm, dr: 11, vr: 6, po: 9).

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Figure 4.

Macrobrachium cf. *leucodactylus* (TL: 31.8 mm, CL:8.7 mm, R: 8.5 mm, H: 13.5 mm, CH: 6.2 mm, L1 & L2: 16.7 & 15.8 mm, C1 & C2: 3.5 mm, P1 & P2: 3.2 mm, D1 & D2: 3.2 mm, Pw1 & Pw2: 0.9 mm, dr: 9, vr: 3, po: 2).

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Figure 5.

Macrobrachium cf. *malayanum* (TL: 35.9 mm, CL: 10.2 mm, R: 10 mm, H: 15.4 mm, CH: 6.7 mm, L1 & L2: 25.7 & 20.4 mm, C1 & C2: 4.8 & 5.3 mm, P1 & P2: 5.9 & 3.9 mm, D1 & D2: 5.2 & 3.9 mm, Pw1 & Pw2: 2.5 & 1.5 mm, dr: 9, vr: 5, po: 3).

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Figure 6.

Macrobrachium cf. *neglectum* (TL: 45.4 mm, CL: 13.2 mm, R: 12.2 mm, H: 20.4 mm, CH: 9.6 mm, L1 & L2: 39.1 & 29.6 mm, C1 & C2: 7.0 & 5.8 mm, P1 & P2: 13.0 & 7.1 mm, D1 & D2: 9.8 & 7.6 mm, Pw1 & Pw2: 6.0 & 2.6 mm, dr: 10, vr: 4, po: 3).

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Figure 7.

Macrobrachium cf. *nipponense* (TL: 45.9 mm, CL: 12.3 mm, R: 12.8 mm, H: 19.9 mm, CH: 8.7 mm, L1 & L2: 23.3 & 26.1 mm, C1 & C2: 5.5 & 6.0 mm, P1 & P2: 4.1 & 5.5 mm, D1 & D2: 3.5 & 4.8 mm, Pw1 & Pw2: 1.4 & 2.0 mm, dr: 10, vr: 4, po: 3.)

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Figure 8.

Macrobrachium pilimanus (TL: 24.9 mm, CL: 6.4 mm, R: 6.2 mm, H: 10.2 mm, CH: 5.0 mm, L1 & L2: 14.5 & 11.5 mm, C1 & C2: 2.0 & 1.6 mm, P1 & P2: 3.9 & 2.4 mm, D1 & D2: 2.9 & 2.1 mm, Pw1 & Pw2: 2.5 & 1.1 mm, dr: 12, vr: 3, po: 4)

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Figure 9.

Macrobrachium cf. scabriculum (TL: 48.9 mm, CL: 13.8 mm, R: 14.3 mm, H: 21.8 mm, CH: 9.3 mm, L1 & L2: 22.1 & 21.2 mm, C1 & C2: 4.8 & 4.2 mm, P1 & P2: 4.0 & 3.2 mm, D1 & D2: 4.3 & 3.7 mm, Pw1 & Pw2: 1.4 & 1.2 mm, dr: 10, vr: 4, po: 4).

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Table 1.

Morphometric and meristic characters used.

Characters	Abbreviation	Description
Morphometric		
Total length	TL	distance between rostrum tip and the distal tip of the telson with shrimp stretched out.
Carapace length	CL	distance between the posterior margin of the right orbit and the mid-point of the posterior margin of the carapace.
Rostrum length	R	distance of epigastric tooth basis to rostrum tip.
Head length	H	distance between the rostrum tip and the mid-point of the posterior.
Carapace height	CH	distance between dorsal and ventral end of carapace.
Pereiopod length	L1 & L2	distance between the proximal margin of the ischium and the distal tip of propodus.
Carpus length	C1 & C2	distance from the proximal to the distal end of carpus.
Palm length	P1 & P2	distance between proximal and distal margin of palm.
Dactylus length	D1 & D2	distance between proximal and distal margin of dactylus.
Palm width	Pw1 & Pw2	distance between lateral lines of palm.
Meristic		
Dorsal teeth	dr	Teeth number on rostrum dorsal line.
Ventral teeth	vr	Teeth number on rostrum ventral line.
Postorbital teeth	po	Number of rostrum postorbital teeth.