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The identity of *Ceratoplax villosa* Zehntner, 1894 (Crustacea: Decapoda: Pilumnidae), with description of a new species of *Zehntneriana* Takeda & Ng, 2010, from Japan

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Re-examination of the holotype male of Zehntneriana villosa *(Zehntner, 1894) (from Ambon, Indonesia) shows that Japanese specimens previously referred to this species should be designated as a new species,* Zehntneriana tadafumii *sp. nov. The new species differs from* Z. villosa *in several characters, including the carapace, epistome, third maxilliped and thoracic sternum. Here, we redescribe and illustrate* Z. villosa *s. str. and the new species. In addition, the taxonomy of* Zehntneriana *Ng & Takeda, 2010, is also discussed.*

Keywords: *Ceratoplax villosa*, *Zehntneriana*, *Zehntneriana tadafumii* sp. nov., Pilumnidae, taxonomy

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INTRODUCTION

The pilumnid genus *Zehntneriana* Ng & Takeda, 2010 currently contains four species, namely, *Z. villosa* (Zehntner, 1894), *Z. amakusae* (Takeda & Miyake, 1969), *Z. miyakei* (Takeda, 1972) and *Z. novaeinsulicola* (Takeda & Kurata, 1977) (Ng *et al.*, 2008). The genus was originally named *Zehntneria* by Takeda (1972) with *Ceratoplax villosa* Zehntner, 1894 designated as the type species. Ng & Takeda (2010) noted that *Zehntneria* Takeda, 1972, was a junior homonym of *Zehntneria* Brunner Von Wattenwyl, 1907 (a phasmid insect); and they proposed a replacement name, *Zehntneriana*.

Ceratoplax villosa Zehntner, 1894, was originally described based on a small male specimen from the island of Ambon in Indonesia; this remains the only report of this specimen. The type specimen was not examined by Takeda (1972) and it has not been redescribed or re-illustrated since. Takeda (1972) identified specimens from Japan with Zehntner's species and based his discussions for a new genus on this material. Here, we re-examine and redescribe *C. villosa* Zehntner, 1894, and show that this species differs from the Japanese material described by Takeda (1972). We designate the Japanese specimens as a new species, *Zehntneriana tadafumii* sp. nov. In addition, we discuss the affinities of *Zehntneriana* and the difficulties regarding its taxonomy.

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MATERIALS AND METHOD

Specimens examined are deposited in the Muséum National d'Histoire Naturelle (MNHG), Geneva, Switzerland; National Museum of Nature and Science (NSMT), Tsukuba, Japan; Marine Arthropod Depository Bank of Korea (MADBK), Korea; and the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum (ex Raffles Museum of Biodiversity Research), National University of Singapore. Measurements provided, in millimetres, are of the carapace width and length, respectively; and made using metric dial calipers or ocular micrometers. The abbreviations G1 and G2 are used for the male first and second pleopods, respectively. Drawings were made with the aid of a camera lucida attached using a digital SLR camera (Nikon D200, D 7000), and were developed with the software Model Helicon Focus®.

SYSTEMATICS

Family Pilumnidae Samouelle, 1819
Subfamily Rhizopinae Stimpson, 1858
Genus *Zehntneriana* Ng & Takeda, 2010

Zehntneria Takeda, 1972: 35 (name pre-occupied by *Zehntneria* Brunner Von Wattenwyl, 1907 [Insecta: Phasmida]).
Zehntneriana Ng & Takeda, 2010: 49 (replacement name for *Zehntneria* Takeda, 1972).

REMARKS

Zehntneriana Takeda & Ng (2010) as currently defined is probably heterogeneous. The type species, *Z. villosa* s. str.

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from Indonesia, differs from congeners in East Asia and Palau in one major character. In *Z. villosa*, the male sternoabdominal cavity reaches to the middle of fused thoracic sternites 3 and 4, adjacent to the transverse groove demarcating them, and reaching an imaginary joining of the midpoints of the coxae of the chelipeds (Figure 3D). In other *Zehntneriana* species, the male sternoabdominal cavity reaches only to the lower third of fused thoracic sternites 3 and 4, at a distance from the transverse groove demarcating them, and reaching an imaginary joining of the posterior edges of the coxae of the chelipeds (Figure 6A). The structure of the male thoracic sternum strongly suggests that the name *Zehntneriana* should be used only for the type species, *Z. villosa*, with the other species being referred to another taxon. The difficulty lies in the fact that *Z. villosa* is known only from one small and poorly preserved male, and the growth-associated changes are unknown. These growth-associated changes are generally not variable, and the male, although small, appears to be fully mature; nevertheless, we prefer to err on the side of caution until more specimens of *Z. villosa* are discovered. In addition, difficulties exist regarding the demarcation of the generic definitions and limits among several genera belonging to the Rhizopinae, notably *Heteropilumnus* De Man, 1895; *Paraselwynia* Tesch, 1918; *Ser* Rathbun, 1931; *Pronotonyx* Ward, 1936; and *Pseudolitochira* Ward, 1942 (see Ng, 1987). Members of the genus *Cryptolutea* Ward, 1936, also superficially resemble *Zehntneriana* s. lat., but they possess a strong wing-like projection of the ambulatory coxa; this structure is absent in the genus *Zehntneriana* (see Ng & Davie, 1991; Davie & Humpherys, 1997). Thus, establishing a separate genus for the East Asian and Palauan *Zehntneriana* is currently not advisable.

Zehntneriana villosa (Zehntner, 1894)
(Figures 1–3)

Ceratoplax villosa Zehntner, 1894: 173, pl. 8, figure 8.
Zehntneria villosa: Takeda, 1982: 35, figure 1; Ng, 1987: 78, 99; Ng *et al.*, 2008: 144.
Zehntneriana villosa: Ng & Takeda, 2010: 49.

TYPE MATERIAL

Holotype: 1 male, 3.3 × 2.8 mm (MNHG), Ambon, Indonesia.

DESCRIPTION

Carapace (Figures 1A & 3A, B) transversely oval, covered with dense, short pubescence, dorsal surface smooth; regions poorly defined with weakly raised mesogastric and cardiac regions. Anterolateral border (Figure 3A) convex, subcristate, with 4 indistinct low spines (including external orbital angle), tubercles or granules, separated by distinct notches. Posterolateral border (Figure 3A) weakly concave. Front (Figures 1B & 3B), with short setae behind frontal border, about half carapace width, with median notch; lateral angle of each lobe not produced, rugose, confluent with supraorbital border. Orbit (Figures 1B & 3A, B) small; eyestalk setose, stout, eye entirely fills orbit, rather protruded anteriorly, beyond contour of carapace, movable; supraorbital border hardly raised along inner part, in dorsal view deeply concave at inner part, directed anteriorly towards blunt external orbital angle; inner angle not prominent, touching short ventral prolongation of front.

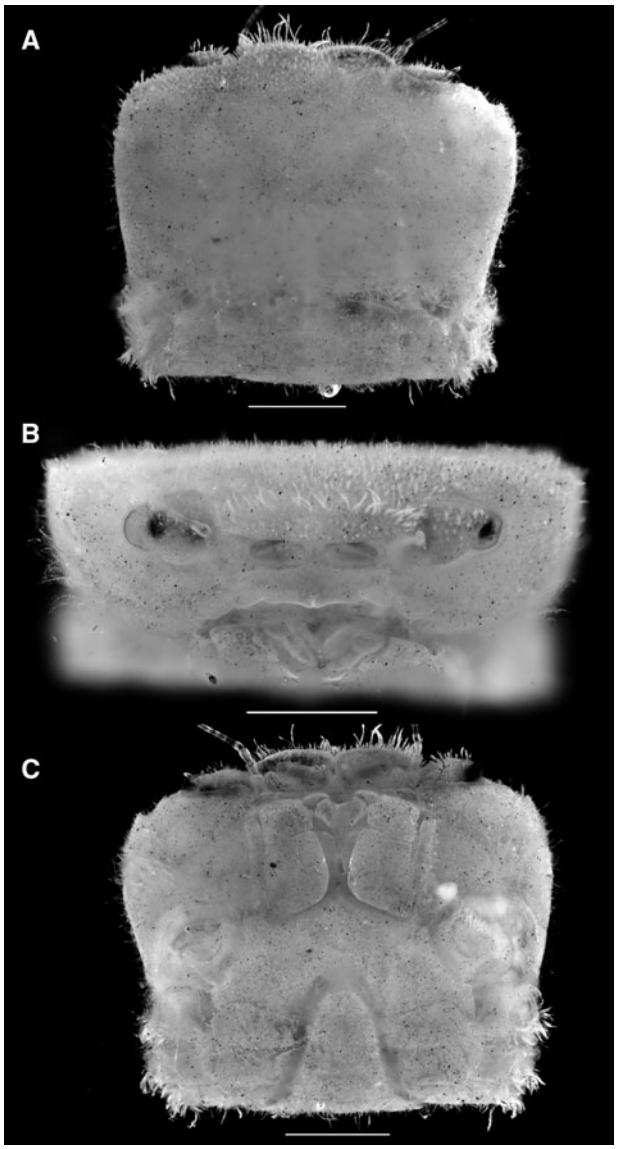

Fig. 1. *Zehntneriana villosa* (Zehntner, 1894), holotype, male, 3.3 × 2.8 mm. (A) carapace, dorsal view; (B) front of carapace, anterior view; (C) third maxillipeds, thoracic sternum and male abdomen. Scale bar: 1.0 mm.

Antennal flagellum (Figure 3A, B) just exceeds twice length of diameter of orbit. Epistome narrow; posterior margin with low median projection with concave lateral margins, separated from lateral parts by shallow notches (Figure 3B). Third maxillipeds (Figures 1C & 3C) sparsely covered with short setae; merus quadrate, antero-external angle angular but not produced.

Thoracic sternum (Figures 1C & 3D) covered with pubescence; sternites 1, 2 completely fused, separated from sternite 3 by distinct suture; suture between sternites 3, 4 with few indistinct tubercles; sternites 3, 4 almost completely fused except for short notches laterally, sternite 3 distinguishable from sternite 4 by shallow transverse groove; sternite 4 relatively larger, surface gently convex. Gonopores coxo-sternal; penis on exposed subtransverse groove formed by thoracic sternites 7, 8.

Chelipeds (Figure 2A, B) asymmetrical. Merus and carpus densely covered with low pubescence. Whole surface of propodus of left cheliped with dense pubescence

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Fig. 2. Left cheliped of *Zehntneriana villosa* (Zehntner, 1894), holotype, male, 3.3 × 2.8 mm. (A) dorsal view; (B) outer view. Scale bar: 1.0 mm.

and scattered long setae; with scattered minute granules beneath. Entire surface of propodus of right cheliped smooth, glabrous; left proximal half of movable finger and proximal end of lower border of immovable finger coarsely granulated, setose.

Ambulatory legs (Figure 3E–H) slender, densely setose. Merus with dense setae on both borders; anterior border not serrated. Dactylus densely fringed with long setae of various lengths, subcylindrical; last pair weakly curved dorsally near small claw.

Abdomen (Figures 1C & 3I) narrow, broadly subtriangular in shape, 6 somites and telson, surfaces pubescent. Width of first somite subequal to third somite. Telson triangular.

G1 (Figure 3J–L) gently curved mesially, with row of small spines on distal region; apical lobe bent at 60° to rest of structure.

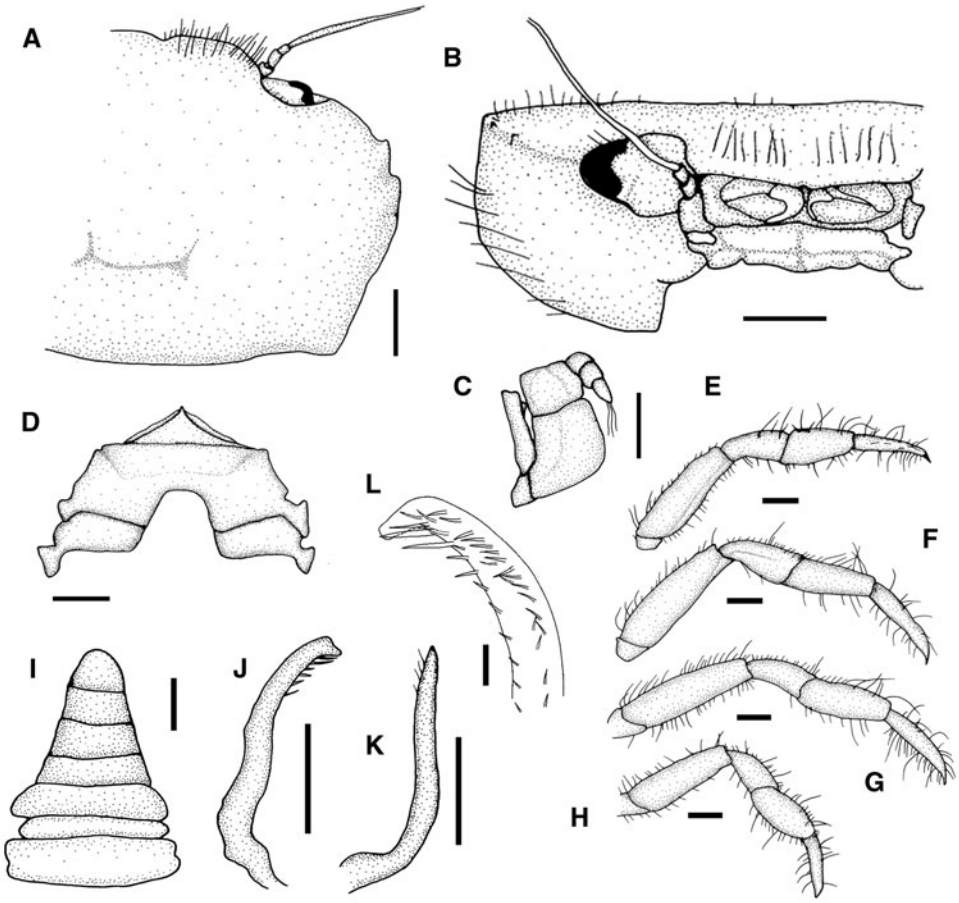

Fig. 3. *Zehntneriana villosa* (Zehntner, 1894), holotype, male, 3.3 × 2.8 mm. (A) right part of carapace, dorsal view; (B) cephalothorax, anterior view; (C) right third maxilliped, ventral view; (D) thoracic sternites 1–5, ventral view; (E–H) first to fourth of ambulatory legs, dorsal views; (I) male abdomen and telson, ventral view; (J) left G1, external view; (K) left G1, lateral view; (L) distal portion of G1, internal view. Scale bars: A–K = 0.5 mm, L = 0.1 mm.

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REMARKS

Zehntner (1894: 173, pl. 8, figure 8a–c) described *Ceratoplax villosa* based on a small male. His description and simple illustrations, although adequate, do not mention many of the characters currently used in pilumnid taxonomy. Takeda (1972: 35, figure 1) redescribed and illustrated specimens of what he believed to be *C. villosa* from the Ryukyu Islands, Japan. Recently, we were able to re-examine the holotype of *C. villosa* in the MNHG. The holotype male is in poor condition. It had dried out sometime in the past, but was subsequently rehydrated and is now preserved in ethanol. Even after rehydration, some parts of the G1 are badly deformed because of the previous dehydration. The G2s are missing. Thus, the current illustration of the G1 (Figure 3J–L) may be somewhat inaccurate.

Zehntneriana tadafumii **sp. nov.**
(Figures 4–6)

Zehntneria villosa: Takeda, 1972: 35, figure 1.

TYPE MATERIAL

Holotype: 1 male 5.1 × 3.5 mm (ZRC 2011.0673), Ohyama, Ginowan City, Okinawa, Japan, coll. T. Maenosono, 12 March 2008.

Paratypes: 4 females, 3.6 × 2.6–5.2 × 3.6 mm (ZRC 2011.0673), Ohyama, Ginowan City, Okinawa, Japan, coll. T. Maenosono, 12 March 2008; 1 female, 7.6 × 5.8 mm (NSMT Cr 5781), Shiono-Misaki, Kii Peninsula, Japan, coll. M. Takeda, 20 July 1978; 1 male, 7.6 × 6.1 mm (NSMT Cr 5882), Shiono-Misaki, Kii Peninsula, Japan, coll. M. Takeda, 20 July 1978; 1 female, 8.0 × 5.8 mm (NSMT Cr 5809), Kushimoto, Kii Peninsula, Japan, coll. M. Takeda, 21 July 1978.

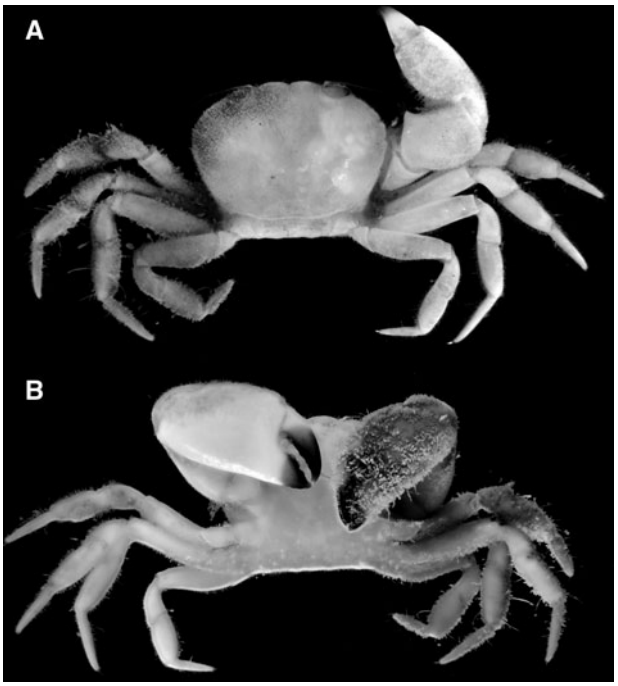

Fig. 4. *Zehntneriana tadafumii* sp. nov., holotype, male, 5.1 × 3.5 mm (ZRC 2011.0673). (A) whole animal, dorsal view; (B) chelipeds, ventral view.

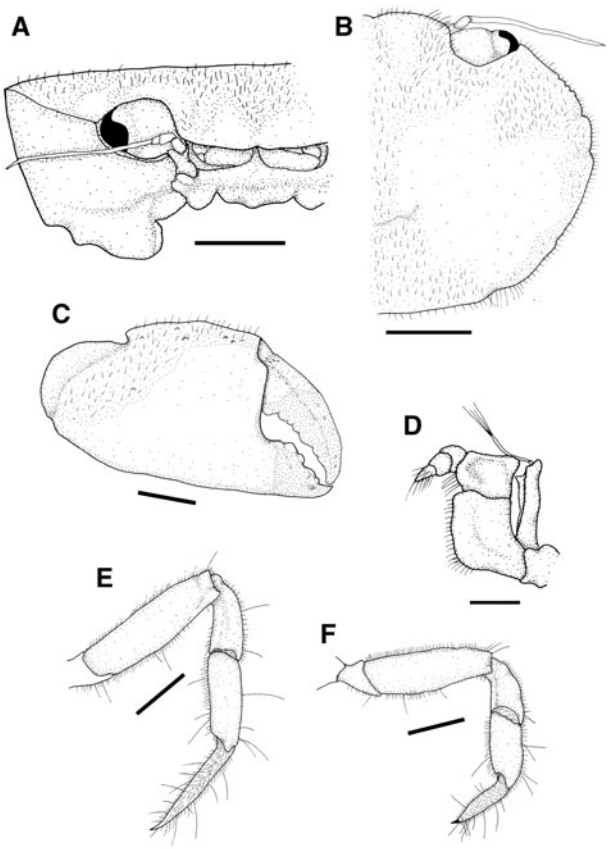

Fig. 5. *Zehntneriana tadafumii* sp. nov., holotype, 1 male, 5.1 × 3.5 mm (ZRC 2011.0673). (A) cephalothorax, epistome and pterygostomial region, anterior view; (B) right part of carapace, dorsal view; (C) right cheliped, outer view; (D) left third maxilliped, ventral view; (E) third ambulatory leg, dorsal view; (F) fourth ambulatory leg, dorsal view. Scale bars: A–C, E, F = 1.0 mm, D = 0.5 mm.

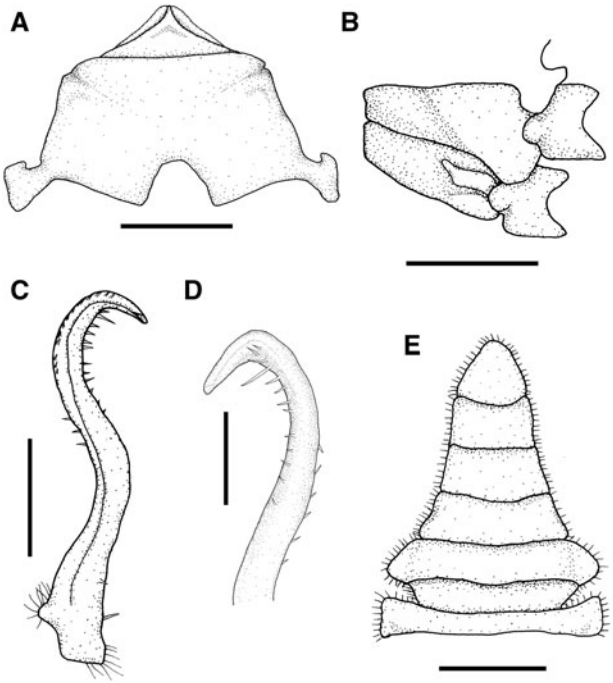

Fig. 6. *Zehntneriana tadafumii* sp. nov., holotype, 1 male, 5.1 × 3.5 mm (ZRC 2011.0673). (A) thoracic sternites 1–4, ventral view; (B) gonopore coxal, external view; (C) whole left G1, external view; (D) distal portion of G1, internal view; (E) male abdomen and telson, ventral view. Scale bars: A, B, E = 1.0 mm, C = 0.5 mm, D = 0.2 mm.

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COMPARATIVE MATERIAL EXAMINED

Zehntneriana amakusae: 1 male, 8.5 × 6.0 mm (NSMT Cr 4133), Tsujishima, Amasuka, Japan, no other data; 1 male, 5.9 × 4.1 mm (NSMT), Doren, Kakeroma-Jima, Japan, station K5-26-2, 7 m, coll. 4 March 2005; 1 male, 6.3 × 4.5 mm (MADBK), Chuja Is., Jejudo province, Korea, coll. S. K. Lee, 31 March 2009; 1 male, 5.5 × 3.7 mm (MADBK), Chagwido, Jeju Is., coll. S. H. Kim, 8 June 2001.

Zehntneria miyakei: Holotype male, 4.8 × 3.5 mm (NSMT Cr 976), south-west Madlâi, Goréor Island, Palau, 7°20′30″N 134°28′28″E, coll. S. Murakami, 20 May 1938; 1 paratype male, 5.2 × 3.7 mm, paratype, 1 female, 5.7 × 3.9 mm (NSMT Cr 977–978), same data as holotype; 1 male, 5.4 × 3.9 mm (NSMT Cr 9747), west side of Nominoura, Oshima Passage, Japan, station 20, 45 m, coll. M. Takeda, 6 August 1988; 1 juvenile female, 3.9 × 2.7 mm (NSMT Cr 9746), near Tawara, Oshima Passage, Japan, station 18, 30 m, coll. M. Takeda, 6 August 1988.

Zehntneria novaeinsulicola: holotype male, 4.1 × 2.8 mm (NSMT Cr 5469), Nishino-shima-shinto, Japan, under coral block, coll. Y. Kurata, 25 July 1975.

DESCRIPTION

Carapace (Figures 4A & 5B) transversely oval; surface uniformly covered with dense short pubescence, without long setae, surface below convex fore and aft, smooth, regions poorly defined with weakly raised mesogastric and cardiac regions; anterolateral border arched, subcristiform with indistinct granules, with 3 notches; posterolateral border moderately to weakly convergent. Front (Figures 4A & 5A, B) slightly less than half-length of carapace, truncated, with median notch; lateral angle of each lobe not produced, rugose, confluent with supraorbital border. Orbit (Figure 5A, B) small; major diameter equal in length to each frontal lobe; eyestalk movable, with short setae, stout, entirely fills orbit, protruded anteriorly beyond general contour of carapace; supraorbital border raised along inner part in anterior view, in dorsal view deeply concave at inner part, lateral half directed anterolaterally towards blunt external orbital angle; inner angle not prominent.

Antennal flagellum slightly exceeds twice length of major diameter of orbit. Epistome narrow; posterior margin with prominent median projection with deeply concave lateral margins. Third maxillipeds (Figure 5D) sparsely covered with short setae; merus quadrate with antero-external angle angulated, weakly produced.

Thoracic sternum (Figure 6A) covered with short pubescence like on carapace; sternites 1, 2 completely fused, separated from sternite 3 by distinct suture; sternite 3, 4 almost completely fused except for short notches laterally, sternite 3 distinguishable from sternite 4 by shallow groove; sternite 4 larger, inflated; sternites 5–8 distinct, separate. Gonopores coxo-sternal (Figure 6B); penis exposed on groove formed by thoracic sternites 7, 8.

Chelipeds (Figures 4A, B & 5C) asymmetry in both sexes. Merus and carpus densely covered with short pubescence like on carapace. Entire surface of palm of both chelae of female and smaller chela of male densely covered with short pubescence and sparsely with long setae; with sparse minute granules beneath.

Ambulatory legs (Figures 4A, B & 5E, F) slender, densely setose as on carapace. Merus densely setose on both borders; anterior border not serrated; surfaces covered with adherent inorganic matter. Dactyli densely fringed with long setae of various lengths; in first 3 pairs, 0.8 length of propodus, subcylindrical; in last pair weakly curved dorsally near terminal small claw.

Abdomen (Figure 6E) narrow, subtriangular, 6 somites and telson, outer surface with short setae. Width of first somite subequal to third somite. Telson triangular.

G1 (Figure 6C, D) generally sinuous, with row of small spines on distal region; apical part bent 60° to rest of structure. G2 short, sigmoid.

ETYMOLOGY

The species is named after the intrepid collector, Tadafumi Maenosono, who obtained the recent specimens of this new species.

DISTRIBUTION

Okinawa-jima, the Ryukyus Island and Wakayama, Kii Peninsula, Japan.

REMARKS

When referring the Japanese specimens to *Zehntneriana villosa*, Takeda (1972) did not examine the type of this species. Despite the difference in size and type locality (in Indonesia), Takeda (1972) did not query the conspecificity with the Japanese specimens. The present comparisons of the type with the Japanese specimens indicate that they are different species. The Japanese specimens, referred to here as *Z. tadafumii* sp. nov., differ from *Z. villosa* s. str. in the following characters: (1) presence of small spines and tubercles on the anterolateral margin (Figure 5B) [*Z. villosa* s. str. has four indistinct lobes separated by shallow notches (Figure 3)]; (2) absence of a transverse setae row behind the frontal margin of the carapace (Figure 5A, B) [in *Z. villosa* s. str., there is a discernible transverse setal row (Figure 3A)]; and (3) the posterior margin of the epistome has a prominent median triangular projection with deeply concave lateral margins, and is separated from the lateral parts by deep notches (Figure 5A) [in *Z. villosa* s. str., the posterior margin of the epistome has a lower median triangular projection with concave lateral margins, and is separated from the lateral parts by shallower notches (Figure 3B)]. These differences are substantial at the species level and cannot be accounted for by size variations.

DISCUSSION

Zehntneriana tadafumii sp. nov. is unusual among members of the genus *Zehntneriana* in having the entire surface of the carapace evenly covered with short and dense pubescence (Figures 4A & 5A, B). In *Z. villosa* s. str., the pubescence is less dense and is concentrated on the anterior half of the carapace (Figures 1A & 3A). The carapaces of *Z. amakusae* and *Z. miyakei* are covered with short pubescence, mainly along the anterolateral border, and the median parts are glabrous or almost so (Takeda & Miyake, 1969: figure 1a; Takeda, 1972: figure 2A, B). The carapace of *Z. novaeinsulicola* is more glabrous and has scattered setae (Takeda & Kurata, 1977: figure 3a, b).

The genus *Zehntneriana* can be divided into two groups according to the anteroexternal angle of the merus of the

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third maxilliped. In *Z. tadafumii* sp. nov., the anteroexternal angle of the merus of the third maxilliped is produced (Figure 5D). In the other species, the anteroexternal angle of the merus of the third maxilliped is angular but not auriculiform (Figure 3C; Takeda & Miyake, 1969: figure 1b; Takeda & Kurata, 1977: figure 4d). In *Z. tadafumii* sp. nov., the outer surfaces of the cheliped are evenly covered with the same short pubescence on the carapace (except for the fingers) (Figures 4B & 5C). In *Z. villosa* s. str., the outer surfaces of the cheliped are also setose, but the setae are longer and more unevenly distributed (Figure 2A, B). The other three species have almost glabrous chelipeds (see Takeda & Miyake, 1969: figure 1c; Takeda, 1972: figures 2C, D and 3A; Takeda & Kurata, 1977: figures 3a, 4b, c). In *Z. tadafumii* sp. nov. and *Z. villosa* s. str., the first three pairs of ambulatory legs are relatively slender, and the margins of the meri are almost smooth and lined with long simple and plumose setae (Figures 3E–G, 4A, B & 5E). In the other three species, the first three pairs of ambulatory legs are more elongate, and the anterior margins of the meri are minutely serrated and lined with scattered setae (see Takeda & Miyake, 1969: figure 1d; Takeda, 1972: figure 3D, C; Takeda & Kurata, 1977: figure 4e, f). In *Z. tadafumii* sp. nov., the male telson is triangular (Figure 6E), whereas in the other four species, the male telson is proportionately broader (Figure 3I; Takeda & Miyake, 1969: figure 1e; Takeda & Kurata, 1977: figure 4h).

The comparisons discussed above clearly indicate that several characters of *Z. tadafumii* sp. nov. differ from those of the other species. The carapace and leg pubescence resemble those of *Z. villosa* s. str.; however, the pattern of seta differs [that of *Z. tadafumii* sp. nov. is short, dense, and uniform throughout (Figures 4A & 5A, B), whereas that of *Z. villosa* s. str. is relatively longer and less evenly distributed (Figures 1A & 3A, B)]. As discussed above, the male thoracic sternal condition suggests that the two species are not congeneric. The male thoracic sternum of *Z. tadafumii* sp. nov. more closely resembles that of *Z. amakusae, Z. miyakei* and *Z. novaeinsulicola*; however, the structures of the third maxillipeds, carapace and legs suggest that these species are not closely related. Further studies to clarify the generic relationships in the genus *Zehntneriana* are required.

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