

Studies on Eumalacostraca: a homage to Masatsune Takeda

By

Hironori Komatsu, Junji Okuno and Kouki Fukuoka
(Editors)

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FIRST *VIRIDOTHERES* MANNING, 1996, FROM JAPAN, WITH A KEY
TO THE SPECIES (DECAPODA, BRACHYURA, PINNOTHERIDAE)

BY

SHANE T. AHYONG^{1,4}), TOMOYUKI KOMAI²) and TETSUYA WATANABE³)

¹) Australian Museum, 6 College St., Sydney, NSW 2010, Australia

²) Natural History Museum and Institute, Chiba, Chiba 260-8682, Japan

³) Osaka Museum of Natural History, Osaka, Osaka 546-0034, Japan

ABSTRACT

Viridothers takedai sp. nov., the seventh species of the genus, is described from Japan. It is the fourth species known from the Indo-West Pacific and the first to be recorded from Japanese waters. *Viridothers takedai* is also the first pinnotherid to be recorded from *Nipponoclava gigantea* (Sowerby), a tube dwelling bivalve. An unusual feature of adult male *V. takedai* is the well-developed exopod on gonopod 2, recognised here for the first time from a brachyuran as a normal feature (rather than the result of a developmental abnormality). The gonopod 2 exopod is absent in the juvenile male, so its presence in adult *V. takedai* may be derived feature. We also report the occurrence of well-developed gonopod 2 exopods in male *Nepinnothers affinis* (Bürger, 1895), *N. androgynus* Manning, 1993, and the hexapodid *Thaumastoplax anomalipes* Miers, 1881. Most pinnotherid species are known at present only from females and when males of these species are discovered, the phenomenon may prove more widespread than currently known. A key to the species of *Viridothers* Manning, 1996 is provided.

INTRODUCTION

Viridothers was established by Manning (1996) for three West African species (two previously assigned to *Nepinnothers* Manning, 1993) sharing a maxilliped 3 palp in which the dactylus articulates near the midlength of the flexor margin of the propodus, the walking legs are left-right symmetrical, and in which the second walking leg (pereopod 3) of females not only had the longest dactylus, but was longest leg overall. Six species of *Viridothers* are presently recognised: three from the eastern Atlantic: *V. marionae* Manning,

⁴) Corresponding author; e-mail: Shane.Ahyong@austmus.gov.au

1996 (type species; Cape Verde Islands) and *V. lillyae* (Manning, 1993) (Ivory Coast), and *V. viridis* (Manning, 1993) (Cape Verde Islands); and three from the Indo-West Pacific: *V. gracilis* (Bürger, 1895) (Philippines), and *V. burgeri* (Rathbun, 1909) (Thailand) and *V. otto* Ahyong & Ng, 2007 (Philippines). Recently, an undescribed species of *Viridothere* was discovered associated with the tube dwelling bivalve, *Nipponoclava gigantea* (Sowerby) from the Ariake and Yatsushiro seas in Kyushu, Japan. The new species, representing the seventh known species of *Viridothere*, is described herein.

Morphological terminology generally follows Ahyong & Ng (2007). Measurements are in millimetres (mm). Carapace length (cl) is measured along the dorsal midline. Carapace width (cw) is the greatest width. Specimens studied are deposited in the Australian Museum, Sydney (AM), Natural History Museum and Institute, Chiba, Japan (CBM) and Senckenberg Museum, Frankfurt-am-Main, Germany (SMF).

TAXONOMY

Family PINNOTHERIDAE De Haan, 1833

Genus *Viridothere* Manning, 1996

***Viridothere takedai* sp. nov.**

[New Japanese name: Deguchi-tsutsugaki-pinno]

(figs. 1-3)

Type material. — Holotype: CBM-ZC 10487, female (cl 12.8 mm, cw 14.3 mm), 2.2 km north-north-west of Yushima, Shimabara Bay, Ariake Sea, Kyushu, 100 m, commercial gill net, associated with *Nipponoclava gigantea*, coll. N. Deguchi, 16 December 2007.

Paratypes: CBM-ZC 10488, 1 male (cl 8.5 mm, cw 9.4 mm), collected with holotype; AM P87160, 1 male (cl 6.5 mm, cw 7.2 mm), 1 female (cl 10.4 mm, cw 11.7 mm), 2.2 km north-north-west of Yushima, Shimabara Bay, Ariake Sea, Kyushu, 100 m, commercial gill net, associated with *Nipponoclava gigantea*, coll. N. Deguchi, 2 February 2008; CBM-ZC 10535, 1 male (cl 6.6 mm, cw 7.6 mm), 1 ovigerous female (cl 10.4 mm, cw 12.0 mm), 2.2 km north-north-west of Yushima, Shimabara Bay, Ariake Sea, Kyushu, 100 m, commercial gill net, associated with *Nipponoclava gigantea*, coll. N. Deguchi, 26 May 2008; CBM-ZC 10489, 1 female (cl 10.1 mm, cw 12.0 mm), off Goshoura, Yatsushiro Sea, Kyushu, coll. H. Shimizu, 15 February 2007; CBM-ZC 10490, 1 juvenile male (cl 2.7 mm, cw 2.7 mm), 1 ovigerous female (cl 11.3 mm, cw 12.5 mm), off Goshoura, Yatsushiro Sea, Kyushu, coll. H. Shimizu, 27 February 2007.

Diagnosis. — Carapace subcircular, dorsal surface glabrous; front slightly produced, anterior margin transverse. Maxilliped 3 with ischiomerus length less than twice width; inner proximal margin straight; inner distal margin with

prominent angle; dactylus apex falling short of propodal apex. Cheliped palm dorsally glabrous. Pereiopods 2-5 dactyli about 0.5 propodi length or less; propodi and carpi sparsely setose or glabrous. Pereiopod 5 merus 0.5 length of pereiopod 3 merus.

Description of adult female. — Carapace subcircular, slightly wider than long. Front slightly produced, anterior margin transverse in dorsal view. Anterolateral margins poorly defined. Dorsum smooth, lateral margins sparsely setose, surface otherwise glabrous; dorsal midline convex in profile.

Antennular sinus larger than orbit; antennules folded slightly obliquely. Antennal articles 1 and 2 fused to epistome. Eyes not visible in dorsal view, filling orbit, cornea pigmented.

Maxilliped 3 with ischiomerus length less than twice width; inner proximal margin straight; inner distal margin with prominent angle, setose; outer margin strongly convex. Carpus shorter than propodus. Propodus spatulate, longer than wide, gently tapering to blunt, setose apex. Dactylus digitiform, distally setose, inserted slightly proximal to propodal midlength, apex falling short of propodal apex. Exopod with straight inner margin and convex outer margin; flagellum 2-articulate, distal article setose.

Chelipeds symmetrical from left to right. Dactylus and pollex relatively straight, crossing distally. Dactylus occlusal margin with blunt proximal tooth, otherwise smooth. Pollex occlusal margin with low crenulate prominence near midlength, otherwise smooth; with fringe of short setae on inner ventral margin. Propodus dorsal margin 2.2 times height, about twice length of dactylus; ventral margin sinuous. Carpus and merus unarmed, inner proximal margins setose.

Pereopods 2-5 (walking legs 1-4) similar and symmetrical from left to right, with few scattered setae; relative lengths in decreasing order pereiopod 3 > pereiopod 2 > pereiopod 4 > pereiopod 5. Dactyli distally spiniform; flexor margins with scattered long setae and rows of minute, closely spaced setae; relative dactylus lengths: pereiopod 3 > pereiopod 2 > pereiopod 4 = pereiopod 5; pereiopod 2 and pereiopod 4 dactyli 0.4 propodus length; pereiopod 3 and pereiopod 5 dactylus 0.5 propodus length. Propodi with long scattered setae along flexor margin; with minute, closely spaced setae on disto-flexor margin adjacent to dactyl articulation. Meri distinctly longer and slightly deeper than other articles; pereiopod 5 merus half-length of pereiopod 3 merus; with row of long setae along proximal extensor margin, extending onto ischium.

Abdomen broader than long, covering thorax; comprising 6 free somites and telson, widest at somite 5.

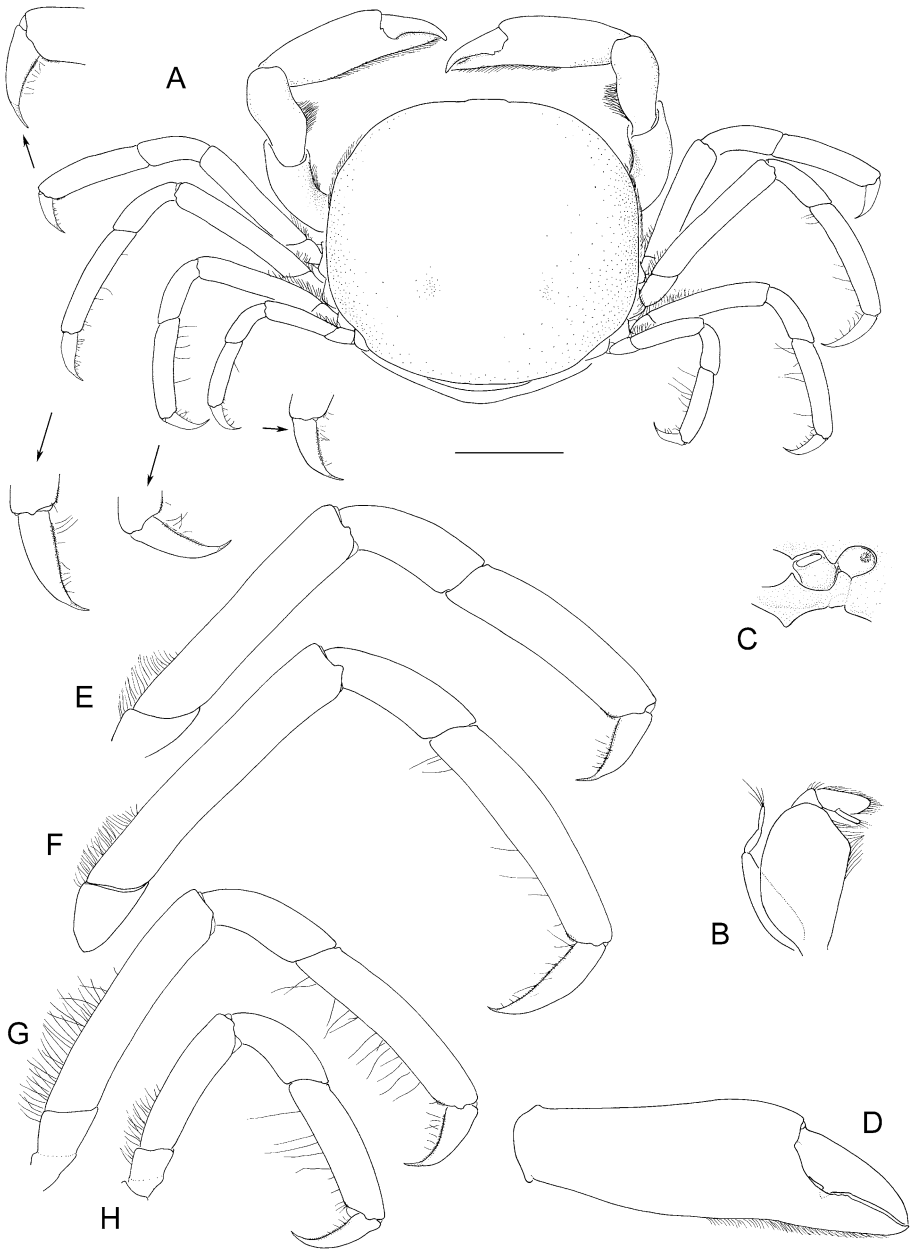


Fig. 1. *Viridotheres takedai* sp. nov., female holotype, cl 12.8 mm, cw 14.3 mm (CBM-ZC 10487). A, dorsal habitus; B, right maxilliped 3; C, left cephalothorax, anterior view; D, right chela; E–H, right pereopod 2–5. Scale: A = 5.0 mm, B–H = 2.5 mm.

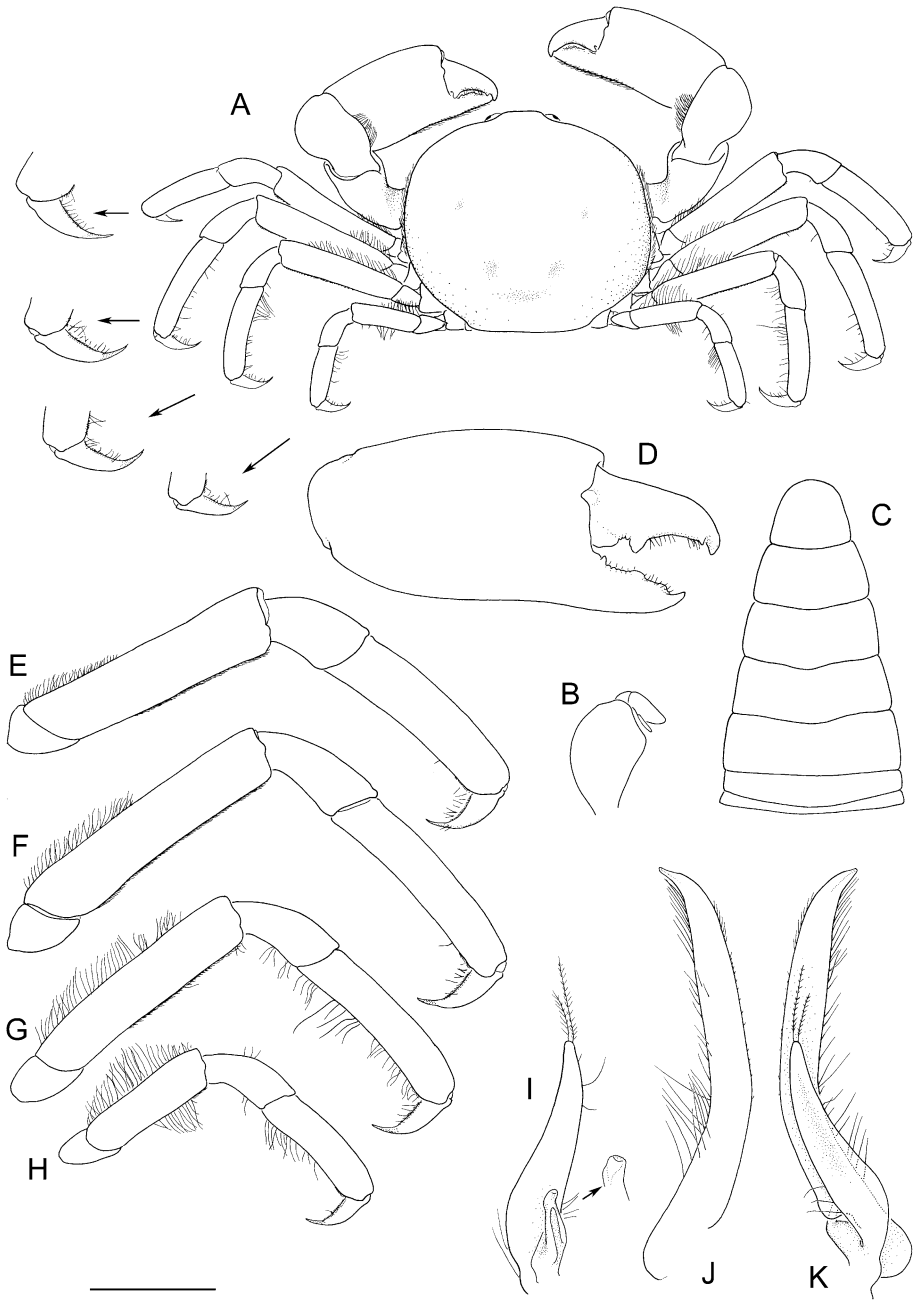


Fig. 2. *Viridotheres takedai* sp. nov., male paratype, cl 8.5 mm, cw 9.4 mm (CBM-ZC 10488). A, dorsal habitus; B, right maxilliped 3; C, abdomen; D, right chela; E–H, right pereopod 2–5; I, left gonopod 2, sternal view; J, left gonopod 1, sternal view; K, left gonopods 1 and 2, abdominal view. Scale: A = 5.0 mm, B–H = 2.5 mm, I–K = 1.25 mm.

Description of adult male. — Carapace subcircular, slightly wider than long. Front produced, anterior margin transverse in dorsal view. Anterolateral margins poorly defined. Dorsum smooth, lateral margins sparsely setose, surface otherwise glabrous; dorsal midline convex in profile. Antennular sinus larger than orbit; antennules folded slightly obliquely. Antennal articles 1 and 2 fused to epistome. Eyes visible in dorsal view, filling orbit, cornea pigmented.

Maxilliped 3 with ischiomerus length less than twice width; inner proximal margin straight; inner distal margin with prominent angle, setose; outer margin strongly convex. Carpus shorter than propodus. Propodus spatulate, longer than wide, gently tapering to blunt, setose apex. Dactylus digitiform, distally setose, inserted slightly proximal to propodal midlength, apex falling short of propodal apex. Exopod with straight inner margin, outer margin convex; flagellum with 2 articles, distal article setose.

Chelipeds symmetrical from left to right, robust, inflated. Dactylus and pollex relatively straight, crossing distally. Dactylus occlusal margin weakly crenulate, with blunt tooth proximal to midlength and smaller distal tooth proximal to apex. Pollex occlusal margin irregularly crenulated, with low blunt prominence near midlength, a small upright tooth proximally and low angular prominence distally near apex; with fringe of short setae on inner ventral margin. Propodus dorsal margin 1.5 times height, 1.7 times length of dactylus; ventral margin sinuous. Carpus unarmed, inner proximal margin setose.

Pereiopods 2-5 (walking legs 1-4) similar and symmetrical from left to right, with few scattered setae; relative lengths in decreasing order pereopod 3 > pereopod 2 > pereopod 4 > pereopod 5. Dactyli distally spiniform; flexor margins with scattered long setae and rows of minute, closely spaced setae; relative dactylus lengths: pereopod 2 = pereopod 3 = pereopod 4 > pereopod 5; pereopod 2-4 dactyli 0.4 propodus length; pereopod 5 dactylus 0.5 propodus length. Propodi with minute, closely spaced setae on disto-flexor margin adjacent to dactyl articulation; pereopod 2-3 propodi with few scattered setae along flexor margins; pereopod 4-5 propodi with long scattered setae along flexor margin. Meri distinctly longer and slightly deeper than other articles; pereopod 5 merus half-length of pereopod 3 merus; with row of long setae along proximal extensor margin on pereopods 2 and 3, extending full length on pereopods 4 and 5; flexor margins with fine setae, and additional long setae on pereopod 5.

Abdomen slender, margins evenly converging posteriorly; comprising 6 free somites and telson, widest at somites 1-3; telson slightly wider than long, apex rounded.

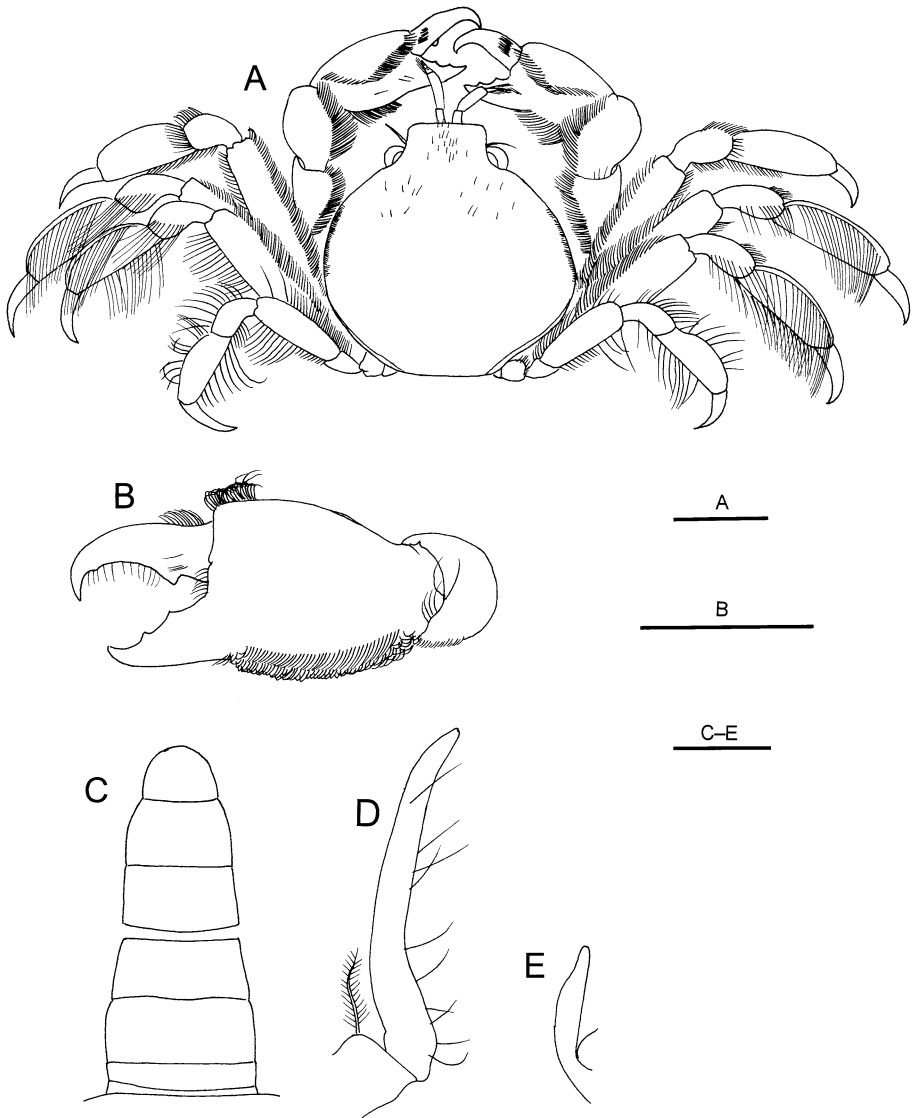


Fig. 3. *Viridothers takedai* sp. nov., juvenile male paratype, cl 2.7 mm, cw 2.7 mm (CBM-ZC 10490). A, dorsal habitus; B, left chela, outer view; C, abdomen, ventral view; D, left gonopod 1, abdominal view; E, left gonopod 2. Scales: A = 1 mm, B–C = 0.5 mm, D–E = 0.25 mm.

Gonopod 1 elongate, slender, arcuate, dorsoventrally compressed, slightly longer than half length of abdomen, tapering to simple apex; outer margin lined with long setae. Gonopod 2 endopod simple, about 1/4 length of gonopod 1; exopod well-developed, slender, flattened, evenly tapering to rounded apex,

almost triple length of endopod; about half length of gonopod 1. Pleopods 3-5 absent.

Description of juvenile male. — Carapace subcircular, as wide as long. Front strongly produced, anterior margin transverse in dorsal view; dorsal surface faintly grooved medially. Anterolateral margins poorly defined. Anteroventral margin (near base of cheliped) with prominent fringe of dense setae directed dorsally. Dorsum smooth, gastric region sparsely setose, surface otherwise glabrous; dorsal midline convex in profile.

Chelipeds symmetrical from left to right, robust, not particularly inflated. Dactylus and pollex with curved tips, crossing distally. Dactylus strongly curved, proximally setose; occlusal margin nearly smooth, with low subdistal swelling and subacute tooth proximal to midlength. Pollex nearly straight except for curved tip, occlusal margin with 2 small triangular teeth. Propodus dorsal margin 1.1 times height and 1.3 times length of dactylus; ventral margin slightly sinuous, with covering of dense setae; inner dorsal margin setose; inner surface with patch of setae near ventral margin proximally. Carpus unarmed, inner proximal and ventral margins with dense setae. Merus with dense setae on dorsal and ventral margins.

Pereiopods 2-5 (walking legs 1-4) similar and symmetrical from left to right; propodi each with dorsal and ventral row of long natatory setae on outer (posterior) surfaces; carpi of same pereiopods each with oblique medial row of natatory setae on outer surfaces. Otherwise similar to those of adult males.

Abdomen similar to that of adult males, but slightly more slender proportionally.

Gonopods not fully differentiated. Gonopod 1 about half as long as abdomen; gently curved outward, gradually tapering to subacute apex; outer margin sparsely setose. Gonopod 2 flattened, tapering to blunt apex, shorter than one-third as long as gonopod 1.

Colouration in life. — Females overall whitish or pale yellowish transparent; brown gonad visible through integument; cornea reddish brown.

Males generally whitish, carapace with symmetrical yellowish brown markings on dorsal surface.

Etymology. — Named in honour of Prof. Masatsune Takeda, in recognition of his major contributions to the taxonomy of Decapoda, especially that of the crabs of Japan.

Distribution. — Presently known only from the Ariake Sea and Yatsushiro Sea off Kyushu, Japan.

Host. — The present seven specimens were all associated with the tube dwelling bivalve, *Nipponoclava gigantea* (Sowerby), representing the first

pinnotherids known from this host. Two females, one ovigerous, were found in a narrow space between the Inner demibranch and pallial retractor muscle of the host. Six of seven specimens were found in heterosexual pairs, suggesting that this species lives in pairs.

Remarks. — *Viridotheres* is very similar to *Nepinnotheres*, the two genera being differentiated only by the latter having the pereopod 3 dactylus as long as, instead of longer than the pereopod 2 dactylus. On the basis of the longer pereopod 2 dactylus, the new species is assigned to *Viridotheres*. As observed by Ahyong & Ng (2007), however, the similarities between *Viridotheres* and *Nepinnotheres* are substantial and the length difference between the pereopod 3 and 4 dactyli may be slight, as in *V. otto* Ahyong & Ng, 2007. Future study may reveal that the two genera are synonymous.

Viridotheres takedai is the seventh known species of the genus and the first to be recorded from Japan. Unfortunately, only *V. lillyae* and *V. takedai* are known from both sexes, so comparisons between congeners are usually based only of females. *Viridotheres takedai* differs from *V. marionae* in the maxilliped 3 ischiomerus having a straight versus concave inner proximal margin and differing proportions (length less than twice width versus length slightly exceeding twice width). From *V. lillyae*, *V. takedai* differs in having proportionally longer walking legs in which the dactyli do not exceed half the propodus length versus two-thirds or more. Additionally, the length of the pereopod 5 merus of *V. takedai* is half that of pereopod 3 versus 0.6 or more in *V. lillyae*. From *V. viridis*, *V. takedai* is readily distinguished by the absence of a prominent upright tooth near the midlength of the occlusal margin on the cheliped pollex. *Viridotheres takedai* is readily distinguished from *V. otto* and *V. burgeri* by the setose instead of glabrous walking legs and proportionally longer pereopod 3 merus, which is twice the length of the pereopod 5 merus (versus less than twice), and the straight rather than concave inner proximal margin of the maxilliped 3 ischiomerus. *Viridotheres gracilis* differs from *V. takedai*, at least in females, in having densely versus very sparsely setose meri, carpi and propodi of the walking legs, and in having a more elongate ischiomerus of maxilliped 3 (length about twice width versus distinctly less than twice width) in which the inner proximal margin is concave rather than straight.

The juvenile male is similar to the adult males in most major respects, and differs in expected ways given its developmental stage, such as the more pronounced front, incipient rather than distinct subdistal tooth on the occlusal margin of the cheliped dactylus, well-developed natatory setae on the

walking legs and incompletely differentiated pleopods 1 and 2. The juvenile male, however, also differs in having setose dorsal margins on the cheliped palm and proximal margin of the cheliped dactyli; these setae are completely absent in adult males. It is noteworthy that the juvenile male appears to be in ‘hard stage’, a stage at which males of other pinnotherids, such as *Juxtafabia muliniarum* (Rathbun, 1918) and *Fabia subquadrata* (Dana, 1851), are sexually mature (Pearce, 1966; Campos, 1993).

Of the local Japanese species, *V. takedai* superficially resembles *Nepinnotheres cardii* (Bürger, 1895) and *Nepinnotheres pholadis* (de Haan, 1835) in the slender, sparsely setose walking legs. In both *N. cardii* and *N. pholadis*, however, the length of the pereopod 3 dactylus is equal to, rather than longer than that of the pereopod 2 dactylus. The maxilliped 3 of *V. takedai* differs from that of *N. cardii* in having a straight rather than concave inner proximal margin on the ischiomerus, and differs from that of *N. pholadis* in having a dactylus that does not exceed the propodus, rather than reaching or extending beyond the apex. Male *V. takedai* have two teeth on the occlusal margin of the dactylus and in this respect also resemble males of two East Asian species, *Pinnotheres bidentatus* Sakai, 1939 (Japan) and *Pinnotheres taichungae* Sakai, 2000 (Taiwan). Male *V. takedai* are readily separated from *P. bidentatus* and *P. taichungae* by the shorter dactylus of maxilliped 3, which does not reach the apex of the propodus (versus overreaching the propodus).

An unusual feature of adult male *V. takedai* is the well-developed exopod of gonopod 2, as evident in all adult males examined (fig. 2I). In-situ, with the gonopod 2 endopod inserted into gonopod 1, the gonopod 2 exopod lies flat against the abdominal surface of gonopod 1 (fig. 2K). In early juvenile male brachyurans, the rami of pleopod 2 are well-developed prior to differentiation of pleopods 1 and 2 into gonopods, in which the exopods typically become vestigial or are lost (Shen, 1935; Hebling & Regier, 2003; Guerau & Rottlant, 2009). The gonopod 2 in the juvenile male *V. takedai*, however, is uniramous, suggesting that the well-developed gonopod 2 exopod of adults is not pedomorphic and may be a derived feature.

Unfortunately, few species of Pinnotheridae are known from males, so we take this opportunity to report a similar occurrence in the gonopod 2 of adult male *Nepinnotheres affinis* (Bürger, 1895) (fig. 4). In *N. affinis*, however, the gonopod 2 endopod is about one-quarter the length of gonopod 1 as in *V. takedai*, but the exopod is as long as or slightly shorter than the endopod, rather than distinctly longer. In addition, males of the gynandromorphic *N. androgynus* Manning, 1993, and the hexapodid *Thaumastoplax anomalipes*

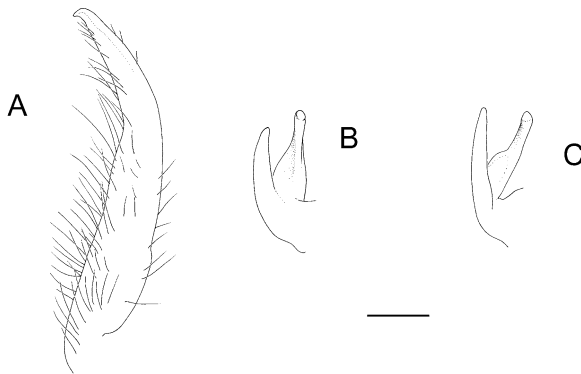


Fig. 4. *Nepinnotheres affinis* (Bürger, 1895). A–B, male paralectotype, Bohol, Philippines, cl 6.3 mm, cw 6.7 mm (SMF-ZMG 171). C, male, Ubay, Philippines, cl 7.2 mm, cw 7.2 mm (SMF-ZMG 175). A, left gonopod 1, sternal view; B–C, left gonopod 2, sternal view. Scale = 0.5 mm.

Miers, 1881, may also have well-developed gonopod 2 exopods if Monod's (1956: figs. 477, 523) and Manning's (1993: fig. 21h) partial figures are correct. Otherwise, only in the case of deformity or developmental abnormality have gonopod 2 exopods been previously recognised, as in the case of a unusual specimen of *Pleistacantha pungens* (Wood-Mason & Alcock, 1891), which, in addition, also bore pleopods 3-5, of which the latter two pairs were left-right asymmetrical (Gordon, 1963). Thus, as far as we are aware, the presence of well-developed gonopod 2 exopods reported here are the first records for normal adult male Brachyura. The gonopod 2, however, is often overlooked in pinnotheroid taxonomy, warranting a more focussed survey of their gonopods (as well as those of many other Brachyura) to determine the extent of exopod development. Most pinnotherid species are known only from females; when males of these species are discovered, the phenomenon may prove more widespread than currently known and the degree of development of gonopod 2 exopod may prove to be taxonomically and phylogenetically useful.

KEY TO SPECIES OF *VIRIDOTHERES* (ADULT FEMALES)

1. Cheliped pollex with prominent, upright tooth near midlength of occlusal margin *V. viridis*
 - Cheliped pollex with at most a low swelling or obtusely angular projection near midlength of occlusal margin 2
2. Maxilliped 3 ischiomerus broad, length distinctly less than twice width 3
 - Maxilliped 3 ischiomerus comparatively narrow, length twice width 4

3. Pereiopod 2-5 dactyli about two-thirds propodi length. Pereiopod 5 merus 0.6 length of pereiopod 3 merus *V. lillyae*
 – Pereiopods 2-5 dactyli 0.5 propodi length or less. Pereiopod 5 merus 0.5 length of pereiopod 3 merus *V. takedai* sp. nov.
4. Pereiopods 2-5 strongly setose. Pereiopods 3 and 4 dactyli 0.4 propodus length 5
 – Pereiopods 2-5 glabrous. Pereiopods 3 and 4 dactyli 0.5-0.6 propodus length 6
5. Dorsal margin of cheliped palm with fine setal patch adjacent to dactyl articulation
 *V. gracilis*
 – Dorsal margin of cheliped palm glabrous *V. marionae*
6. Pereiopods 2-5 dactyli not exceeding 0.6 propodus length. Maxilliped 3 dactylus not reaching propodal apex *V. otto*
 – Pereiopods 2-5 dactyli exceeding 0.7 propodus length. Maxilliped 3 dactylus reaching propodal apex *V. burgeri*

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