

A revision of the genus *Rhabdonotus* A. Milne Edwards, 1879, with descriptions of two new species and the first zoeal stage of *R. pictus* A. Milne Edwards, 1879 (Brachyura: Eumedonidae)

Diana G. B. Chia and Peter K. L. Ng

Abstract. — The genus *Rhabdonotus* A. Milne Edwards, 1879, is revised. The identity of *Rhabdonotus pictus* A. Milne Edwards, 1879, is clarified. A specimen from Singapore is designated as the simultaneous neotype of *Rhabdonotus pictus* A. Milne Edwards, 1879, and its junior synonym, *Caphyra archeri* Walker, 1887. Two new species, *Rhabdonotus pilipes* and *Rhabdonotus xynon*, are described. A key to the three species is provided. The first zoeal stage of *R. pictus* A. Milne Edwards, 1879, is also described for the first time.

Introduction

The peculiar crab symbiotic with comatulid crinoids, *Rhabdonotus pictus* A. Milne Edwards, 1879, is poorly known, and the genus has been regarded as monotypic. This species has been recorded from Thailand, Singapore, China and Australia (Stevcic *et al.*, 1988; Stevcic, 1991). In a recent review of the family Eumedonidae Dana, 1853, Stevcic *et al.* (1988) placed *Rhabdonotus* in the subfamily Eumedoninae, allying it with the symbionts of echinoids like *Echinoecus* Rathbun, 1894, and *Proechnoecus* Ward, 1934, mainly because of its rounded carapace features.

As part of a comprehensive revision of the Eumedonidae, the authors examined specimens of *Rhabdonotus* from Thailand, Singapore, Australia, Philippines

and Vanuatu. Three species of *Rhabdonotus* are now recognised, including two new species, one from Australia, and the other from the Philippines and Vanuatu. Both are described here.

A recent series of dredges conducted off the east coast of Singapore also resulted in the collection of a gravid female of *Rhabdonotus pictus* from which larvae were obtained. Comparisons of the *R. pictus* larvae were made with the known larvae of other species of eumedonids, *viz.* *Harrovia longipes* Lanchester, 1900, *Harrovia albolineata* Adams & White, 1849, *Echinoecus pentagonus* Rathbun, 1894, and *Zebrida adamsii* White, 1847.

Materials and methods

The abbreviations G1 and G2 are used for the male first and second gonopods respectively. Specimens are deposited in the Nationaal Natuurhistorisch Museum, Leiden, The Netherlands (previously Rijksmuseum van Natuurlijke Historie, RMNH); Natural History Museum, London England (previously British Museum Natural History, BMNH); Northern Territory Museum of Arts and Sciences, Darwin, Australia (NTM); Muséum National d'Histoire Naturelle, Paris, France (MNHN); Phuket Marine Biological Centre, Phuket, Thailand (PMBC); Queensland Museum, Brisbane, Australia (QM); Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt-am-Main, Germany (SMF); Zoological Reference Collec-

tion, Department of Zoology, National University of Singapore, Singapore (ZRC). The length of the carapace (cl) was measured from the tip of the rostrum to the posterior margin of the carapace; the width (cb) from one antero-posterior angle to the other. All length and width measurements are in millimeters. The term 'supra-orbital teeth' used in the present paper is equivalent to the 'lateral rostral lobule' used by other workers. 'Infra-orbital' teeth is equivalent to 'suborbital teeth'.

The gravid female of *Rhabdonotus pictus*, collected from its crinoid host, was maintained in an aquarium at 28°C. The larvae released were preserved in Steedman's preservative (Griffiths *et al.*, 1976). Appendages of larvae were dissected in glycerin with entomological needles and drawn with the aid of a camera lucida under dissecting and compound microscopes. Structural details were based on at least six specimens. Length of the carapace was measured from the tip of the rostrum to the posterior margin of the carapace. All measurements are in millimetres.

Taxonomy

Eumedonidae Dana, 1853

Rhabdonotus A. Milne Edwards, 1879

Rhabdonotus A. Milne Edwards, 1879: 107. — de Man, 1887-1888: 325. — Balss, 1957: 1650. — Johnson, 1962: 285. — Serène & Romimohtarto, 1963: 9, 12. — Wu, 1983: 318 [name in Chinese]. Stevcic *et al.*, 1988: 1312, 1317. — Stevcic, 1991: 126.

Caphyra — Walker, 1887: 116 (part) [not *Caphyra* Guérin, 1832].

Diagnosis. — Carapace rounded, dorsal surfaces very convex; rostrum pronounced but not elongate; supraorbital teeth present, frontal margin bilobed, separated by a cleft; regions poorly defined; surface of carapace smooth without granules except for the anterolateral and frontal margins; dorsal surface of cara-

pace glabrous, not covered with pubescence. Antero- and posterolateral margins gradually merging; anterolateral margin entire or with epibranchial cleft and tooth. Antennules folding obliquely, ca. 45° from horizontal. Second antennal segment slightly shorter than basal segment. Merus of first ambulatory leg more slender than others, dactylus elongated, slender, ca. 2 times length of that on other legs; dorsal margin of merus smooth, not cristate but can be tuberculated on the outer lobe; outer margins of carpus and propodus can be mildly or heavily tuberculated.

Type species. — *Rhabdonotus pictus* A. Milne Edwards, 1879, by monotypy.

Etymology. — The genus name was probably derived from the Greek "rhabdotos" for striped and "notos" for back, alluding to the transversely striped carapace pattern of the type species. Gender masculine.

Remarks. — The systematic position of *Rhabdonotus* has been quite ambiguous. The genus was first included in the family Xanthidae by A. Milne Edwards (1879), who allied it with the trapeziines. This was subsequently maintained by de Man (1888) and Balss (1957). However, Johnson (1962) indicated that *Rhabdonotus* perhaps belonged to the subfamily Eumedoninae (family Parthenopidae) due to its close association with crinoids and its general appearance. Johnson's suggestion (1962: 286) was probably prompted by R. Serène since he made reference to Serène's investigation of the problem. Subsequently, Serène & Romimohtarto (1963) using Johnson's specimens from Singapore and field observations (from C. Sankarankutty, via a letter) transferred the genus to the Eumedoninae on the basis of its habits as an echinoderm symbiont and its external morphology. In the same study, Serène & Romimohtarto (1963) also determined that *Caphyra archeri* Walker, 1887 (type locality Singapore), is a junior synonym of

Rhabdonotus pictus A. Milne Edwards, 1879 (type locality Vietnam), noting the similarities in the descriptions and figures provided by Walker (1887) and A. Milne Edwards (1879). A synopsis of the taxonomic history of this species can be found in Stevcic (1991).

Stevcic *et al.* (1988), in reviewing the family Eumedonidae, recognised two subfamilies: Eumedoninae Dana, 1853, and a new subfamily, Ceratocarcininae. They referred the genus *Rhabdonotus* to the subfamily Eumedoninae, together with *Echinoecus* Rathbun, 1894, *Eumedonus* H. Milne Edwards, 1834, *Gonatonotus* Adams & White, 1847, *Proechnoecus* Ward, 1934, and *Zebrida* White, 1847. This scheme of classification however, is probably incorrect because in *Rhabdonotus* the first leg is elongated and it is a crinoid symbiont, which allies it with other crinoid-associated genera like *Harrovia* Adams & White, 1849, and *Ceratocarcinus* White, 1847. Other than *Rhabdonotus*, all other echinoecines (*sensu* Stevcic *et al.*, 1988) are symbionts on echinoids. Only in the general form of the carapace does *Rhabdonotus* superficially resemble *Echinoecus* Rathbun, 1894.

Rhabdonotus previously contained only one species, *R. pictus* A. Milne Edwards, 1879. However, with the present revision, it now has three species, two of which are here regarded as new.

Key to species

1. Frontal margin with very pronounced cleft, frontal lobes triangular, supra-orbital teeth not as distinct; infra-orbital teeth triangular; posterolateral margin straight; external angle of merus of third maxilliped rounded; dorsal margins of all ambulatory meri end with a subdistal triangular lobe .
 *Rhabdonotus xynon* new species
- Frontal margin with shallower cleft,

frontal lobes rounded, supra-orbital teeth distinct; infra-orbital teeth rounded; posterolateral margin more converging; external angle of merus of third maxilliped angular; dorsal margins of all ambulatory legs with a subdistal rounded lobe 2

2. Frontal margin and anterolateral margin with numerous strong tubercles, appearing serrated; epibranchial cleft and tooth usually present; posterolateral margin not as converging; surfaces of cheliped heavily tuberculated; ambulatory legs very hairy, outer margins of ambulatory carpus and propodus lined with strong spines
 *Rhabdonotus pilipes* new species
- Frontal margin and anterolateral margin mildly tuberculated, not appearing serrated; epibranchial cleft and tooth usually absent in females and juveniles; posterolateral margin converging; surfaces of cheliped mildly tuberculated; ambulatory legs not distinctly hairy, outer margins of ambulatory carpus and propodus mildly tuberculated *Rhabdonotus pictus*
 A. Milne Edwards, 1879

Rhabdonotus pictus A. Milne

Edwards, 1879

Figs. 1-4, 9, 10A-B

Rhabdonotus pictus A. Milne Edwards, 1879: 108, pl. 2: fig. 2, 2a [type locality "Cochinchine" = Vietnam]. - ?de Man, 1887-1888b: 325, 586 [Ambon, Moluccas = Maluku Islands, Indonesia]. - Johnson, 1962: 285 [Singapore]. - Serène & Romimohtarto, 1963: 9, fig. 1C, 5, pl. 2: fig. F, G [Singapore]. - Sankarankutty, 1966: 347, 349, 352, fig. 1-4 [Gulf of Manaar, south-east India]. - Johnson, 1967: 521 [list only]. - Serène, 1968: 63 [list only]. - Lunderoer, 1974: 5 [Phuket Island, Thailand, Andaman Sea]. - Naiyanetr, 1980: 31 [list only]. - Shen *et al.*, 1982: 147, fig. 5: 15, pl. 2: fig. 14 [Beibu Gulf = Gulf of Tonkin, China]. - Wu, 1983: 318 [name in Chinese].

ERRATA

The figures on page 107 and 110 have been inadvertently transposed. The photograph for the neotype male (6.9 by 6.4 mm) on Fig. 1 has been accidentally printed on Fig. 2 instead.

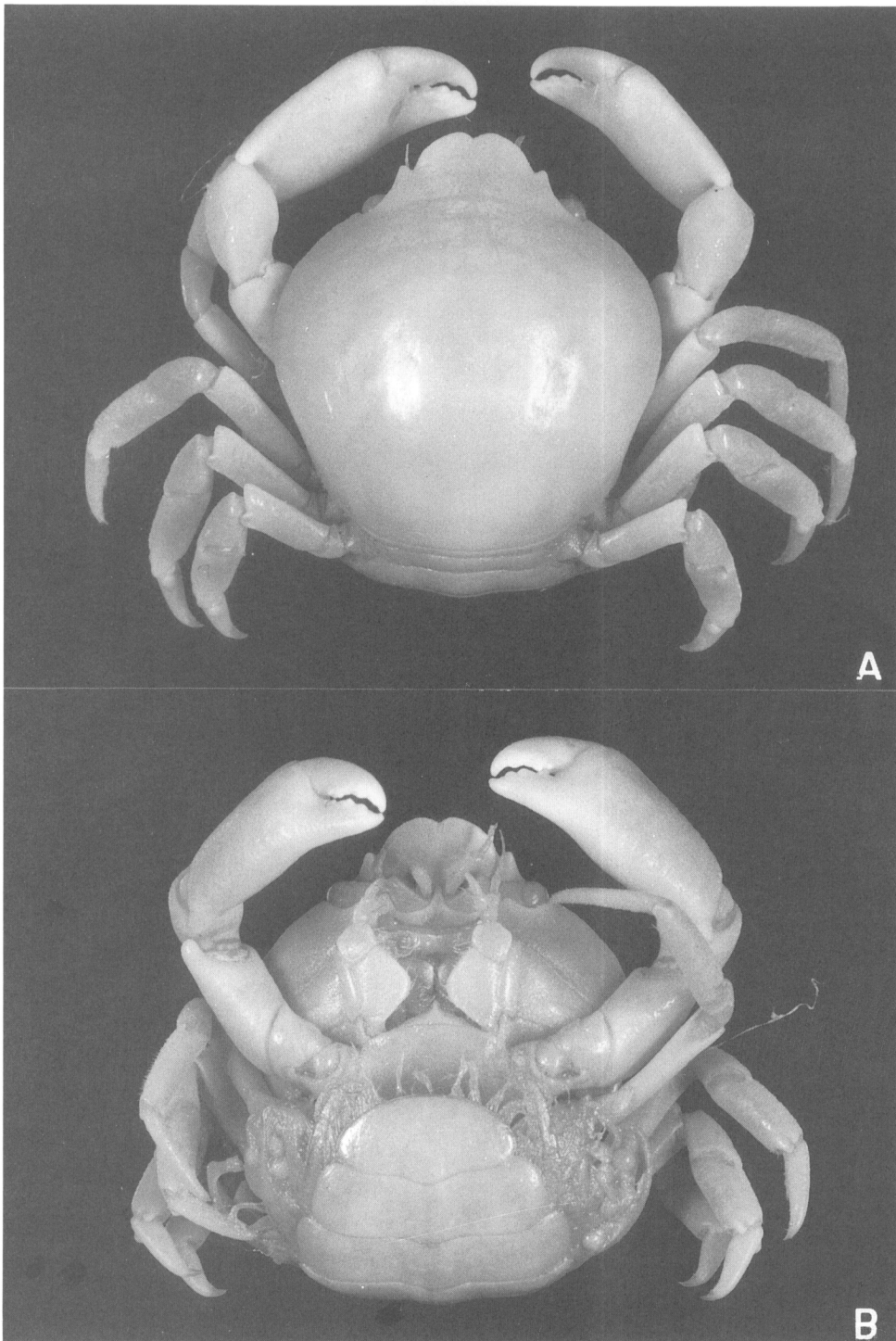


Fig. 1. *Rhabdonotus pictus* A. Milne Edwards, 1879, neotype male, cl 6.9 mm, cb 6.4 mm (ZRC 1984.7862): A, dorsal view; B, ventral view.

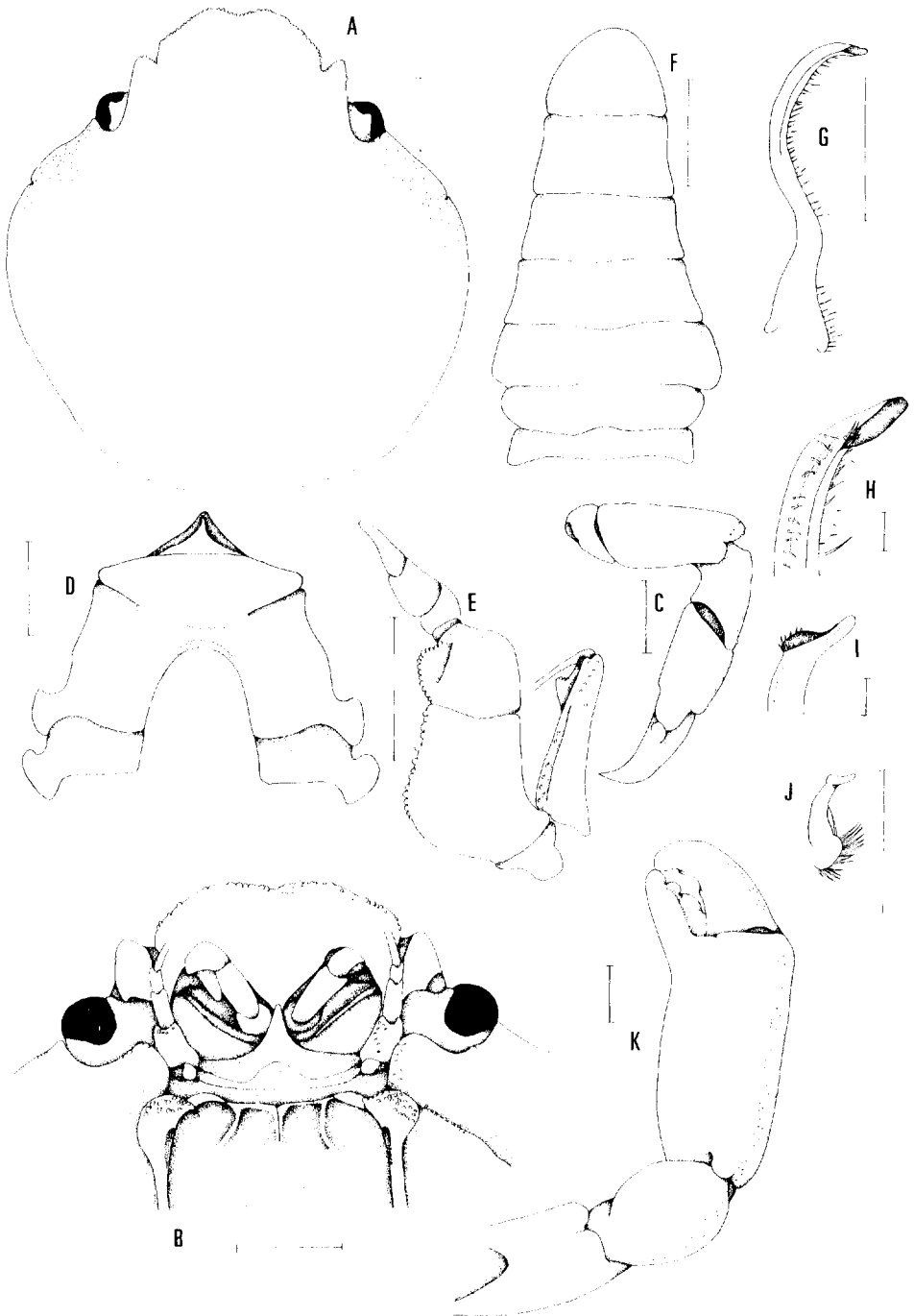


Fig. 2. *Rhabdonotus pictus* A. Milne Edwards, 1879, neotype male, cl 6.9 mm, cb 6.4 mm, (ZRC 1984.7862): A, carapace; B, face of carapace; C, right fourth ambulatory leg; D, anterior sternites; E, left third maxilliped; F, abdomen; G, ventral view of left G1; H, ventral view of tip of left G1; I, ventral view of tip of left G2; J, ventral view of left G2; K, right cheliped. Scales for A–G, J–K = 1.0 mm; for H–I = 0.1 mm.

– Dai *et al.*, 1986: 166, fig. 99, pl. 22: fig. 7 [list only]. – Stevcic *et al.*, 1988: 1312 [list only]. Dai & Yang, 1991: 185, fig. 99, pl. 22: fig. 7 [list only].

Caphyra archeri Walker, 1887: 110, 116, pl. 9: fig. 4, 5 [type locality Singapore]. – Nobili, 1901: 11 [in key]; 1906: 188 [in key]. – Balss, 1934: 506 [list only]. – Stephenson & Campbell, 1960: 96 [in key], 105 [list only]. – Stephenson, 1962: 313 [list only]. – Crosnier, 1962: 27 [in footnote]. – Stephenson, 1972: 7 [in key], 25 [list only].
? *Caphyra archeri* – Leene, 1938: 144, 147 [list only].

Materials examined. — Neotype (for both *Rhabdonotus pictus* A. Milne Edwards, 1879, and *Caphyra archeri* Walker, 1887, here designated), Johore Shoal, Singapore, dredged, coll. D.S. Johnson, 17 June 1953, ♂, cl 6.9 mm, cb 6.4 mm (ZRC 1984.7862).

Others. — Johore Shoal, Singapore, dredged, coll. D.S. Johnson, 17 June 1953, ♀, cl 7.4 mm, cb 6.8 mm, (ZRC 1984.7863). — Johore Shoal, Singapore, dredged, coll. D.S. Johnson, 17 June 1953, 2 ♂, 2 ♀ (ZRC 1984.7864–67). — Johore Shoal, Singapore, trawled, coll. D.S. Johnson, 42–44 m, 15 September 1955, 1 ♂ (ZRC 1984.7861). — Johore Shoal, Singapore, dredged, on crinoid, coll. D.S. Johnson, 17 June 1954, 1 ♀ (NTM). — Johore Shoal, Singapore, dredged, coll. D.G.B. Chia, 20 m, 29 August 1994, 1 ♀ (ZRC 1995.224). — Johore Shoal, Singapore, dredged, B25, B66, coll. Singapore Fisheries Research Station, 1954–5, 2 ♂, 3 ♀ (ZRC 1984.7868–7873). — Kuala Kedah, at Telok Bahang, near Muka Head, Penang, Malaysia, from fishing boat, trawled, coll. T.M. Wong, 3 May 1979, 1 ♂, 2 ♀ (ZRC 1989.2043–45). — Kuala Kedah, at Telok Bahang, near Muka Head, Penang, Malaysia, from fishing boat, trawled, coll. T.M. Wong, 3 May 1979, 1 ♂, 1 ♀ (RMNH 37261). — Off Batu Maung, Penang, Malaysia, from trawler, coll. K. Sagathevan, Jan 1983, 1 ♀, cl 7.5 mm, cb 7.2 mm (ZRC 1989.2046). — Phuket, Thailand, bottom trawl, subtidal, 22 November 1972, 1 ♀

(PMBC 2250). — Ceylon (= Sri Lanka), coll. W.H. Holdsworth, 1 ♀, cl 9.7 mm, cb 9.4 mm, (re-registered as BMNH 1965.1.6.1) (old registration number, BMNH 75.14). — Amboina, Moluccas, Indonesia, on comatulid, coll. J. Brock, July–September 1885, 1 ♀ (SMF).

Diagnosis. — Carapace very smooth, except for frontal, anterolateral margins of carapace. Frontal margin bilobed, lobes rounded, cleft between lobes shallow. Supra-orbital teeth distinct. Infra-orbital teeth rounded. Anterolateral margin maybe entire especially in adult females, or with weak epibranchial cleft and tooth in adult males; antero- and posterolateral margins not clearly demarcated; posterolateral margin converging and rounded. Third maxilliped smooth except for tuberculated anterior and inner margins of merus and inner margin of ischium; external angle of merus angular. Cheliped subequal, surfaces of the chelipeds appearing mildly tuberculated. Ambulatory legs relatively little hair; dorsal margins of meri end in a rounded lobe; outer margins of carpus and propodus with few tubercles, appearing rather smooth.

Etymology. — The species name “pictus” was probably derived from Latin meaning colourful, possibly alluding to the two tone stripes on the carapace. Gender masculine.

Remarks. — The figure of A. Milne Edwards (1879: pl. 2, 2a) featured the carapace of his specimen bearing many transverse stripes of equal length reaching the posterior margin, which seems unusual. Though the first four stripes do agree with that of the specimens examined here, the posterior ones certainly do not (see Fig. 10A, B). At the cardiac region there is usually a dark concentric ring enveloped by dark stripes along the posterolateral and posterior margins. The differences could be due to the fact that A. Milne Edwards (1879) was examining a preserved specimen whose colour has

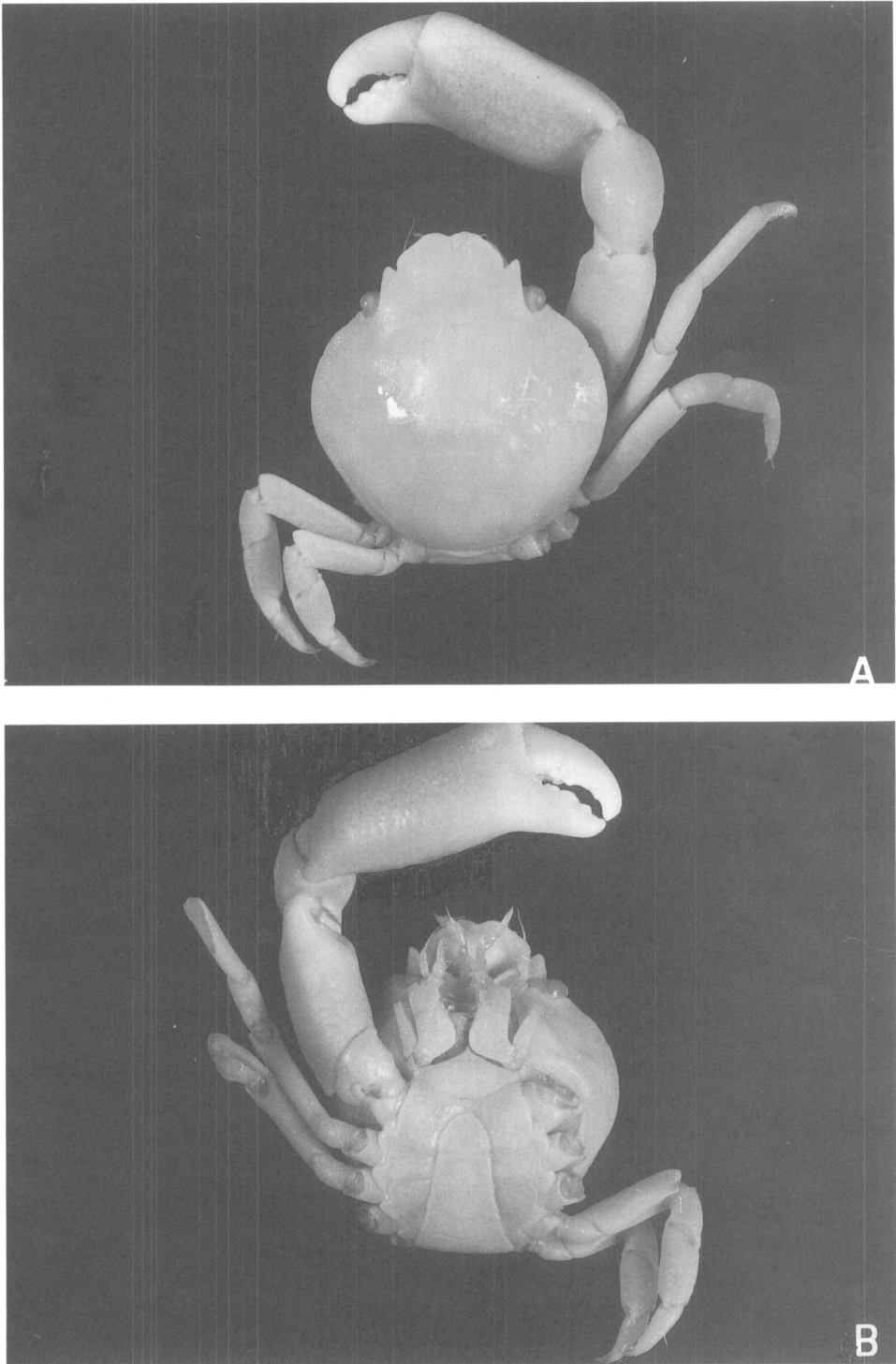


Fig. 3. *Rhabdonotus pictus* A. Milne Edwards, 1879, female, cl 7.4 mm, cb 6.8 mm (ZRC 1984.7863): A, dorsal view; B, ventral view.

been leached by preservatives and/or desiccation, thus rendering the markings faded and unclear. Some preserved specimens, examined by the present authors, whose dark pigmentation has mostly disappeared, bear only an outline of the remnant transverse stripes and closely resemble the figure of A. Milne Edwards (1879: pl. 2, 2a). We are confident from A. Milne Edwards' description (1879: 6) that the transverse stripes are red in colour, which agrees with our specimens (see Fig. 10A, B). The other disparity in the figure of A. Milne Edwards (1879: pl. 2, 2a) is the apparent sharpness of the left frontal lobe as compared to the right. But in all other aspects, his figure agrees with our specimens, and we have no doubt about their conspecificity.

De Man (1887-8: 325) reported a very large female of *R. pictus* (cl 11.5mm, cb 10.6mm), collected from a comatulid in Ambon, Indonesia, as bearing red lines on the legs. This condition is not observed in any of the specimens examined here. The authors have examined de Man's specimen (SMF) – its red pigmentation has faded (if it existed before). Except for this unusual colouration, in all other aspects, this specimen agrees well with the current concept of the species. For the moment, it is retained in *R. pictus*.

The records by Johnson (1962) and Serène & Romimohtarto (1963) from Singapore have been discussed earlier on.

Sankarankutty (1966) first recorded the species from southern India, and his description of the colour markings fit well with our present definition of *R. pictus*. From his simplified illustration, all aspects agree with the current concept of the species except for the frontal lobes which appear to be rather pointed. This feature is also seen in a Sri Lankan specimen (BMNH 1965.1.6.1); being the largest specimen we examined (cl 9.7mm, cb 9.4mm), it has very sharp and rather serrated frontal lobes (see Fig. 4I) almost approaching that of *R. xynon* new species

(see Fig 8A). However, in the other aspects like the last ambulatory leg, third maxilliped (see Fig. 4J, k) and colour, the specimen falls within the present definition of the species. Unless more specimens are obtained and studied, the Sri Lanka specimen is here regarded as representing the extreme known variation in *R. pictus*.

The Thai specimen (PMBC 2250) examined was probably the one reported by Lundoer (1974). Shen *et al.* (1982) reported two specimens from Beibu Gulf (= Gulf of Tonkin), China. This is perhaps the first report of specimens collected from near type locality (Vietnam) since the description of the species. Unfortunately, the specimens could not be located (Dai A. Y., pers. comm.). However, from Shen *et al.*'s description and figure (1982: 147, fig. 5: 15, pl. 2: fig. 14; see also Dai *et al.*, 1986; Dai & Yang, 1991), the Gulf of Tonkin specimens seem to agree well with what is here recognised as *R. pictus*.

There had been some confusion as to how *Caphyra archeri* Walker, 1887, should be classified. Several workers on the Portunidae (e.g. Stephenson & Campbell, 1960; Crosnier, 1962) have queried the placement of Walker's species in the genus *Caphyra*. Serène & Romimohtarto (1963) were the first to suggest that the resemblance between *Caphyra* and *Rhabdonotus* is superficial, and *C. archeri* is a junior synonym of *R. pictus*.

Serène & Romimohtarto (1963) stated that the type(s) of *R. pictus* A. Milne Edwards, 1879 could not be found in the MNHN and should be considered as lost. In a recent visit to the MNHN, the present authors were also unsuccessful in locating the type specimen(s). At the same time, D. Guinot has also confirmed this predicament in a letter to the authors on 29 November 1994, noting " ... le type *Rhabdonotus pictus* ne se trouve pas au MNHN...". In the absence of the type material and with two new species being assigned to this previously monotypic ge-

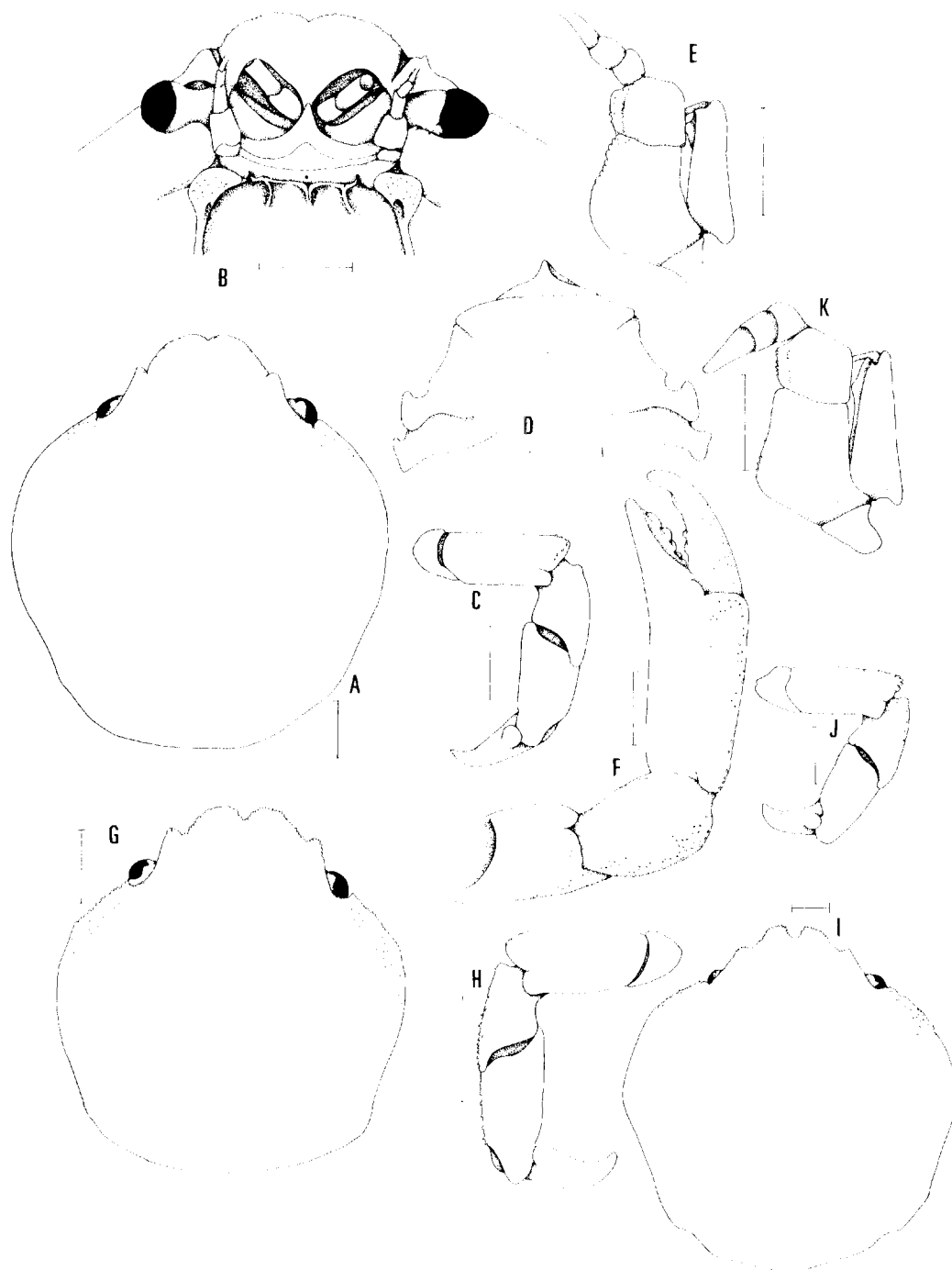


Fig. 4. *Rhabdonotus pictus* A. Milne Edwards, 1879. A–F, female, cl 7.4 mm, cb 6.8 mm, (ZRC 1984.7863): A, carapace; B, face of carapace; C, right fourth ambulatory leg; D, anterior sternites; E, left third maxilliped; F, right cheliped. G–H, female, cl 5.3 mm, cb 4.8 mm, (ZRC 1995.224): G, carapace; H, left fourth ambulatory leg. I–K, female, cl 9.7 mm, cb 9.4 mm, (BMNH 1965.1.6.1): I, carapace; J, left fourth ambulatory leg; K, left third maxilliped. Scales = 1.0 mm.

nus, the designation of a neotype for *R. pictus* A. Milne Edwards, 1879, is essential to ensure a stable taxonomy. Furthermore, the type of the junior synonym *Caphyra archeri* Walker, 1887, is also missing from the BMNH (pers. obs.; P. Clark, pers. comm.). The authors therefore here propose that a male specimen from Singapore (ZRC 1984.7862) be designated as the simultaneous neotype of both *Rhabdonotus pictus* A. Milne Edwards, 1879, and *Caphyra archeri* Walker, 1887. It is unfortunate that there are no extant specimens of *R. pictus* collected from the type locality, Vietnam, but the present lot of specimens from Singapore, Malaysia and Thailand, fit the descriptions and figures of A. Milne Edwards (1879) and Walker (1887), and there is little doubt of their conspecificity. In any case, the present neotype selection would fit the current concept of the species, which follows Serène & Romimohtarto (1963).

Rhabdonotus pictus is closely related to *R. pilipes* new species, but the former species appears to be a smoother species on the whole, with distinctly less hairy ambulatory legs (see Table 1 for more differences). Granules, if present in *R. pictus*, are low, small and weak (see Figs. 2A, E, K, 4A, E, F), very unlike the kind of granules seen in *R. pilipes* new species (see Fig. 6A, E, F) which are large and strong, making the frontal and anterolateral margins appear serrated. For both species, it appears that the juvenile forms are usually more granulated when young (see Fig. 4G-H), as it is evident in the recently collected *R. pictus* (ZRC 1995.224) from Johore Shoal, Singapore. However, this specimen is still relatively glabrous on the ambulatory legs as compared to the distinctly hairy juveniles of *R. pilipes* new species.

There is some variation in the presence or absence of the epibranchial cleft and tooth in both species. In most cases, for the adults, this character can be used to separate *R. pictus* from *R. pilipes* new

species, the epibranchial cleft and tooth being more prominent in the latter. In most female specimens of *R. pictus* examined, the epibranchial cleft and tooth are usually absent. It is, however, not the case for *R. pilipes* new species. Of all the perfect specimens (seven females and one male) examined, six specimens bear the epibranchial cleft and tooth. Only two female specimens (NTM Cr 008807, ZRC 1994.4226) do not have a distinct epibranchial cleft and tooth. It would thus seem that the presence of the epibranchial cleft and tooth is usually more pronounced in *R. pilipes* new species.

In *R. pictus*, the outer margins of the ambulatory carpus and propodus are only mildly tuberculated (see Fig. 2C, 4C) as compared to those of *R. pilipes* new species, which are lined with strong tubercles (see Fig. 6C). Although the smaller specimens of *R. pictus* (ZRC 1995.224, ZRC 1984.7867) are more tuberculated (see Fig. 4H) than the adult forms, the extent of tuberculation still does not reach the degree of *R. pilipes* new species.

Thus, *R. pictus* can be separated from *R. pilipes* new species with the use of the following characters: 1) smoother appearance in general, on all surfaces; 2) very weak (or absence of) epibranchial cleft and tooth; 3) the posterolateral margins are more converging; 4) relatively few hairs on the ambulatory legs; 5) the outer margins of the ambulatory carpus and propodus are smooth or mildly tuberculated and 6) colour pattern (see colour remarks for *R. pictus*).

Host records. — Host records for *R. pictus* are not well documented. Most workers merely mentioned that the possible host could be comatulid crinoids without providing names of the hosts (de Man, 1887-8; Johnson, 1962). Contrary to others, Sankarankutty (1966) commented that the host could possibly be an anthozoan, *Virgularia* sp., instead of a crinoid. The host of the recently collected specimen (ZRC 1995.224) is a crinoid, prob-

ably, *Cyllometra manca*, family Colobometridae.

Distribution. — Known from localities in: Gulf of Manaar, Sri Lanka, Phuket, Penang, Singapore, Vietnam, Gulf of Tonkin and Ambon.

Colour. — Based on the colour slide of a Penang specimen and a freshly collected Singapore specimen (ZRC 1995.224): Carapace with 4 main transverse maroon stripes on anterior dorsal half of carapace; first stripe narrow between supraorbital lobes; second to fourth stripes medially broadest with median part pale yellow. Lateral and posterior margins of carapace with a continuous dark maroon band which is confluent with transverse stripes. Posterior half of carapace with a broad oval ring (dark maroon margin, pale yellow centre), the edges of which may reach lateral maroon band (see Fig. 10A, B).

Biology. — The recently collected *R. pictus* (ZRC 1995.224) with its host were observed in the aquarium. It was usually found on the oral side of the crinoid clinging onto the host using its last two ambulatory legs. The crab was seen constantly scraping mucus off the arms of the host with the help of its chelipeds and first two ambulatory legs. Thereafter it would feed on the mucus.

Rhabdonotus pilipes new species

Figs. 5, 6, 10C

Rhabdonotus pictus – Stevcic, 1991: 126 (part) [Western Australia] [not *Rhabdonotus pictus* A. Milne Edwards, 1879]

Material examined. — Holotype: West of Weipa, northern Queensland, Australia, stn (= station) 46, 12°27.4'S, 141°14.9'E, dredge, coll. A.J. Bruce, vessel F.R.V. "Southern Surveyor", 40 m, 27 November 1991, 1 ♀, cl 7.2 mm, cb 6.8mm (NTM Cr008806).

Paratypes. — Gulf of Carpentaria, northern Queensland, Australia, stn 36,

13°2'S, 139°22.2'E, dredge, coll. A.J. Bruce, vessel F.R.V. "Southern Surveyor", 58 m, on *Heterometra crenulata*, 25 November 1991, 1 ♀, cl 6.4mm, cb 6.1mm (NTM Cr008863). — Gulf of Carpentaria, northern Queensland, Australia, stn 36, 13°2'S, 139°22.2'E, dredge, coll. A.J. Bruce, vessel F.R.V. "Southern Surveyor", 58 m, 25 November 1991, 1 ♀, cl 7.6 mm, cb 7.1 mm (ZRC 1994.4226). — Gulf of Carpentaria, northern Queensland, Australia, 13°01.3'S, 140°12.0'E, dredge, marine, subtidal, coll. Commonwealth Scientific and Industrial Research Organization (CSIRO), vessel F.R.V. "Southern Surveyor", 47–63 m, 1 December 1990, 3 ♀, cl 6.3 mm, cb 6.0 mm, cl 5.9 mm, cb 5.5 mm, 1 badly damaged (QM W18709). — West of Weipa, northern Queensland, Australia, stn 46, 12°27.4'S, 141°14.9'E, dredge, coll. A.J. Bruce, vessel F.R.V. "Southern Surveyor", 40m, 27 November 1991, 1 ♀, cl 7.4 mm, cb 7.0 mm (NTM Cr008805). — West of Weipa, northern Queensland, Australia, stn 42, 12°24.8'S, 140°42.4'E, dredge, coll. A.J. Bruce, vessel F.R.V. "Southern Surveyor", 58 m, 26 November 1991, 1 ♀, cl 5.7 mm, cb 5.5 mm (NTM Cr 008807).

Others. — Northwest Shelf, western Australia, stn 0483 B7 BT, 19°30.8'S, 118°49.3'E, dredge, coll. T. Ward, R.V. "Soela", 39 m, 30 August 1983, 1 ♂, cl 5.2 mm, cb 4.9 mm (NTM Cr0007875).

Diagnosis. — Frontal and anterolateral margins of carapace, anterior and inner margins of third maxillipedal merus, inner margin of third maxillipedal ischium and surfaces of the chelipeds heavily tuberculated. Anterolateral margin rarely entire; antero- and posterolateral margins usually demarcated with epibranchial cleft and tooth; posterolateral margin appearing slightly straight. Ambulatory legs very hairy; outer margins of carpus and propodus with strong tubercles, appearing spiny.

Etymology. — The name "pilipes" is

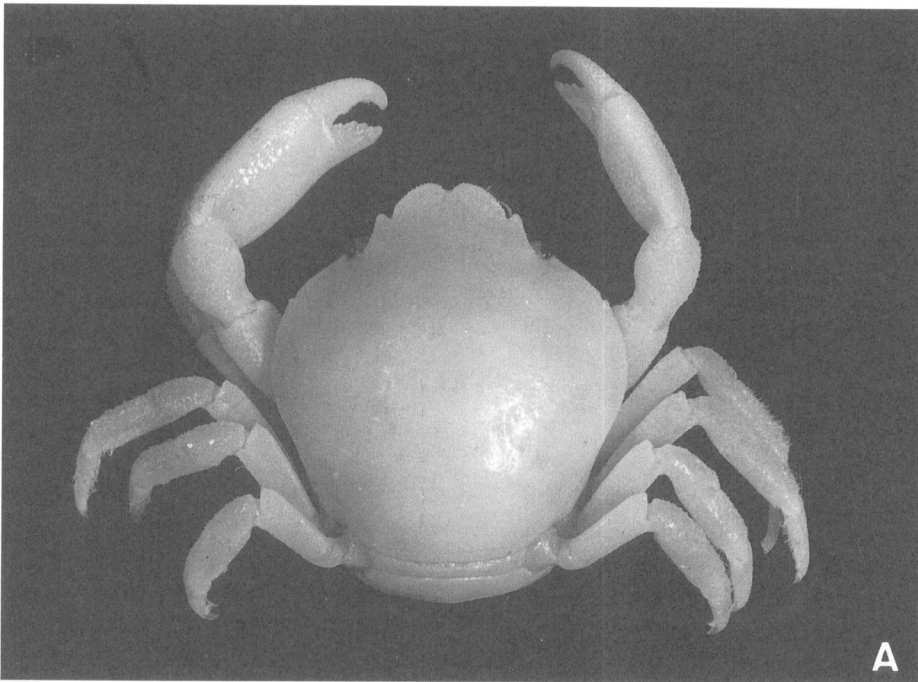


Fig. 5. *Rhabdonotus pilipes* new species, holotype female, cl 7.2 mm, cb 6.8 mm (NTM Cr008806): A, dorsal view; B, ventral view.



Fig. 2. *Rhabdonotus pictus* A. Milne Edwards, 1879, neotype male, cl 6.9 mm, cb 6.4 mm, (ZRC 1984.7862): A, carapace; B, face of carapace; C, right fourth ambulatory leg; D, anterior sternites; E, left third maxilliped; F, abdomen; G, ventral view of left G1; H, ventral view of tip of left G1; I, ventral view of tip of left G2; J, ventral view of left G2; K, right cheliped. Scales for A–G, J–K = 1.0 mm; for H–I = 0.1 mm.

derived from Latin 'pilus' for hair, in combination with 'pes' for legs alluding to the hairy legs. Used as a noun in apposition.

Remarks. — The differences between *R. pictus* and *R. pilipes* new species have been discussed in the earlier section and outlined in Table 1 and the key. In general, as mentioned before, *R. pilipes* new species, compared to *R. pictus*, is a more granulated and pilose species. Although there is variation in the extent of tuberculation within species, when comparing specimens of similar sizes between *R. pilipes* new species, and *R. pictus*, the former species is still distinctly more granulated.

The specimen (Fig. 6G) reported by Stevcic (1991: 126) from Western Australia was re-examined. Being a small male, it has a distinct epibranchial cleft and tooth, and in all other aspects agree with the current concept of *R. pilipes* new species.

Host records. — Known only from a comatulid crinoid, *Heterometra crenulata*.

Distribution. — Known only from the Gulf of Carpentaria, Northwest Shelf, Australia.

Colours. — Based on the colour slide of a live specimen, *R. pilipes* new species, closely resembles *R. pictus* in the colour pattern. The differences however, are: 1) the first transverse stripe, which runs between the two inner supra-orbital teeth, appears to be broader, diffused and not as distinctive; 2) the posterior margin seems not to have any markings; 3) the chelipeds bear no markings; 4) all stripes are brown (vs. maroon in *R. pictus*), and the centre of the stripes do not appear as pale and the outline is only slightly darker (Fig. 10C).

***Rhabdonotus xynon* new species**

Figs. 7, 8, 10D

Material examined. — Holotype: Philippines, stn CP121, 12°08'N, 121°18'E, dredge, coll. MUSORSTOM 3, vessel N.O.

"Coriolis", 73-84m, 3 June 1985, 1 ♀, cl 8.4mm, cb 7.7mm (MNHN).

Other. — Vanuatu, stn CP1027, 17°53.05'S, 168°39.35'E, dredge, coll. MUSORSTOM 8, 550-571m, 28 September 1994, 1 ♀, cl 5.2 mm, cb 4.9 mm (MNHN).

Diagnosis. — Carapace appears to be very smooth, except for frontal, antero-lateral margins of carapace and surfaces of the chelipeds heavily tuberculated. Frontal margin bilobed, lobes triangular or slightly rounded, cleft between lobes deeper. Supra-orbital teeth less distinct. Infra-orbital teeth triangular. Antero-lateral margin may be entire, antero- and posterolateral margins appear gradually merging; antero- and posterolateral margins maybe demarcated with small epibranchial cleft and very small, weak tooth; posterolateral margin straight. Third maxilliped mildly granulated; external angle of merus rounded. Ambulatory legs hairless; dorsal margins end in a triangular lobe; outer margins of carpus and propodus with few tubercles.

Etymology. — The species name "xynon" is derived from Greek meaning companion, alluding to the close association of the crab with crinoid host. Used as a noun in apposition.

Remarks. — Through the courtesy of Dr. A. Crosnier of the ORSTOM, two specimens collected from the Philippines and Vanuatu were sent to us for study. These two specimens are found to be different from the earlier two species in the aspects of: 1) the frontal lobes are more triangular instead of rounded thus the cleft between the two lobes appears to be deeper; 2) the supra-orbital teeth are less distinct; 3) the infra-orbital teeth are triangular instead of rounded; 4) the posterolateral margins are straight; 5) the external angle of the merus of the third maxilliped is rounded instead of angular; 6) the dorsal margins of all ambulatory

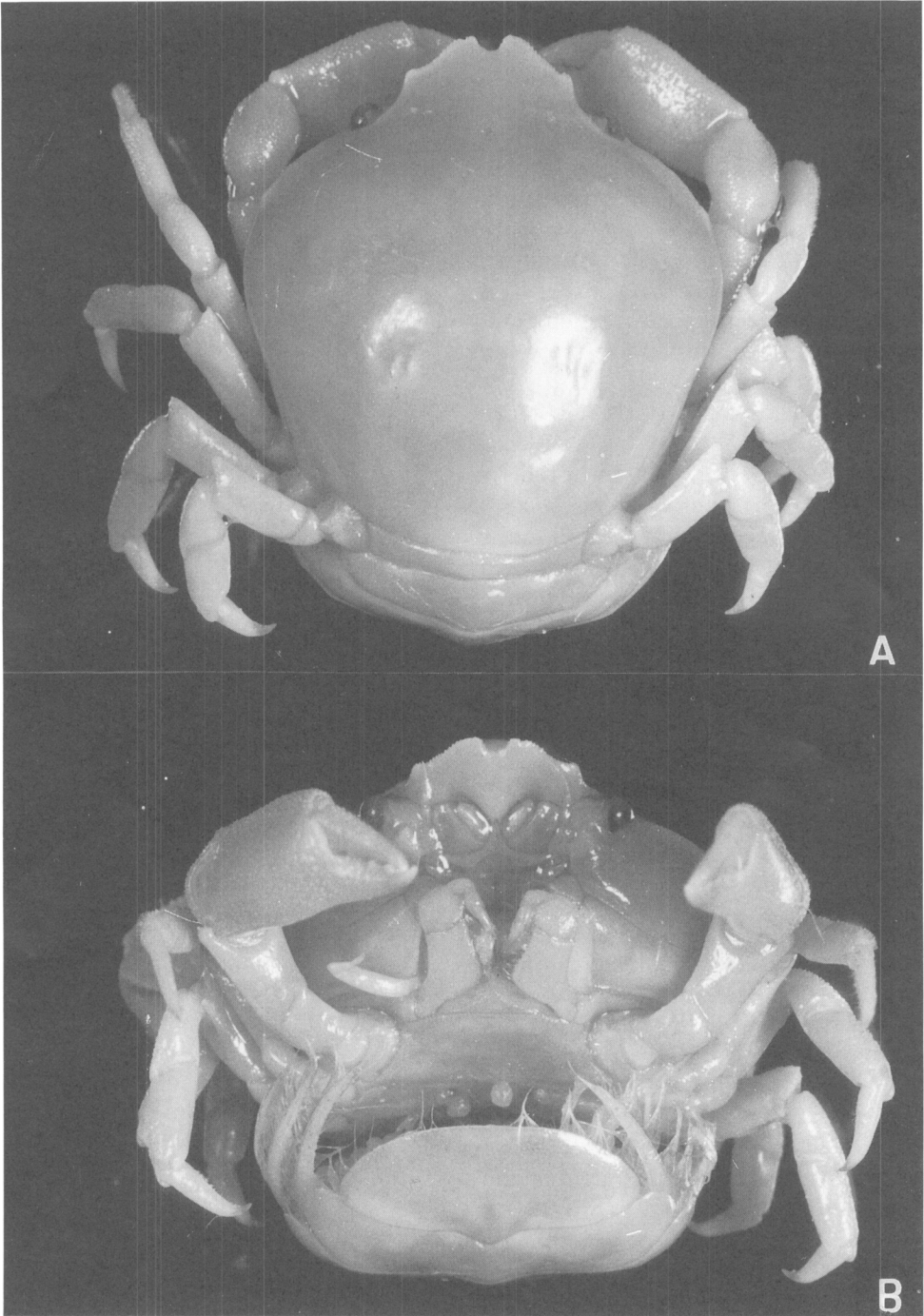


Fig. 7. *Rhabdonotus xyxon* new species, holotype female, cl 8.4 mm, cb 7.7 mm (MNHN): A, dorsal view; B, ventral view.

Table 1. Differences between *Rhabdonotus pictus* A. Milne Edwards, 1879, *R. pilipes* new species and *R. xynon* new species.

	<i>Rhabdonotus pictus</i>	<i>R. pilipes</i>	<i>R. xynon</i>
Frontal margin	Mildly tuberculated; bilobed, lobes rounded; cleft between lobes shallow (Fig. 2A, 4A, 4G)	Heavily tuberculated, margin appears serrated; bilobed, lobes rounded; cleft between lobes shallow (Fig. 6A)	Heavily tuberculated, margin appears serrated; bilobed, lobes more triangular; cleft between lobes deeper (Figs. 8A, 8G)
Supraorbital teeth	Distinct (Figs. 2A, 4A, 4G)	Distinct (Fig. 6A)	Less distinct (Fig. 8A)
Infraorbital teeth	Rounded	Rounded	Triangular
Anterolateral margin	Lined with flat and small granules (Figs. 2A, 4A, 4G)	Heavily tuberculated with tall granules, margin appearing serrated (fig. 6A)	Heavily tuberculated with tall granules (Fig. 8A)
Epibranchial cleft	More often present in adult males than in females; in adult specimens than juveniles (Figs. 2A, 4A, 4G)	Very often present in females (Fig. 6A)	May be present in small females (Fig. 8G)
Epibranchial tooth	Very small and weak tooth (Fig. 2A)	Stronger (Fig. 6A)	May be present in small females (Fig. 8G)
Posterolateral margin	Converging (Figs. 2A, 4A, 4G)	Slightly straighter (Fig. 6A)	Straight (Fig. 8A)
Third maxilliped:			
1. Anterior and inner margins of merus	Usually tuberculated	Usually heavily tuberculated	Not tuberculated (mildly tuberculated in young)
2. External angle of merus	Quadrangle	Quadrangle	Rounded
3. Inner margin of ischium	Tuberculated (Figs. 2E, 4E)	Heavily tuberculated (Fig. 6E)	Not tuberculated (mildly tuberculated in young) (Fig. 8E)
Cheliped	Mildly tuberculated with flat granules (Figs. 2K, 4F)	Heavily tuberculated with tall granules (Fig. 6F)	Heavily tuberculated with tall granules (Fig. 8F)
Dorsal margins of all ambulatory legs end in a triangular lobe	Absent	Absent	Present
Hairiness of ambulatory legs	Slightly hairy	Very hairy	Not hairy
Outer margins of ambulatory carpus and propodus	Mildly granulated (more granulated in juveniles) (Figs. 2C, 4C, 4H)	Lined with strong tubercles (Fig. 6C)	Carpus mildly granulated; propodus appears smooth (Fig. 8C)
Colour pattern	Outer and inner margins of chelipeds bear two parallel stripes; all stripes are red or dark brown in color; in transverse stripes 2-4 and concentric ring, centre of stripes appearing pale yellow (Fig. 10A, B)	Chelipeds bear no markings; all stripes are brown in colour, centre of stripes do not appear as pale (Fig. 10C)	Overall colour appearing purplish-brown. Possible pale reddish-orange markings along the frontal and anterolateral margins, cardiac region and chelipeds (Fig. 10D)

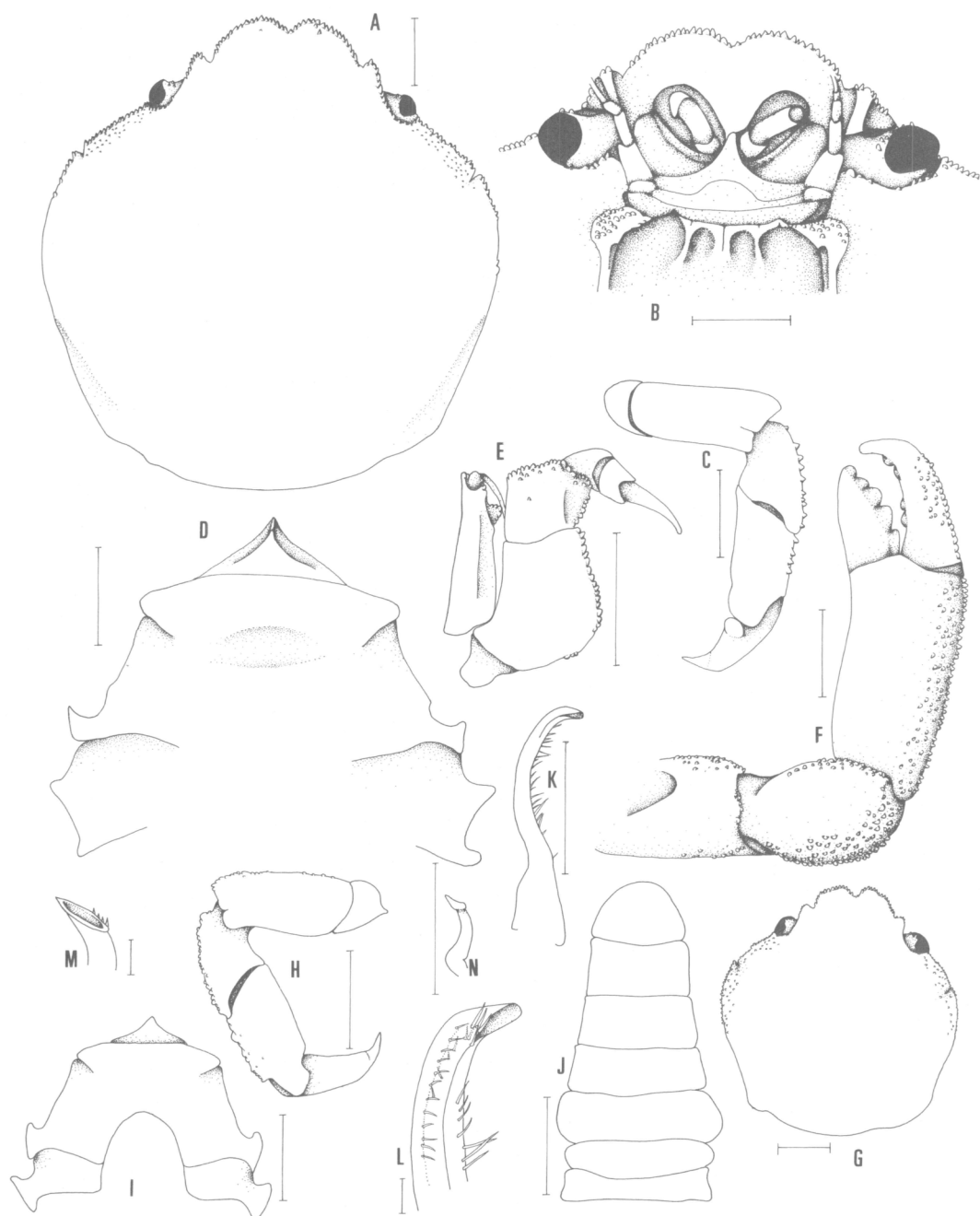


Fig. 6. *Rhabdonotus pilipes* new species. A–F, holotype female, cl 7.2 mm, cb 6.8 mm, (NTM Cr008806): A, carapace; B, face of carapace; C, right fourth ambulatory leg; D, anterior sternites; E, right third maxilliped; F, right cheliped. G–N, male, cl 5.2 mm, cb 4.9 mm, (NTM Cr007875): G, carapace; H, left fourth ambulatory leg; I, anterior sternites; J, abdomen; K, ventral view of tip of left G1; L, ventral view of tip of left G2; M, ventral view of tip of left G1; N, ventral view of left G2. Scales for A–K, N = 1.0 mm; for L–M = 0.1 mm.

more tuberculated, the supra-orbital teeth more pronounced, with the distinct epibranchial cleft and tooth, narrower sternum and more distinctive colour pattern. As seen in *R. pictus* and *R. pilipes* new species, smaller specimens are usually more tuberculated than the larger ones. The narrower sternum of the Vanuatu specimen could be size related — the sterna of females generally become broader as they increase in size. The Vanuatu specimen still has its colour markings on the carapace as opposed to the holotype. Most of the markings have already faded in the holotype. Thus, we cannot ascertain if the difference (see later in descriptions of colour) observed here is due to preservation or merely variation within the species. As for the other differences, with only two specimens on hand, we prefer to regard them as infra-specific variation for the moment. It is interesting to note that both the specimens were collected from very different depths (holotype from 73-84m; Vanuatu specimen from 550-571m). Whether the depth reading for either specimen is erroneous cannot be determined. Externally, the differences observed at present on the basis of only two female specimens do not warrant their recognition as a separate species.

Host records. — Although an arm of a crinoid was collected together with the holotype, identification was not possible. It at least confirms that *R. xynon* new species, is also a crinoid symbiont.

Distribution. — At the present moment, this species is only known from the Philippines and Vanuatu.

Colour. — Holotype: overall colour appearing purplish-brown including legs and chelipeds; a faint reddish-orange transverse stripe runs between the orbits reaching the anterolateral margins. Vanuatu specimen: overall appearing purplish-brown as well with additional reddish-orange markings; a transverse marking runs along the frontal and

anterolateral margins; a concentric ring and a crescent shape marking present on the cardiac region; a whitish stripe runs longitudinally along the chelipeds; between the supra-orbital teeth there is a dark transverse stripe (see Fig. 10D).

Morphology of the first zoea of
Rhabdonotus pictus

Fig. 9A-I

Description (Fig. 9). — Length of carapace (Fig. 9A) is ca. 0.7mm. Carapace with slightly hooked dorsal, short lateral and short rostral spine straight. Regions adjacent to lateral and dorsal spines heavily tuberculated, with scattered short setae, anterolateral margin lined with numerous sharp denticles. Eyes sessile. Abdomen (Fig. 9B) with five somites, six fused to telson. Dorsal surfaces of somite 2 with a pair of robust, lateral knobs, somites 3 to 5 each with a pair of distinct upward and backwardly directed spines. Somites 2-5 with a pair of posterolateral processes each, blunt on somite 2, sharp on somites 3-5. Dorsal surfaces of somites 2-5 with varying number of short setae: 4-6, 4-6, 4-5, 4-6 respectively; somites 2-5 with two additional long hairs. Postero-dorsal margins of somites 2-5 with 8, 10, 10, 8 minute denticles respectively. Pleopods absent on all somites. Telson (Fig. 9B) bifurcate, margins of furcae spinulose, each with 1 large lateral spine and 1 small dorsal spine. Inner margin of telson fork with 3 pairs of large setose spines.

Antennule (Fig. 9C) uniramous, unsegmented, cone-shaped, with 2 stout and long, 2 thin and short aesthetascs, 2 simple terminal setae.

Antennal exopod (Fig. 9D) approximately equal in length to spinous process, both sharply tapering. Spinous process with 2 rows of spinules on distal margin. Outer margin of exopod with 2 thick median spine; distal part with 2 rows of spinules.

Mandible (Fig. 9E) heavily chitinised,



Fig. 9. *Rhadonotus pictus* A Milne Edwards, 1879, first zoea: A, lateral view; B, Abdomen (dorsal view); C, Antennule; D, Antenna; E, mandibles; F, Maxillule; G, Maxilla; H, First maxilliped; I, Second maxilliped. Scale bar = 0.1 mm.



Fig. 10A–B. *Rhabdonotus pictus* A Milne Edwards, 1879: A, female, cl. 5.3mm, cb 4.8mm, (ZRC 1995.224); B, female, cl 7.5mm, cb 7.2mm (ZRC 1989.2046) (Photo courtesy of K. Sagathevan); C, *Rhabdonotus pilipes* new species, one of the ovigerous paratypes, size not recorded (Photo courtesy of A. J. Bruce); D, *Rhabdonotus xynon* new species, female, cl 5.2mm, cb 4.9mm (MNHN) (Photo courtesy of A. Crosnier).

both with inter-digitating incisor and molar processes, palp absent.

Coxal endite of maxillule (Fig. 9F) with 7 stout setae (4 terminal, 3 subterminal, stepped), basal endite with 2 serrated spines, 3 setae and 1 tubercle. Endopod 2-

segmented, proximal segment with 1 long seta, distal segment with 2 subterminal and 4 terminal setae, stepped.

Coxal and basal endites of maxilla (Fig. 9G) bilobed, with 6, 5 setae on proximal lobes and 4, 4 setae on distal lobes re-

Table 2. Differences between the first zoeal stages of *Rhabdonotus pictus* A. Milne Edwards, 1879, *Harrovia longipes* Lanchester, 1900 (fide Lim & Ng, 1988) *H. albolineata* Adams & White, 1849 (fide Chia *et al.*, 1993), *Echinoecus pentagonus* Rathbun, 1894 (fide Van Dover *et al.*, 1986) and *Zebrida adamsi* White, 1847 (fide Mori *et al.*, 1991).

	<i>Rhabdonotus pictus</i>	<i>Harrovia longipes</i>	<i>Harrovia albolineata</i>	<i>Echinoecus pentagonus</i>	<i>Zebrida adamsi</i>
Carapace	Regions around lateral and dorsal spines heavily tuberculated, with scattered short setae, anterolateral margin lined with numerous sharp denticles	Regions around lateral and dorsal spines finely tuberculated, with scattered setae	Regions around lateral and dorsal spines finely tuberculated, with scattered setae	All regions smooth	All regions smooth
Antennule	4 aesthetascs, 2 long, 2 short with 2 terminal setae	4 aesthetascs, 2 long, 2 short	4 aesthetascs, 2 long, 2 short	3 aesthetascs, with 2 terminal setae	3 aesthetascs, with 1-3 terminal setae
Maxillule:	7 setae	7 setae	8 setae	7 setae	7 setae
Coxa					
Maxilla:					
Setal formula (distal-proximal) of					
Basial	4, 5	4, 4	4, 5	4, 5	4, 5
Coxa	4, 6	4, 5	6, 2	4, 5	4, 6
Second maxilliped:					
Setal formula (proximal-distal) of					
endopod	1, 1, 6	1, 1, 6	1, 1, 5	1, 1, 6	1, 1, 6
Abdomen:					
Posterolateral process	Somites 3-5 sharp	Somites 3, 4 sharp	Somites 3-5 sharp	Somites 3-5 sharp	Somites 3-5 sharp

spectively. Endopod bilobed, with 3 setae on proximal lobe, setae on distal lobe stepped, in the arrangement of: 3, 2; outer margin with fringe of fine hairs. Scaphognathite with 4 stout, plumose marginal setae; tip strongly tapered, plumose.

Coxa of first maxilliped (Fig. 9H) bare, basis with 10 setae (2, 2, 3, 3, proximal to distal). Endopod five-segmented, setation from proximal to distal segment 3, 2, 1, 2, 5. Exopod constricted medially, appearing 2-segmented, with 4 stout, setose terminal natatory setae.

Coxa of second maxilliped (Fig. 9I) bare, basis with 4 setae (1, 1, 1, 1).

Endopod 3-segmented, setation from proximal to distal segment 1, 1, 6. Exopod constricted medially, with 4 stout, setose terminal setae. Third maxilliped absent.

Remarks. — The first zoeal stage of *Rhabdonotus pictus* is compared to those described for *Harrovia longipes* Lanchester, 1900 (fide Lim & Ng, 1988), *H. albolineata* Adams & White, 1849 (fide Chia *et al.*, 1993), *Echinoecus pentagonus* (A. Milne Edwards, 1879) (fide Van Dover *et al.*, 1986) and *Zebrida adamsi* White, 1847 (fide Mori *et al.*, 1991). The differences (Table 1) observed are not significant at the species or genus level. The similarities observed are: 1) in the gen-

eral shape of carapace, abdomen and antennule; 2) antenna's subequal spinous protopodal process and exopod; 3) setae arrangement on the endopod segment of maxillule in the groups of 4, 2, 1 and on basal segment 5; 4) setae arrangement on the endopod of maxilla in the groups of 5, 3, and the scaphognathite bearing 4 plumose setae; 5) first maxilliped (see description above) is entirely the same for all species; and 6) setae arrangement on the basis of second maxilliped being 1, 1, 1, 1. The many similarities support the current contention that these genera belong to one monophyletic taxon (i.e. Eumedonidae).

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