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Biological observations on the commensal shrimp *Paranchistus armatus* (H. Milne Edwards) (Crustacea: Decapoda: Pontoniinae)

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ABSTRACT

Some aspects of the biology of the commensal pontoniine shrimp, *Paranchistus armatus* (H. Milne Edwards), on the Great Barrier Reef, are reported. The species is an obligatory commensal living as heterosexual pairs only in the giant clam, *Tridacna gigas* (L.). Features of the morphology, fecundity, population structure, infection rate, and reproductive mechanisms are described. It is considered possible that the species shows indications of serial male protandrous hermaphroditism, not previously noted to occur in shrimps of the subfamily Pontoniinae. It may also be considered an endangered species as its host animal is under threat.

KEYWORDS: *Paranchistus armatus*, Pontoniinae, Decapoda, biology, possible hermaphroditism, *Tridacna gigas* commensal, Australia, Great Barrier Reef, endangered species.

INTRODUCTION

The pontoniine shrimps associated with bivalve hosts have attracted a certain amount of biological study, particularly the species of the genera *Anchistus*, *Paranchistus* and *Conchodytes*, found in association with hosts in the family Pinnidae (Johnson and Liang, 1966; Hipeau-Jacquotte 1974; Morton 1987). The species associated with the family Tridacnidae have received little attention, probably as the result of the clam's legal protection on most coral reefs and a reluctance to sacrifice a significant number of these hosts.

The shrimp *Paranchistus armatus* is unusual in the subfamily Pontoniinae, as it is one of the largest species known, and is found only in association with the giant clam *Tridacna gigas* (L.). The latter has a restricted distribution in the Malaysian-Western Pacific region (Rosewater 1965) and the shrimp, although first described by Henri Milne Edwards in 1837, has so far only been recorded from a relatively small number of localities within that region. The giant clam is now a protected species in Queensland waters, where specimens can only be collected by special permit. The Queensland Fisheries Service has been carrying out an investigation of the biology of *T. gigas*, which has enabled numerous specimens of *P. armatus* to be examined without involving any unnecessary sampling of the host animal. Previous reports on these shrimps have generally been concerned with one to three individuals and the present collection of 164 specimens represents the first time that a small population, together with some data concerning the hosts, have been available for study. I am most grateful to Dr R.G. Pearson, of the Queensland Fisheries Service, Department of Primary Industry, and Dr V. Harriot, for this opportunity to report upon these specimens.

Measurements (mm) refer to the postorbital carapace length (CL) of the shrimps. Representative specimens have been deposited in the collections of the Northern Territory Museum, Darwin, (Cr.008674) and the Queensland Museum, Brisbane (W25447).

DESCRIPTION

***Paranchistus armatus* (H. Milne Edwards, 1837)**
(Figs 1-3)

Restricted synonymy:

Pontonia armata H. Milne Edwards, 1837: 359.

Anchistus biunguiculatus Borradaile, 1898: 387.

Tridacnocaris biunguiculatus - Nobili 1899: 235.

Anchistus oshimai Kubo, 1949: 26

Paranchistus biunguiculatus - Holthuis 1952: 13, 93-97, figs 36-38.

Anchistus armatus - Bruce 1967: 564-568.

Paranchistus armatus - Bruce 1975: 49-54, figs 1-3.

Material examined. (i) 61 adult pairs, 5 ovig.♀, 2 ♀, 4 ♂, 3 immature, Arlington Reef, 16°45.0'S, 146°00.0'E, from reef flat, 2 November 1978 to 12 November 1979. (ii) 4 pairs, 15 juveniles, Hastings Reef, 26 November 1979. (iii) 1 pair, 1 ♂, 3 juveniles, Michaelmas Cay, 5 December 1979.

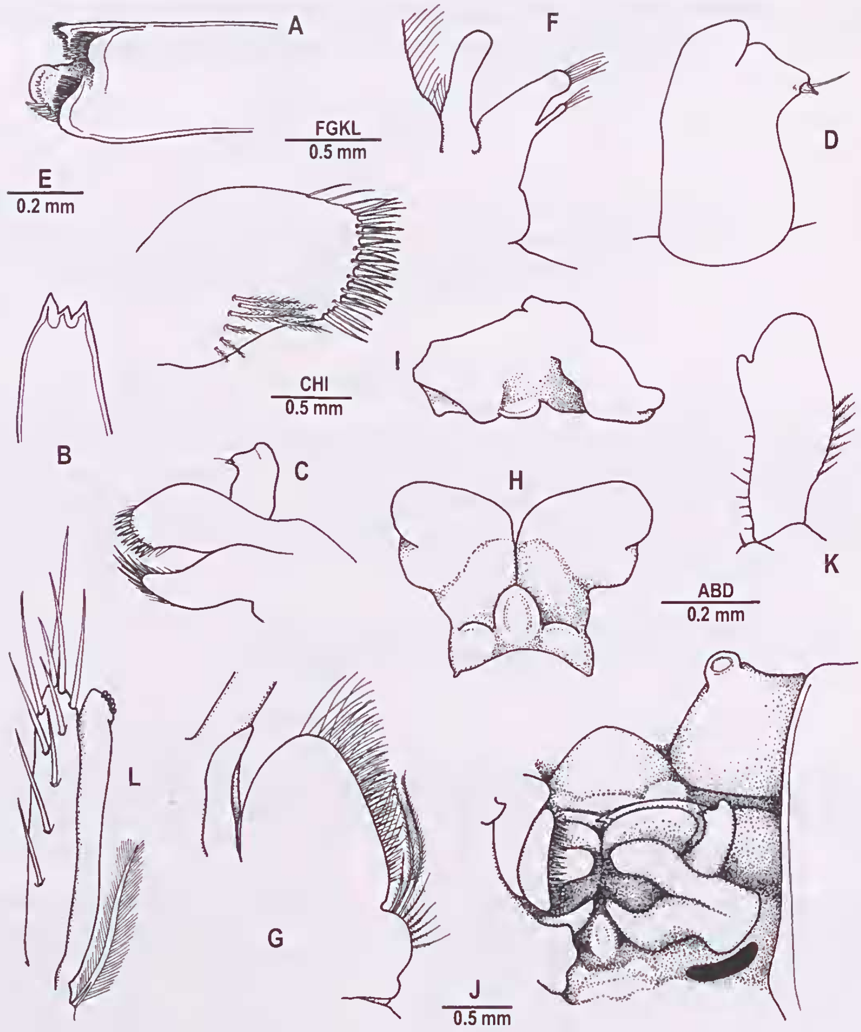

Fig. 1. *Paranchistus armatus* (H. Milne Edwards), Arlington Reef, Queensland, Australia. **A**, left mandible. **B**, same, incisor process. **C**, maxillula. **D**, same, palp. **E**, same, upper lacinia. **F**, maxilla. **G**, first maxilliped, palp and endites. **H**, paragnaths, ventral aspect. **I**, same, left lateral. **J**, buccal region, left maxilla to third maxilliped removed. **K**, first pleopod, endopod. **L**, second pleopod, endopod, appendices. A-J, ovigerous female. KL,. male.

Morphology. The present specimens agree closely with the previously published descriptions given by Kubo (1949, as *Anchistus oshimai*), Holthuis (1952, as *P. biunguiculatus*), and Bruce (1975).

In the large specimens, particularly the females, the hepatic spine is very small and could only be identified with considerable difficulty, even in dry specimens. The dorsal rostral dentition on small specimens is relatively conspicuous, in contrast to the condition in large females in which it is obsolete.

The mouthparts correspond closely with the illustrations provided by Holthuis (1952). The maxillula has short simple spines along the inner aspect and simple setae on the outer side of the distal margin of the upper lacinia (Figs 1 C, E). The palp is bilobed, with a short simple seta on the lower lobe (Fig. 1 D). The maxilla has the basal endite bilobed, with the distal lobe larger than the proximal and bearing six short setae, in contrast to five (Fig. 1 F). The palp is broad and flattened, without a subterminal seta but with a few short plumose setae on the proximal lateral border. The setae on the endites of the first maxilliped are simple. The coxal endite bears a single long slender seta. The palp is non-setose and the caridean lobe of the exopod is fringed with short plumose setae. The dactyl of the second maxilliped is provided with numerous finely serrated spiniform setae

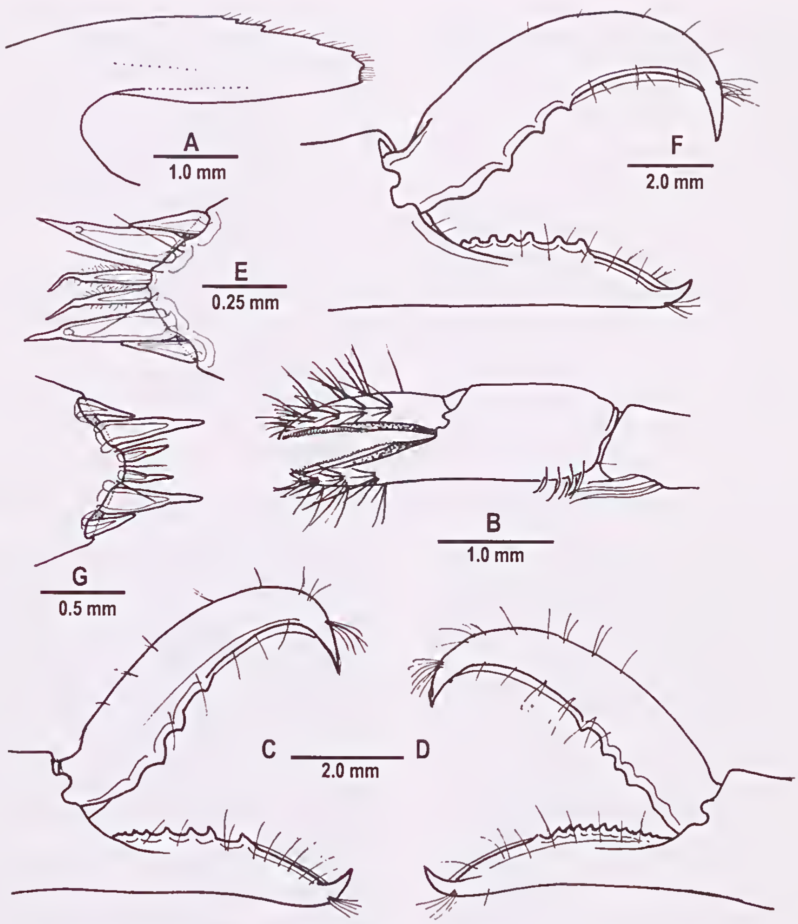

Fig. 2. *Paranchistus armatus* (H. Milne Edwards), Arlington Reef, Queensland, Australia. Male, CL 8.0 mm. **A**, rostrum. **B**, chela of first pereiopod. **C**, fingers of right second pereiopod. **D**, fingers of left second pereiopod. **E**, posterior telson spines. Female, CL 14.0 mm. **F**, fingers of second pereiopod. **G**, posterior telson spines.

(Fig. 1 J). The anteromedial border of the propodal segment bears long slender simple spines. The setae of the third maxilliped are simple (Fig. 1 G). The epipods of the three maxillipeds are deeply bilobed, subrectangular and oval respectively (Figs 1 K, L). The third maxilliped also bears a small six lamellar arthrobranch. The flagella of all exopods are well developed and broad, with numerous plumose setae along the margins of the distal third.

The chelae of the first pereiopod are subspatulate, with the laterally situated cutting edges of the fingers fully finely pectinate (Fig. 2 B). The fourth thoracic sternite bears a low transverse ridge with a small median notch, and a similar but slightly large ridge is also present on the fifth sternite.

The second pereiopods are generally subequal and similar in both males and females, but relatively larger in the former (Figs 2 C, D, F) The dactyl is generally armed with 3-4 small acute teeth on the proximal cutting edge and the fixed finger has 7-12, the most proximal of which may be very small.

The telson is provided with three pairs of posterior spines and two pairs of small dorsal spines (Figs 2 E, G). The latter are situated at about 0.70 and 0.85 of the telson length. The dorsal spines are relatively longer in the males. The intermediate posterior spines are about 4.5 times longer than wide, about 0.1 of the telson length, and about twice the length of the lateral spines. The submedian spines are slender, feebly setulose and 0.4 - 0.7 of the length of the intermediate spines.

Colouration. The body, antennal peduncles,second pereiopods and caudal fan are white, with the antennal flagella purplish.

BIOLOGY

Fecundity. Of the 73 females over 11 mm CL, all except four were ovigerous, and one of these appeared

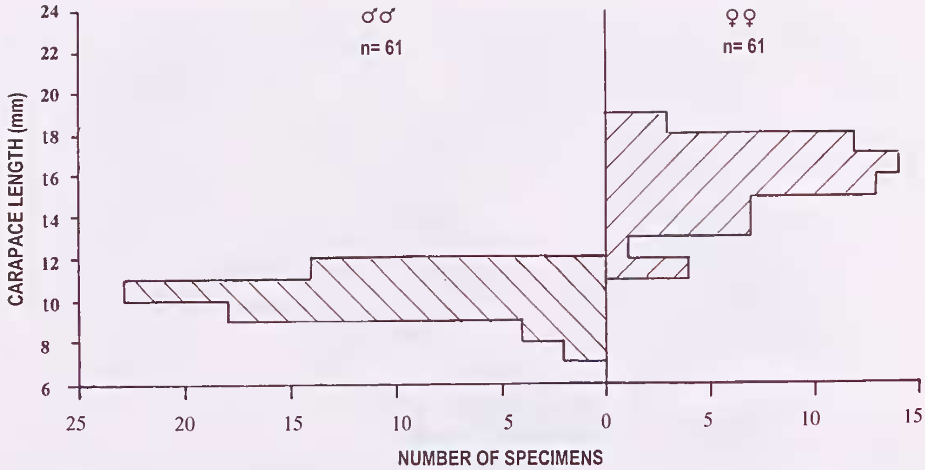

Fig. 3. *Paranchistus armatus* (H. Milne Edwards), carapace length distributions of the paired specimens from Arlington Reef.

to have just hatched its ova. The smallest ovigerous female, CL 11 mm, carried 1,550 ova, and the largest, CL 18mm, carried 8,901 ova. Intermediate size females carried the following numbers of ova: (i) CL 13 mm, 4646; (ii) CL 15 mm, 5638; (iii) CL 17 mm, 7,788. The ova are about 0.5 mm in length when freshly laid and 1.7 mm when about to hatch.

Population structure. Of the 138 specimens from Arlington Reef, the males ranged in size from CL 7-11 mm and the females 8-18 mm. No juveniles below CL 7 mm were found and the appendix masculina is recognisable in males of this carapace length. The distribution of carapace length is shown in Figure 3.

It is noteworthy that no males occur with a CL of over 12 mm and that very few females occur with a carapace length below 11 mm, less than 3 %. As males are readily identifiable from CL, 7-11 mm, it appears that this population did not contain any juvenile females and suggests that males of this species may be a protandrous hermaphrodites, with the transition from male to female occurring at about CL 11 mm.

In general the larger females are paired with the larger males but considerable variation exists and a larger sample is needed to clarify apparent discrepancies. The relationships are summarised in Table 1.

Table 1. Range of carapace length (CL) in males paired with females of specified CL

♀ CL	♂ CL, range	n	mean
11	8 - 11	5	9.8
12	7 - 9	2	8.0
13	9 - 11	6	9.6
14	7 - 10	7	8.2
15	9 - 11	15	10.5
16	8 - 11	14	9.7
17	9 - 11	13	10.4
18	10 - 11	3	10.6

Almost all specimens were found as male-female pairs. At Arlington Reef, 61 pairs were collected, together with 6 six ovigerous females without male partners and 2 non-ovigerous females, CL 16 and 8 mm. It is most probable that the males of the six ovigerous females were overlooked in dissection of the host clam, or escaped during its removal from the reef. Of the four cases where isolated females were found, three were small, CL 8 mm, and could have been without males or again, the males may have been overlooked during collection.

In only one instance, at Arlington Reef, was more than a pair of shrimps found in the host clam. In this case a pair of small individuals, both of CL 10 mm were accompanied by an additional small male of 7.5 mm CL, the smallest identifiable male found. The female of this association was without ova.

The two largest female shrimps (both 18 mm CL) were found in two of the largest host clams, with shell lengths of 83 cm and 95.5 cm. Two larger clams from Hastings Reef were sampled, valve length 100 cm and 102.5 cm, both with a breeding pair of shrimps. The smallest breeding pairs of shrimps were of 7.5 and 12 mm CL, and 10 and 11.5 mm CL in clams of 37.1 cm and 43.0 cm respectively. The smallest pair of shrimps, CLs 4.5 and 5.0 mm, were from Hastings Reef, from a clam of 22.2 cm valve length.

Juveniles. The Arlington Reef population of *P. armatus* is remarkable for the apparent absence of juveniles, although sampling was carried out in the months November, December, January, July, August, September and October and ovigerous females were found at all times, so that breeding may occur throughout the year. Additional samples were also collected from Hastings Reef, where clams of a larger size and smaller size were sampled. At Hastings Reef two juveniles CL 4.5 and 5.0 mm, were found in clams of valve lengths

28 and 23 cm respectively. A pair with an ovigerous female were also found in a clam of valve length 43 cm. At Michaelmas Cay, eight additional small specimens of *T. gigas* were sampled, of which three contained juveniles shrimps CL 4, 4, and 5 mm, clam valve lengths 30, 31 and 27 cm respectively. One clam, valve length 34 cm, contained a single male, CL 7 mm, and another, valve length 37 cm., a small pair with an ovigerous female, CLs 7.5 and 12 mm.

Two particularly large clams were also examined at Hastings Reef in November 1979, valve lengths 100 and 102 cm. Each contained a male-female pair of adult shrimp, CLs 11 and 15 mm and 11 and 17 mm. These were accompanied by 7 and 6 juvenile shrimp respectively, CLs 1.5, 4, 4, 4, 5.5, 7, 7 mm and 4, 4.5, 5, 6, 7, 7 mm in each case. The 1.5 mm CL specimen was the smallest found and is probably only a little over the first post-larval stage size.

Autotomy. 89 specimens were examined in detail for evidence for autotomy and limb regeneration. In not a single example was there any evidence of limb loss, injury or regeneration.

Host. All specimens were found in association with the giant clam *Tridacna gigas* (L.). Hosts sampled ranged in size from 22 - 102 cm in valve length. Small numbers of *Tridacna crocea, T. derasa, T. maxima, T. squamosa* and *Hippopus hippopus* were also sampled from Michaelmas Cay but all were without associated *P. armatus* (Pearson pers. comm.). The exact situation within the host clam was not observable or recorded.

Infestation rate. Details are available of 91 clams from Arlington Reef. Of these, 84 contained associated shrimps, giving an infection rate of 92.3 %. Including clams from other localities, 118 clams were infested on 100 occasions, with an overall infection rate of 84.7%.

Associated fauna. One specimen of *Tridacna gigas,* valve length 18.2 cm, also contained two specimens of the pinnotherid crab *Xanthasia murigera* White in addition to *Paranchistus armatus.* No bopyrid parasitization of the shrimps was found.

Distribution. *Type locality*: New Ireland, Papua New Guinea. Also known from *Indonesia*: Batanta; Mefour (Nobili 1899); Obi Latu (Holthuis 1952); *Papua New Guinea*: New Ireland (H. Milne Edwards 1837); Tubetube, Engineer Islands (Borradaile 1898); Hansa Bay (De Grave 1999); *Australia*: Undine Reef (McNeill 1968); Chapman Island (Bruce 1975); Cairns; Arlington Reef, Michaelmas Cay (Bruce 1983); *Caroline Islands*: Helen Atoll, Palau (Kubo 1949); Ngadarak Reef and Ngaianges Island (Miyake and Fujino 1968); *Marshall Islands*: Ujae Atoll (Holthuis 1953); Eniwetak Atoll (Rosewater 1965; Bruce 1975; Bruce 1979; Devaney and Bruce 1989); Bikini Atoll (Chace and Bruce 1993); *Kiribati*: Onotoa Atoll (Holthuis 1953).

Remarks. Giant clams are notorious for their longevity and it may be safely assumed that each clam provides a home for many generations of commensal shrimp. No information is available on the life span of the infesting shrimps. Their relatively large size, in relation to other pontoniine shrimps, may indicate that they live longer than about 12 months as suggested for *Periclimenes ornatus,* a small pontoniine associate of Japanese sea anemones (Omori *et al.* 1994). Morton (1987) has discussed the biology of the commensal pontoniine shrimps, *Anchistus custos* (Forsskål) and *Conchodytes monodactylus* Holthuis, 1952, associated with the pinnid bivalve *Pinna bicolor* Gmelin. This host is comparatively short lived in comparison with *T. gigas* and the situation is not comparable. No information is available on the recruitment of these shrimps but it seems likely that they arrive as post-larvae from the plankton. In the present study the smallest individuals were little above the typical size of pontoniine post-larvae. The small ova indicate that there is no abbreviated larval development that would enable recruitment to be derived from the occupying pair of shrimps. The frequency of heterosexual pairs of adult shrimps only also suggests that, in general, their presence suppresses or prevents further colonisation by juveniles. The high infestation rate suggests that replacement of shrimps is efficient and quick. The range of shrimps sizes indicates a continuous process without marked seasonality. Possibly the death of an adult female results in the change of the male partner into a female and the recruitment of a new shrimp from the larvae in the plankton, which would develop into a male. Death of a male would follow similar recruitment, with the post-larva also developing into a male. Protandrous and simultaneous hermaphroditism have been reported in a number of caridean shrimp families (Bauer and Holt 1998) but sex changes have so far not been recorded in the Palaemonidae.

The absence of any signs of trauma or autotomy suggests that life in *Tridacna gigas* represents a particularly secure niche. This may be contrasted with the situation reported in *Coralliocaris graminea* (Dana) living in *Acropora* corals (Bruce 1976), where signs of damage to the shrimp were frequent. In this species a minimum of 23% of specimens examined showed signs of significant regeneration after serious damage. The species lives in small communities depending upon the size of the coral host. The incidence of damage increases with the size of the population, reaching up to 77% in the larger populations. This damage was attributed to intraspecific combat, particularly between females (Bruce 1976), factors that would not be present in the case of *P. armatus.*

The giant clam, *Tridacna gigas* (L.), was formerly widely distributed in the Malaysian — northern Australian — Western Pacific- region (Rosewater 1965) but has recently been reported as "? extinct" in Taiwan, Vanuatu, Fiji, Guam, New Caledonia and the Northern Marianas (Wells 1997). Although unreported from these localities, it is likely that *P. armatus* was also present in these regions but is now similarly extinct. All species of Tridacnidae are listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora, APPENDICES I and II, as adopted by the Conference of the Parties, valid from 16 February 1995 (http://www.iwec.org/cites1.htm). If *T. gigas* is considered to be an endangered species, logically its obligate "commensal" associate, *P. armatus*, must be in equal danger.

Much remains to be studied in the life histories of "commensal" shrimps such as *Paranchistus armatus* and most others. Information on their food and feeding habits is minimal, as is data on their larval stages and life history, mechanism of host colonisation, longevity and reproductive biology. The term "commensalism" is frequently a euphemism for ignorance of details of the lifestyle involved.

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