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New records of *Macrobrachium* (Crustacea: Decapoda: Palaemonidae) from Christmas Island, Indian Ocean

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Abstract – The first collection of *Macrobrachium* from caves on Christmas Island, Indian Ocean is reported. Represented in the collection is the wide-ranging *M. lar* (Fabricius, 1798), and *M. microps* Holthuis, 1978, previously known from freshwater caves in the Southwest Pacific. The former is more typically an epigeal species and has previously been reported from surface waters on Christmas Island, while the latter appears to be an obligate hypogeal species.

INTRODUCTION

The *Macrobrachium* fauna of Christmas Island previously consisted of two wide-ranging Indo-West Pacific species, viz. *M. lar* (Fabricius, 1798) and *M. rosenbergii* (De Man, 1879). The first record of the genus from the island was by De Man (1905) who recorded *M. lar* from a small freshwater pool above a waterfall. This material resulted from collections made by Dr R. Hanitsch of the Raffles Museum, Singapore. Gibson-Hill (1947) provided further details on Hanitsch's collection site and the distribution of *M. lar* on Christmas Island, 'occurs only in this small stream running into Panchoran Bay [now known as Waterfall], and in the water-storage tank which is supplied from it'. Calman (1909) also recorded *M. lar* from Hugh's Dale and Sidney's Dale on the west coast, based on material collected by Dr C. W. Andrews during 1897–1898 and 1908.

Gordon (1935) listed *M. rosenbergii* from Flying Fish Cove on the northwest side of the island and recorded further material of *M. lar*, including a record from Dolly Beach on the eastern side.

The present material results from collections made by Humphreys and Eberhard (1998) in caves on the north coast, one of the present authors (P.M.) in Daniel Roux Cave in 1996 and D. Powell at Waterfall in 1978. Included are the first cave records of the genus from Christmas Island and the first records of the obligate hypogeal species, *M. microps* Holthuis, 1978. Apart from Henderson's Spring and Waterfall, all of the collection sites are anchialine habitats – fresh groundwater systems overlying seawater with limited surface expression (W.F. Humphreys, personal communication). The only other anchialine system reported from Australia is in the vicinity of Cape Range and Barrow Island in northwestern Australia (Humphreys, 1993; Yager and Humphreys, 1996). Anchialine systems are noted both for their relict faunas, species richness (Sket, 1981, 1996) and their extraordinary vulnerability to even the slightest organic pollution (Iliffe *et al.*, 1984; Notenboom *et al.*, 1994).

In the following accounts all carapace lengths (CL) are measured from the orbital margin to the posterior carapace. Female specimens are non-ovigerous unless stated otherwise. Numbers enclosed in parentheses and with the prefix 'WAM C' refer to registered lots in the Crustacea collection, Department of Aquatic Zoology, Western Australian Museum. Field numbers used by Dr W.F. Humphreys, Department of Terrestrial Invertebrates, Western Australian Museum have the prefix 'BES'. In the diagnoses the abbreviation 'P2' refers to the second pereiopods. The rostrum formula is given as the number of dorsal rostral teeth over the number of ventral rostral teeth. Line drawings were made with the aid of a camera lucida and stereo microscope.

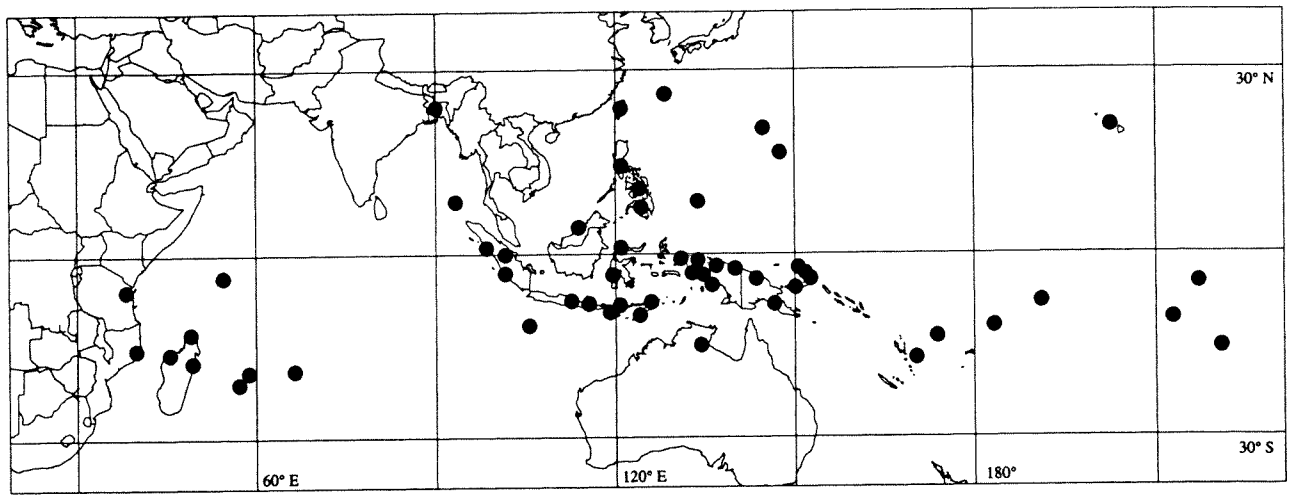

Figure 1 Distribution of *Macrobrachium lar* (Fabricius, 1798).

SYSTEMATICS

Macrobrachium lar (Fabricius, 1798)

Figure 1

Restricted synonymy

Palaemon Lar Fabricius, 1798: 402.

Palaemon lar: Bosc, 1801: 104; Gordon, 1935: 629; Gibson-Hill, 1947: 44 (footnote).

Bithynis lar: Bate, 1888: 789, plate 129, figure 1.

Palaemon (*Eupalaemon*) *lar* var.?: De Man, 1905: 544, plate 18.

Palaemon lar var.: Calman, 1909: 706.

Macrobrachium lar: Maki and Tsuchiya, 1923: 56, plate 5, figure 1; Holthuis, 1950: 16, 108 (key), 176–190; Chace and Bruce, 1993: 23 (key), 30–31, figure 9.

Material Examined

Australia: **Christmas Island**: Adult ♂, 32.8 mm CL, ovigerous ♀, 19.2 mm CL, Henderson's Spring outflow, *ca.* 80 m above sea level, Karst CI 64, from net filtering pump house outlet, 10°29'13"S, 105°40'40"E, W.F. Humphreys, R. Webb, 7 April 1998, BES 5861 (WAM C24439); adult ♀, 19.9 mm CL, Waterfall, at night on wet rock face, D. Powell, 17 October 1978 (WAM C12457); undeveloped ♂, 21.1 mm CL, Karst CI 54, 10°25'23"S, 105°42'03"E, depth 0.2 m, W.F. Humphreys, 30 March 1998, BES 5777 (WAM C24440); 2 postlarvae ("dionyx" stage), 2.5, 2.6 mm CL, Karst CI 54, 10°25'23"S, 105°42'03"E, brackish, 2 m, baited net, S.M. Eberhard, 17 April 1998, BES 5948 (WAM C24441); 1 postlarva ("dionyx" stage), 2.3 mm CL, Karst CI 54, 10°25'23"S, 105°42'03"E, brackish, 3 m, baited net, S.M. Eberhard, 7 April 1998, BES 5952 (WAM C24442).

Diagnosis

Rostrum short in fully developed males, developmental range 0.5-0.7 CL; dorsal and ventral carinae well developed; dorsal carina sinuous or upturned, dentate along entire length, teeth tending to be more closely spaced at mid-length, 7-10 teeth, 1-2 completely postorbital; ventral carina dentate, 2-4 teeth, first tooth located in proximal half or at about mid-length of ventral carina.

Ocular cornea large, well-pigmented, accessory pigment spot present. Inferior orbit moderately produced, obtuse, postantennular carapace margin evenly rounded. Bec ocellaire moderately developed. Epistome completely divided into two lobes, lobes strongly produced anteroventrally.

P2 of developed males isomorphic in setation and shape, unequal in length; long, merus of minor cheliped reaching distal end of scaphocerite; fingers with well developed gape; pollex elongate, not noticeably broadened basally, about equal in breadth to basal dactylus, strongly uncinate at tip, proximal cutting edge with dentate ridge ending in tooth, distinct gap then very large incisor tooth, distally entire; dactylus elongate, strongly uncinate at tip, proximal cutting edge with few low crenulations then very large incisor tooth well advanced of most distal tooth on pollex, distally entire; manus subcylindrical, much longer than dactylus; carpus of moderate length, less than half length of chela; merus slightly longer than carpus.

Thoracic sternite 4 with well-developed median process. Inter-uropodal sclerite with strongly-developed pre-anal carina.

Colour

As is typical of many species of the genus there is significant geographic and developmental colour variation. General body colour varies from light olive to dark brown or blue. In adults, the carapace

is often marked with swirls of orange brown, blue grey and light olive grey. The dorsal abdomen is typically much darker than the lower pleurae and the condyles distinctively marked with light cream to orange.

The first chelipeds and ambulatory legs vary from olive to dark brown or blue. The second chelipeds are olive to dark brown, sometimes marbled with irregular brown, olive or blue-grey blotches. The fingers are dark reddish brown. The manus has an orange or light red blotch near the base of the dactylus.

Habitat

Although adults of the species are predominantly found in fresh waters, juveniles have been reported in the literature from estuaries, lowland fresh waters and inshore marine areas. The specimens from Karst CI 54 are the first anchialine records of the species.

In northern Australia, the species is largely restricted to permanently-flowing, high gradient coastal streams. Adults show a preference for well oxygenated pools below riffles or waterfalls and shelter in poorly lit areas among tree roots, piles of large rocks or fallen timber.

Distribution

Wide-ranging Indo-West Pacific: eastern Africa to the Ryukyu Islands and the Marquesas. Introduced to the Hawaiian Islands (Atkinson, 1977).

Remarks

This species has been extensively illustrated in the literature (e.g. Bate, 1888; Chace and Bruce, 1993; Holthuis, 1950; De Man, 1905). Among Indo-West Pacific species, fully developed males of *M. lar* are highly distinctive and are easily distinguished by the short, sinuous rostrum and long, robust second pereiopods with widely gaping fingers, each bearing a very large incisor tooth on the cutting edge. The P2 merus in adult specimens is also longer than the carpus. This character easily separates *M. lar* from the other large *Macrobrachium* recorded from the island, *M. rosenbergii*, which has the carpus clearly longer than the merus.

The postlarval specimens examined show general agreement with the description of the "dionyx" stage by Holthuis (1950) although all are somewhat damaged and poorly preserved. In particular the hepatic spine is in a submarginal branchiostegal position, the dactyli of the third to fifth pereiopods vary from feebly to distinctly biunguiculate and in one of the three specimens there is a clear supraorbital tubercle on each side of the carapace. The shape of the rostrum and arrangement of rostral teeth is also as figured by Holthuis (1950), with the posterior dorsal teeth more widely spaced than the anterior teeth. The rostral formula for the three specimens is 7-9/2-3.

The eggs of this species are small (0.9 mm maximum length) and numerous (up to 40 000 per brood; Kubota, 1972). Larval development is extended, with at least 11 planktonic stages and over 89 days to metamorphosis in seawater at 23–26.5°C (Atkinson, 1977).

Macrobrachium microps Holthuis, 1978

Figures 2–3

Macrobrachium microps Holthuis 1978: 210–214, figures 1, 2; Bruce and Iliffe 1993: 83–96, figures

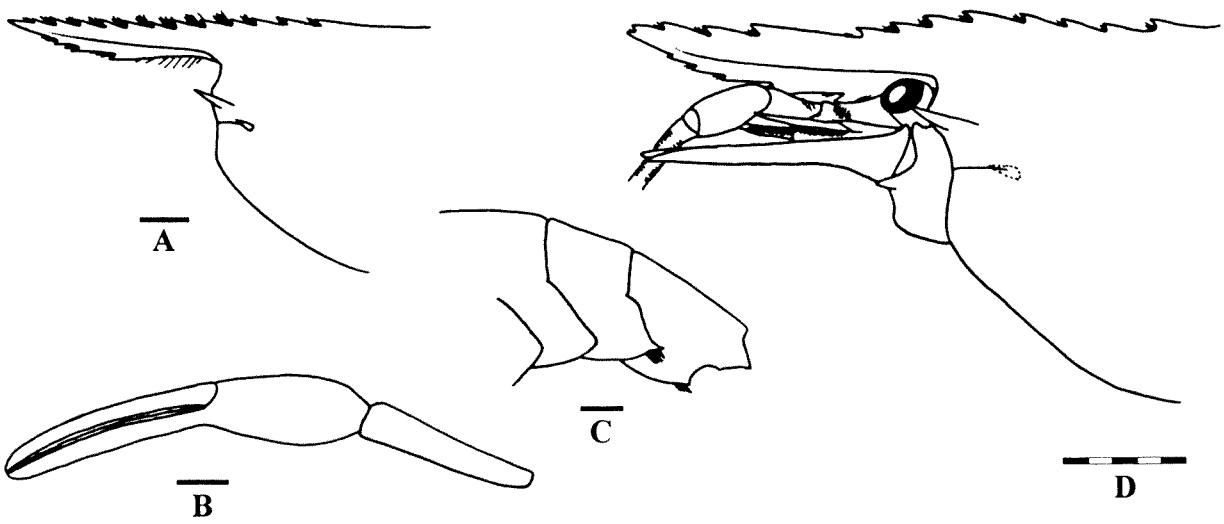

Figure 2 *Macrobrachium microps* Holthuis, 1978. **A–C**, small undeveloped ♂, 11.9 mm CL, WAM C24444: **A**, rostrum; **B**, right chela and carpus of P2; **C**, abdominal pleurae 3–6. **D**, adult ♀, 23.8 mm CL, WAM C24443, anterior cephalothorax. Scale bar divisions (D) and solid scale bars (A–C), 1 mm.

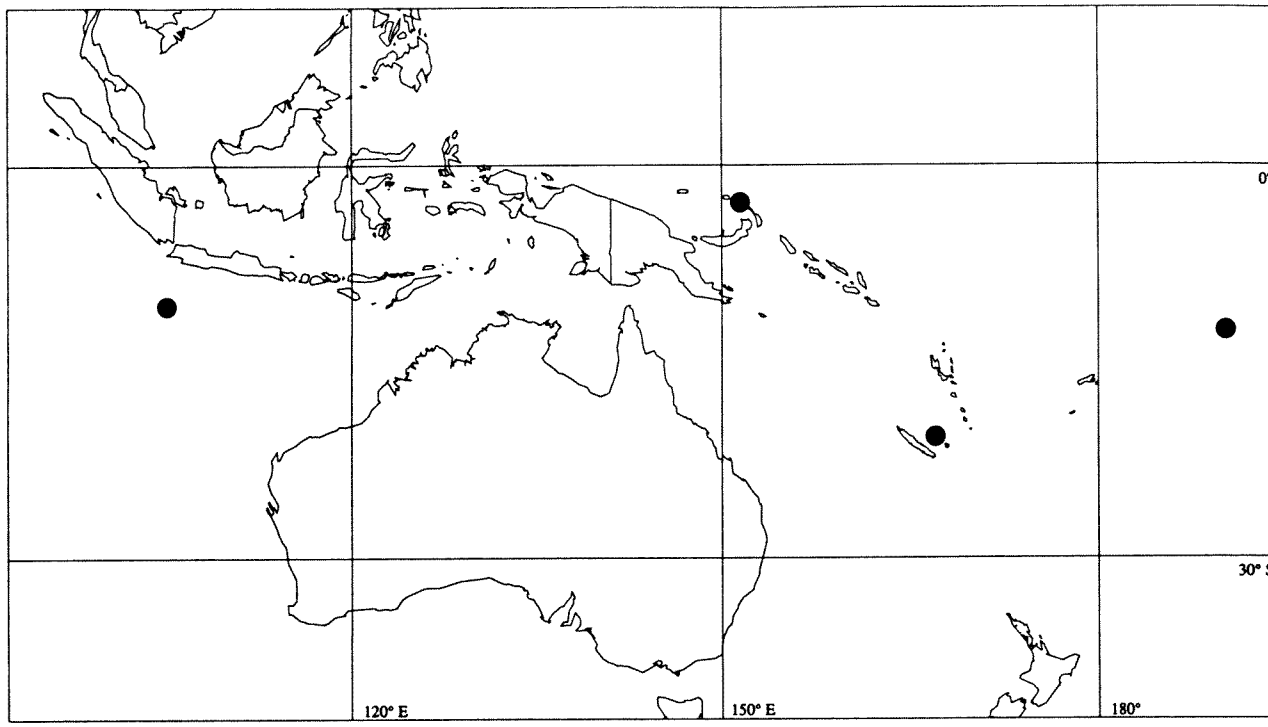

Figure 3 Distribution of *Macrobrachium microps* Holthuis, 1978.

1–6; Short and Marquet, 1998: 403 (key), 407–408, figure 4.

Material Examined

Australia: **Christmas Island**: Adult ♀, 23.8 mm CL, main Daniel Roux Cave (6CI-3), 10°26'26"S, 105°39'38"E, hand collected, 50 cm depth, P. Meek, 1996 (WAM C24443); undeveloped ♂, 11.9 mm CL, freshwater cave, Karst CI 10, 10°30'48"S, 105°37'24"E, trapped, W.F. Humphreys, 2 April 1998 (WAM C24444).

Diagnosis

Rostrum short in fully developed males; dorsal and ventral carinae well developed (ventral carina typically slender); dorsal carina slightly sinuous, armed with 10–12 teeth, 4–5 completely postorbital; ventral carina with 3–5 teeth, first tooth located in proximal half or at about mid-length.

Ocular cornea reduced, well-pigmented. Inferior orbit poorly to moderately produced, obtuse, postantennular carapace margin evenly rounded. Epistome bilobed, lobes poorly developed, rounded, widely separated, strongly divergent anteriorly.

P2 of developed males fully dimorphic, short, minor cheliped reaching scaphocerite by carpus or more distal segments. Major cheliped without setal pubescence, chela without gape between fingers, manus broadened, maximum breadth much greater than maximum merus breadth; carpus clearly shorter than chela; merus *ca.* equal in length to carpus or slightly shorter. Minor cheliped without setal pubescence, chela with well developed gape between fingers, manus moderately broadened, breadth clearly greater than maximum merus breadth, clearly shorter in length than dactylus; carpus clearly shorter than chela; merus slightly shorter than carpus.

Thoracic sternite 4 with median boss. Fourth and fifth abdominal pleurae posteroventrally acute (fourth pleura angular in small undeveloped male), inter-uropodal sclerite with elevated, setose, pre-anal carina.

Colour

The adult female from Daniel Roux Cave was rather uniformly pale cream in colour and lacked a distinct colour pattern. The cephalothorax was slightly tinged with olive and the dorsal abdomen tinged with yellow.

Habitat

Lower and upper Daniel Roux Cave consists of quaternary limestones (Spate and Webb 1998) which are tidal influenced (0–1.4 metres) (Faukland, 1999) although pools do remain at very low tides. Habitat is anchialine and there is a freshwater lens over salt water. Conductivity of the freshwater input (Gusher) has a mean value of 0.6–2 mS cm^{-1} and subterranean water conductivity ranges from <1–25 mS cm^{-1} (Faukland, 1999; Humphreys and Eberhard, 1989).

Freshwater Cave, which is on the opposite side of the island from Daniel Roux Cave, is also part of an anchialine system and opens from a marine terrace at an altitude of *ca.* 30 m. The fresh water within the cave is at sea level and is under strong tidal influence (W.F. Humphreys, personal communication).

Distribution

Previously recorded from freshwater caves in the Southwest Pacific: Danmin Cave, near Konogusgus, New Ireland (type locality); West Samoa; and Lifou Island, New Caledonia.

Remarks

The single adult female agrees closely with previously described specimens although the rostral formula (12/5) is slightly higher than given by Short and Marquet (1998) for the species (10-11/3-4). The dorsal series of rostral teeth is irregularly spaced near the mid-length in the present specimen whereas in previous specimens the rostral teeth are sub-equally spaced. The antennal and hepatic spines are well-developed, although the latter is broken off on the left side.

The species can easily be distinguished from congeners using the following combination of characters: fourth and fifth abdominal pleurae posteroventrally acute (fourth angular in small undeveloped male); ocular cornea reduced, but well pigmented; and an obtuse, evenly rounded inferior orbit.

The size of the ova in this species remains unknown. The presence of the species in freshwater caves on Christmas Island, quite a considerable distance from previous records in the Southwest Pacific, strongly suggests that *M. microps* has extended larval development and tolerance of seawater during the larval phase.

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Dr Bill Humphreys (Western Australian Museum, Perth) provided most of the material reported and supplied useful habitat information. He also gave the details of a number of important published studies on anchialine cave systems. Tony Faukland, ACT Electricity and Water (Research), led the expedition into Lower Daniel Roux Cave.

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