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Relative carapace and chela proportions of Australian *Macrophthalmus pistrosinus* compared with Japanese *M. japonicus* (Decapoda, Brachyura, Macrophthalmidae)

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Abstract.— *Macrophthalmus pistrosinus* Barnes & Davie, 2008, which is endemic to Western Australia, was formerly treated as *M. japonicus* in East Asia because of their morphological similarity. Examination of the proportional features, such as carapace length relative to carapace width in each sex and propodus length relative to carapace width in mature males, revealed more similarities to *M. japonicus* compared with *M. banzai*, which is phylogenetically more closely allied to *M. japonicus* than to *M. pistrosinus*.

Key words: *Proportional features, Macrophthalmus, tidal flat, sentinel crabs, western Australia*

Introduction

The macrophthalmid crab *Macrophthalmus pistrosinus* Barnes & Davie, 2008, which is endemic to the area around Shark Bay in Western Australis (Barnes & Davie, 2008), was formerly treated as *Macrophthalmus japonicus* (De Haan, 1835) (Barnes, 1967), which is distributed in Japan, Korea, and North China (Wada, 1991). Although *M. pistrosinus* is morphologically similar to disjunct *M. japonicus*, its genetic characters exhibit more divergence from Asian *M. japonicus* and the allied *Macrophthalmus banzai* (Wada & Sakai, 1989) (Kitaura *et al*., 2002). Barnes & Davie (2008) enumerated the morphological differences between *M. pistrosinus* and *M. japonicus*, but all of the differences were subtle, except for the presence (*M. pistrosinus*) or absence (*M. japonicus*) of a band of fine setae on the inner surface of the palm of the male chela. The motion of the waving display is also very similar in *M. pistrosinus* and *M. japonicus*, *i.e*., both chelipeds moved vertically up-and-down in both species (Kitaura *et al*., 2002); this contrasts with the lateral movement by *M. banzai* (Wada & Sakai, 1989), which is phylogenetically more closely allied to *M. japonicus*.

The proportional sizes of body parts, such as carapace or chela length relative to carapace width (CW), have been useful for distinguishing macrophthalmid species (Barnes, 1968; Wada, 1991). The two allied species *M. japonicus* and *M. banzai* are distinguished by the relationships between carapace length (CL) or chela length and CW (Wada, 1978, 1991). However, the description of *M. pistrosinus* (Barnes & Davie, 2008) did not mention any of its proportional features. Therefore, this study reports data on the CL relative to CW, and chela length relative to CW, for Australian *M. pistrosinus* and compares these relationships with those of the morphologically and behaviorally similar Japanese species, *M. japonicus*.

Materials and Methods

The morphology of specimens of *M. pistrosinus* deposited in the Western Australian Museum (WAM) and collected by the author in Carnarvon, Western Australia, and specimens of *M. japonicus* collected by the author in Shirahama,

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Wakayama, Japan, was examined.

M. pistrosinus **materials**: two males (WAM655–65), Teggs Channel, Shark Bay, Australia, Aug. 14, 1965; two females (WAM655–65), Teggs Channel, Shark Bay, Australia, Aug. 14, 1965; one female (WAM651–65), Denham Hummock, Shark Bay, Australia, Jan. 9, 1963; 23 males, collected by K. Wada, Carnarvon, Australia, Aug. 20–22, 1995; 15 females, collected by K. Wada, Carnarvon, Australia, Aug. 20–22, 1995.

M. japonicus **materials**: 66 males, collected by K. Wada, Shirahama, Wakayama, Japan, Jul. 24/Aug. 24–26/Sep. 8, 1976, Jul. 31, 1981; 36 females, collected by K. Wada, Shirahama, Wakayama, Japan, Jul. 31, 1981.

Morphometric data on the specimens were obtained by measuring CL along the median line from the anterior to posterior margin, CW between the external orbital angles (not the widest part of the carapace), and propodus length (PL) of the right cheliped of mature males (those with a large wedge-shaped tooth on the cutting margin of the immovable finger, a secondary sexual character) from the ventral articulation with the carpus to the tip of the immovable finger.

Results and Discussion

The maximum body size was larger in *M. pistrosinus* than in *M. japonicus*, with males being larger than females in both species (Table 1). However, another Japanese population of *M. japonicus* is known to attain 40.0 mm CW in males and 38.25 mm CW in females (Wada, 1991), similar to the maximum sizes of *M. pistrosinus*. *Macrophthalmus banzai*, which is more closely related to *M. japonicus*, attains 29.45 mm CW in males and 24.95 mm CW in females (Wada, 1991), which is evidently smaller than *M. japonicus* or *M. pistrosinus*.

Regression equations between CL and CW were determined separately for males and females (Table 1). Based on these equations, CL was estimated against three values of CW: 10, 20, and 30 mm (Table 2). The CL estimated against the three CW values was similar in *M. pistrosinus* and *M. japonicus*. Covariance analysis between the two species revealed that the CW/CL relationship of males did not differ between them (slope: $F = 0.26$, $P = 0.61$; elevation: $F = 0.30$, $P = 0.58$), while the relationship

Table 1. Constants of the regression equations ($y = \mathrm{a} + \mathrm{b}x$) ($x$ = carapace width (CW) in mm; y = carapace length (CL) in mm) for *Macrophthalmus pistrosinus* from Western Australia and *M. japonicus* from Shirahama, Japan. n = number of samples. The correlation was significant in all the four groups ($P < 0.001$).

	n	Range (x)	a	b	r
M. pistrosinus					
Male	24	10.25–39.8	0.616	0.657	0.998
Female	18	8.2–36.7	0.091	0.691	0.998
M. japonicus					
Male	66	9.95–31.1	0.451	0.663	0.997
Female	36	8.9–28.35	0.418	0.663	0.998

Table 2. Carapace lengths (CLs; in mm) and propodus length of the male cheliped (PLs; in mm) for three carapace widths (CWs; 10, 20, and 30 mm) estimated from the regression equations (Tables 1 & 3) for *Macrophthalmus pistrosinus* from Western Australia and *M. japonicus* from Shirahama, Japan.

	Males			Females		
	CW = 10	CW = 20	CW = 30	CW = 10	CW = 20	CW = 30
CL						
M. pistrosinus	7.19	13.76	20.33	7.00	13.91	20.82
M. japonicus	7.08	13.71	20.34	7.05	13.68	20.31
PL						
M. pistrosinus		12.45	21.58			
M. japonicus		10.46	24.56			

differed in females (slope: $F = 5.64$, $P = 0.02$; elevation: $F = 9.70$, $P < 0.01$). Therefore, CL relative to CW in male crabs did not differ between *M. pistrosinus* and *M. japonicus*, in contrast to the distinct difference between *M. japonicus* and *M. banzai* in terms of that proportional feature (Wada, 1978, 1991).

Separate regression equations between log PL and log CW in mature males were obtained for *M. pistrosinus* and *M. japonicus* (Table 3). Based on these equations, PL was estimated against two values of CW: 20 and 30 mm (Table 2). The estimated PL was larger in *M. pistrosinus* than in *M. japonicus* in smaller crabs, but the reverse was true in larger crabs. Therefore, the PL of small males of *M. pistrosinus* was more similar to *M. banzai* compared with *M. japonicus*, whereas the length of large males of *M. pistrosinus* was more similar to *M. japonicus* compared with *M. banzai*. Covariance analysis between the two species revealed that the PL/CW relationship differed between them (slope: $F = 20.23$, $P < 0.01$; elevation: $F = 0.22$, $P = 0.64$).

Table 3. Constants for the regression equations ($\log y = \log a + b \log x$) ($x$, carapace width (CW) in mm; y, propodus length of cheliped (PL) in mm) for mature males of *Macrophthalmus pistrosinus* from Western Australia and *M. japonicus* from Shirahama, Japan. n = number of samples. The correlation was significant in the both species ($P < 0.001$).

	n	Range (x)	log a	b	r
M. pistrosinus	15	14.3–39.8	−0.669	1.356	0.987
M. japonicus	42	20.75–31.1	−1.719	2.105	0.913

As described above, the morphometric features of the carapace and cheliped of *M. pistrosinus* were more similar to *M. japonicus* than to *M. banzai*. Observations of the other morphological characters of specimens of *M. pistrosinus* that distinguish between *M. japonicus* and *M. banzai* revealed the similarity of *M. pistrosinus* to *M. japonicus*: the anterior half of the ventral surface of the carpus and propodus of the third leg bears no or few setae; the upper margin of the male gonopod tip is horizontal and not thickened; and the large wedge-shaped tooth on the cutting margin of the immovable finger of the male is located one fourth of the distance from the base, not close to the base. The body color of live specimens was greenish blue (Fig. 1), like *M. japonicus*.

The waving display by *M. pistrosinus* involves vertical motion, as in *M. japonicus* (Kitaura *et al*., 2002), not the lateral motion that is typical of *M. banzai*. The greater morphological and behavioral similarities of *M. pistrosinus* with *M. japonicus* than with *M. banzai*, which is phylogenetically more closely related to *M. japonicus* than to *M. pistrosinus* (Kitaura *et al*., 2002), indicate that morphology and behavior do not always reflect phylogenetic relationships.

Fig. 1. A live male (left) and female (right) *Macrophthalmus pistrosinus* in Carnarvon, Western Australia.

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