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Sexual Dimorphism of the Cheliped in the Prawn *Macrobrachium nipponense* (de Haan) and Its Significance in Reproductive Behavior

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ABSTRACT The male of the freshwater prawn *Macrobrachium nipponense* shows great growth in cheliped length relative to body length after maturation. The significance of the male's long chelipeds was investigated in relation to its reproductive behavior in captivity. The mating took place between a mature male and female. The female was guarded between the long chelipeds of the male throughout pair formation for several hours. Direct and persistent interference with the pairing male and female by another mature male was observed. Moreover, other immature individuals and females approaching the pair were also observed. The long chelipeds of the male are regarded as an effective apparatus for his reproductive success in the two aspects: to guard the soft-shelled female immediately after pre-spawning moult from cannibalistic predators, and to guard the female during mating from other male rivals. (*Zool. Mag. 90: 333-337, 1981*)

Macrobrachium nipponense (de Haan) is a comparatively large prawn which is widely distributed in lakes, swamps, estuaries, and often in the upper sluggish flow of large rivers in Japan except for Hokkaido. Their morphology and ecology have been studied by several authors (Kubo, 1949, 1950; Kamita, 1970; Uno, 1971; Ohno *et al.*, 1977). The male possesses a pair of longer cheliped (the second thoracic leg) and is larger in body size than the female. The sexual dimorphism in cheliped is not rare in its congeners (Kamita, 1970; Fujino, 1972). However, little is known about the role of the male's long chelipeds except a few brief descriptions on *Macrobrachium rosenbergii* which was studied in the interest of commercial culture. Ling (1969) reported that the male of *M. rosenbergii* embraced the female with his long chelipeds at mating. Rao (1965) also remarked that in *M. rosenbergii*, attacks on the soft female immediately after pre-spawning moult by other females were prevented by the male's powerful chelipeds. I intend to clarify the allometric relation between the cheliped length and body length in *M. nipponense*, and the role of the male's long chelipeds in relation to reproductive behavior.

Materials and Methods

The prawn were collected with nets from the middle and lower course of the Sagami River, Kanagawa Prefecture, in the summers of 1979 and 1980. Body length (BL: from base of compound eye to tip of telson) and cheliped length (CL: from basipodite, *i.e.*, second protopodite, to tip of dactylopodite) were measured in the laboratory to the nearest 0.1 mm with a slide caliper after every collection. As the lengths of the left and right chelipeds usually showed no significant difference, the left one was measured as a rule. But the longer cheliped was measured in the few individuals whose lengths were unbalanced. Sex was identified from the male copulatory organ on the endopodite of the second pleopod (Kamita, 1970).

Reproductive behavior was observed throughout the breeding season in 1980 by keeping several pairs of mature prawn together in

several glass aquaria (30×60×30 cm), and also by keeping *ca.* 180 individuals consisting of adult and immature prawn in a large rectangle aquarium (2×1×0.3 m) constructed of transparent polyvinyl-chloride. Precise movements and patterns in reproductive behavior were observed in the former aquaria, and interfering movements against the coupled male and female by other individuals were observed in the latter aquarium. Water in the aquaria was circulated and filtered. Water temperature fluctuated between 20°-25°C during the breeding season. The prawn were mainly fed minced fish meat.

Results

Figures 1 and 2 show the allometric relations between the body length (BL) and the cheliped length (CL) in 169 females and 154 males, respectively. They consisted of adults and young after metamorphosis, from 10 to 190 mm in body length. The allometric relation in females of all lengths measured can be represented by a straight line, and a regression equation,

$$CL = 0.248\ BL^{1.2686} \quad (r = 0.989) \qquad (1)$$

is given for an allometric growth equation. On the other hand, the allometric relation of the males is obviously discontinuous near the value 1.6 of the common logarithm of body length, *i.e.* about 40 mm in body length. This relation can be represented by two different regression equations,

$$CL = 0.215\ BL^{1.3355} \quad (r = 0.978) \qquad (2)$$

for males smaller then 40 mm in body length, and

$$CL = 0.0119\ BL^{2.1322} \quad (r = 0.902) \qquad (3)$$

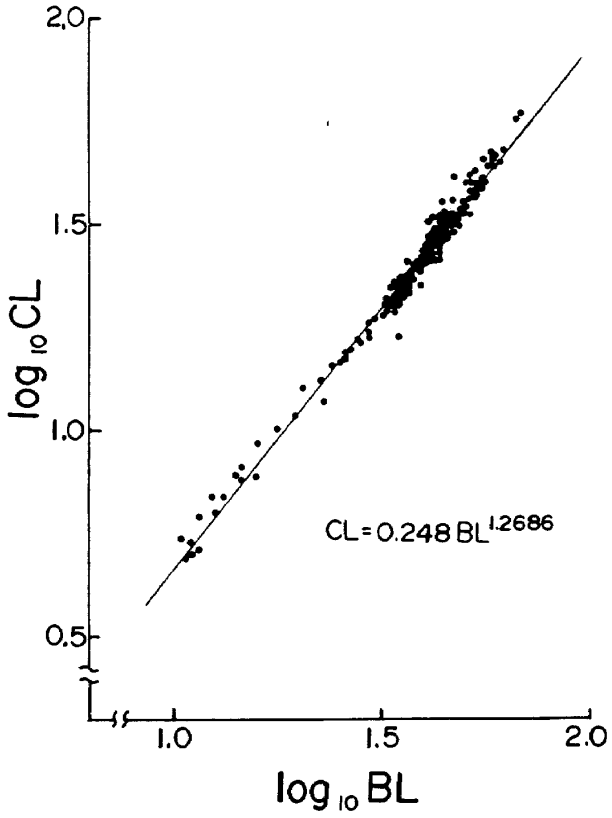

Fig. 1. Allometric relation between female body length (BL) in mm and cheliped length (CL) in mm. Both lengths are represented by common logarithms.

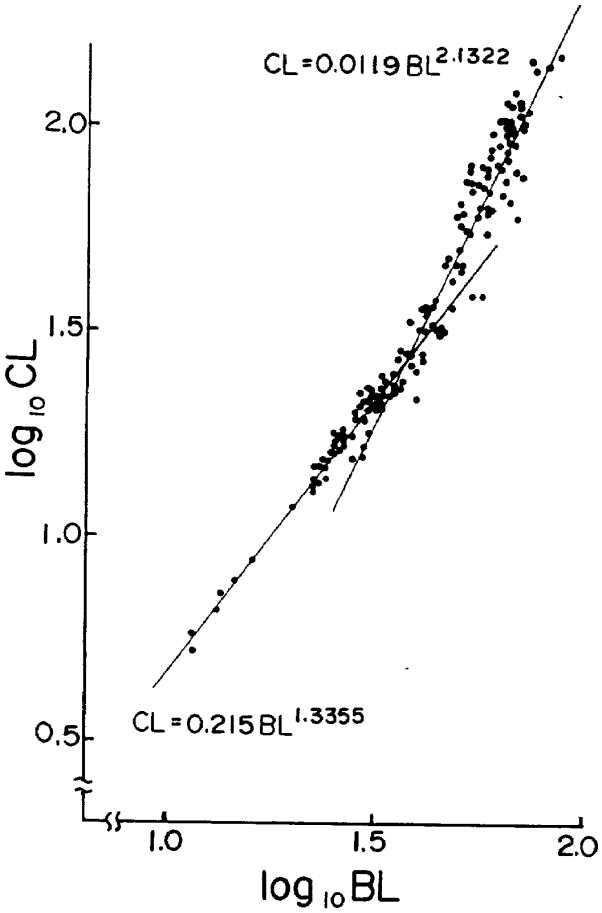

Fig. 2. Allometric relation between male body length (BL) in mm and cheliped length (CL) in mm. Both lengths are represented by the common logarithms.

for males larger than that. The slopes in regression equations (1) and (2) are quite close to each other, whereas the slope in equation (3) for larger males is significantly steeper. The rapid growth of cheliped length in males beyond 40 mm in body length must be related to their sexual maturity, because mating of males smaller than this body size was not observed at all in the aquaria.

During the breeding season, reproductive behavior was observed 13 times. Several stages of reproductive behavior are show in Fig. 3,

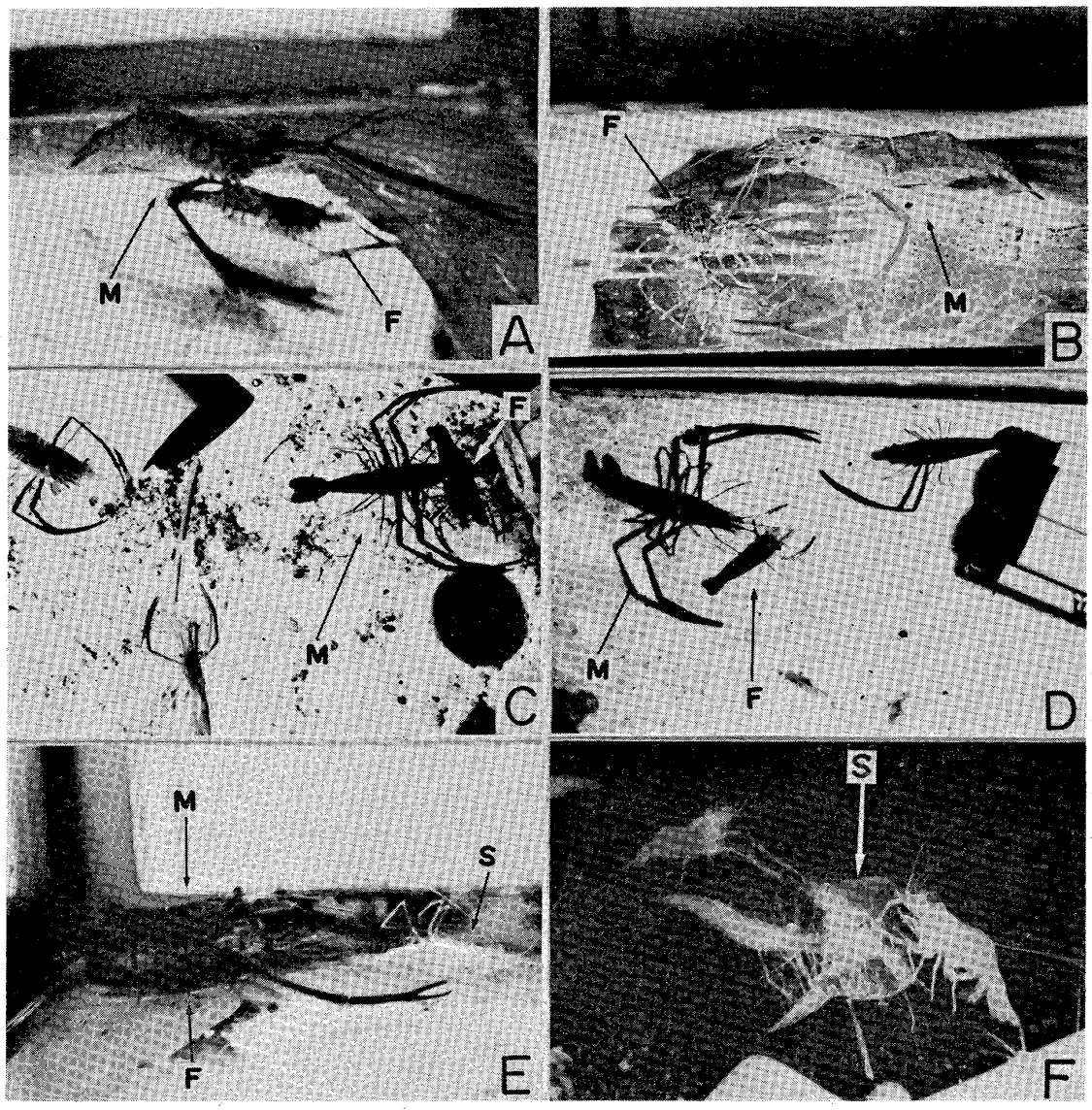

Fig. 3. Reproductive behavior of *M. nipponense*, and interference against the pairing male and female by other individuals kept together in the aquarium. The symbols F, M, and S in the plate indicate the paired female, the paired male, and the slough left by the mating female after pre-spawning moult, respectively. (A) Male chasing a ripe female and opening both his long chelipeds. (B) The pairing male and female. The female is enclosed between the male's long chelipeds. (C) One pair and other individuals approaching them. (D) Fighting between the pairing male and another male, whose one cheliped is lost. (E) The pair immediately after the female's pre-spawning moult, and the slough. (F) Scrambling observed among three individuals for the slough left by the female after pre-spawning moult. They are eating the slough voraciously.

A~F. Pair formation starts from active movements of the male on the bottom of the aquarium with frequent fluttering of his long antennas in search of a ripe female. The ripe and copulation-ready female becomes inactive upon pre-spawning moult. When the male finds out such a female, he begins to chase her slowly with his long chelipeds opened widely (Fig. 3, A). Moreover, the male makes frequent contact with the female with his long antennas. Followed by the male for a few minutes in this state, the female becomes motionless. Then the pair becomes still in the fixed place such as the corner or behind the shelter in the aquarium (Fig. 3, B). Other individuals in the same aquarium often approached the pair as if to surround them (Fig. 3, C). Especially, a few large males among them advanced quite closely and attempted to interfere with the pair with their long chelipeds. Sometimes violent mutual nippings with the cheliped were observed between the paired male and another approaching one. The paired male guarded his mating partner from the intruder by shaking his long chelipeds, and/or abruptly stretching out his bent chelipeds (Fig. 3, D). The paired male guarded his partner not only from approaching larger males but also from small immature individuals when they approached too closely. The paired female rarely guarded herself by shaking her small chelipeds at the others. Among these individuals, interference by large adult males was especially persistent. Forty-one instances of interference were observed in a larger male with repetitive approach and retreat due to the pairing male's defense during an observation period of 30 mintes in the large aquarium. In Table 1, the body lengths and sex of individuals approaching the pair are shown. These individuals were picked up randomly with a net for several minutes without disturbing the pair-forming in the large aquarium. They consisted of males and females of various body sizes including small immature individuals. Only the largest male (55.0 mm in body length) among these individuals made a direct fighting affempt with the pairing male.

Table 1. Body length and sex of the individuals approaching a pair (male of 64.3 mm and female of 40.6 mm in BL) in a large aquarium.

No.	BL (mm)	Sex
1	55.0	Male
2	42.8	Female
3	38.0	Male
4	35.0	Female
5	32.7	Male
6	29.5	Male
7	23.8	Female
8	23.6	Female
9	23.3	Male

The paired female begins the pre-spawning moult between her partner's long chelipeds 1 to 5 hr after pair formation, and completes it within a few seconds (Fig. 3, E). Then, the male instantly grasps her with his third to fifth pereiopods, and turns the female into the supine position. The male accomplishes coitus in a few seconds by pressing his abdomen to the female's as they faced each other longitudinally, or a little crosswise. Other individuals near the pair scramble for the slough left by the mating female, and eat it voraciously (Fig. 3, F). The slough is often eaten by the paired male, preferably after coitus. The male again guards his motionless partner between his long chelipeds for 10 sec to 1 hr after coitus. As activity is recovered, the female leaves the male and hides herself in an appropreate place in the aquarium. Deposition and holding of the eggs were observed 9 to 12 hr after the mating in four females.

Discussion

The chemical substance from a copulation-ready female works as a effective signal in attracting the mating partner diffusively or adhesively, as reported in some prawns (Burkenroad, 1947; Kamiguchi, 1972). In *M. nip-*

ponense also, searching for a ripe female immediately before pre-spawning moult must be induced mainly by a chemical attractant(s) released by the female. In my preliminary experiment, the excited movements of the male, kept with an immature female, were observed by introducing aquarium water in which another pair had just mated. Since the chemical attractant should be released from the female throughout the pair formation to keep her partner beside her, another mature male's approach to the female as reported here is fairly probable. The attempt at interference by such a male was persistent and aggressive, especially to the pairing male. This interaction accompanied by aggression between the pairing male and intruding male can be regarded as a struggle for a mating partner.

However, small immature individuals and other females approached the pair too, though persistent direct attacks against the pair were not observed. The pairing male also guarded his partner from these individuals by shaking his long chelipeds. The scrambling for the slough and voracious feeding on it by these individuals suggest that the chemical substances released from the pairing female stimulated their feeding activity. It is conceivable that the chemical substances from a copulation-ready female about to begin the pre-spawning moult act as the mating attractant for the mature male, and as the feeding stimulator for young and females. It is a widely known fact in prawn culture that soft-shelled individuals are apt to be victims of cannibalism. Thus, long chelipeds in the male of *M. nipponense* should be preferred for reproductive success in two aspects: for the exclusion of the mating rival from his partner, and in defense of his partner at the critical time of moulting. The male's guarding behaviors in *M. nipponense* are nearly same as *M. rosenbergii* reported by Ling (1969) and Rao (1965), but these two aspects of defense were not discriminated by them.

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