

BREEDING BEHAVIOUR IN *MACROBRACHIUM ROSENBERGII* (DE MAN)

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[During the course of experimentations on the inducement of breeding in *Macrobrachium rosenbergii* (de Man) under laboratory conditions, detailed observations on the mating behaviour of the species have been made, which have been elaborated in this account. Various behaviour patterns have been analysed critically and the probable directive and releasive factors for these behaviour patterns discussed. Differences in behaviour of the male resulting from the introduction of another mature male in the arena have been described. An aberrant displacement activity which has been observed in one of the males has also been discussed.]

INTRODUCTION

A recognition of the need to intensify prawn production through culture has spurred an interest in the inducement of breeding commercially important prawns in confinement. Ling (1961) has successfully induced breeding in *Macrobrachium rosenbergii* of Malaya and similar experiments have been attempted by the author at the Central Inland Fisheries Research Institute, Barrackpore. During the course of these experiments, several interesting aspects of behaviour have been observed, which are presented in this account.

Studies on ethological aspects of prawn behaviour are very scarce, particularly in India. An understanding of the different environmental releasive and directive factors for various patterns of the behaviour and the optimum environmental conditions for successful consummation of the released behaviour is very essential for a proper study of the biology. No detailed studies on the breeding behaviour have been made, barring the isolated reference to mating by Ling (1961) and spawning migration by John (1957). Höglund (1943) and Burkenroad (1947) have contributed to the knowledge of spawning behaviour in some other palaemonids and Palombi (1939), Pieplow (1938) and Hudinaga (1942) in penaeids. Observa-

tions of the above authors generally pertain to the study of the behaviour of a single mature male in the presence of a nubile female. In the present investigation attempts have been made to study, in addition, the complex behaviour patterns that develop by the introduction of an additional male into the arena.

Methods

Ripe females and mature males were collected from the Hooghly estuary in the vicinity of Barrackpore, during April to June, 1963. They were kept in cement cisterns of dimensions 180 × 100 × 70 cm. The subjects were fed on a variety of food items like cooked hens' eggs, fresh prawn and fish flesh, wheat flour, soaked and crushed peas, fish meal and live earthworms. Observations on mating were made in the cement cisterns and in cloth cages, of size 55 × 50 × 40 cm.

Mating was observed both in fresh and 7‰ saline water of temperature 24.3—29.5°C, dissolved oxygen content 3.76 — 5.89 ppm, and pH 8.3 — 8.4. Saline water was prepared by the addition of the required amount of crude salt to tap water. Altogether five matings were observed and Table I indicates conditions of water under which the matings were observed.

Observations

TABLE — I. CONDITIONS OF WATER MAINTAINED DURING MATING

Sl. No.	No. of matings observed	Temperature O°C	Salinity ‰	D. O. ppm.	pH	Remarks
1.	2	26.2 — 27.0	2.7	4.4 — 5.04	8.3	Mating observed 12 hrs. after pre-spawning moult.
2.	2	24.3 — 26.5	6.34	3.83 — 5.89	8.4	— do —
3.	1	27 — 29.5	0.2 (Tap water)	3.77 — 5.52	8.5	Mating observed 8 hrs. after pre-spawning moult.

Pre-spawning (Puberty) moult : In prawns mating does not take place in the ordinary conditions of female. Some special 'ripe' condition of female is important. Females after pre-spawning moult when they enter into puberty only are attractive to males. Similar observations were made in *Palaeomonetes* (Burkenroad, 1947), *Crangon crangon* (Nouvel, 1937), *Macrobrachium rosenbergii* (Ling, 1961) and *Penaeus japonicus* (Hudinaga, 1942). This puberty condition lasts for about 20 minutes in *Palaeomonetes* though in *M. rosenbergii* it is for nearly 24 hrs. During this time, "definite chemical mechanical stimuli emanating from mature females must be involved in this post-moult attractiveness" (Burkenroad, 1947). Ling (1961) opines that soon after the pre-mating moult the female prawn secretes a certain kind of substance which strongly attracts the male. All the observed pre-spawning moults of females took place during the night.

The identification of just moulted females which attain puberty was possible by their orange-brown ovaries occupying the dorsal and lateral sides of cephalothorax and formation of brood pouch and branched setae which develop prominently on the first three pairs of pleopods on their inner margins (Ling, 1961). Apart from this, the general appearance of females is distinctive particularly because they assume a pale yellow colour in place of the normal light blue tint.

The male is observed to take food freely before mating whereas the females abstain from feeding, probably because of the con-

stricted condition of the gut caused by the elaboration of the gonad. The movements of female are generally sluggish while the males are active and agile.

It is observed that a female immediately after it attains puberty is attacked by other females in the arena and also predated upon. However, introduction of a male prevents such attacks as the male protects the soft females by arresting them within its powerful chelipeds.

Mating behaviour was observed both in cases where the males and freshly moulted females were introduced in a cage or a cistern a few hours (8—12 hrs.) after the pre-spawning moult (Table I).

Establishment of Territory : The female in the initial stages exhibits an avoidance reaction by moving away from the male to a corner and by hiding itself behind small stones. The male does not pay much attention to the female but busies itself brushing its antennae and pincers with its first pair of chelipeds and abdomen and telson with the last pair of thoracic legs. Later it establishes the territory by stretching out its big chelipeds to the fullest length and chasing off or fighting any other male which approaches the vicinity.

When two males are introduced along with a single ripe female in one cage or cistern sexual fight between the males ensues for about 20 minutes. The males face each other in opposite directions and assume what may probably be called a fighting posture, 'threat or bluff position (Tinbergen, 1951)'. They stand on their walking legs with the telson

resting on the ground and big chelipeds held high and stretched horizontally. The two males come close together, trying to hold each other's chelipeds and in this process push the other backwards (Fig. 1). These postures are repeated at intervals for four or five times. The stronger one occasionally takes quick chances to encircle the body of the other with its pincers and bites the posterior abdominal portion about telson. It also takes chances to bite or pinch the cephalothorax and the big chelipeds of the other trying to injure it. With successive attempts the weaker one is ultimately chased away.

Beconing Behaviour: After the establishment of a territory the male searches for and locates the female after which it performs certain quick spasmodic movements of the second chelate leg. These are very rapid convulsive movements performed in quick succession and are repeated till the female slightly comes out of the corner in which it lodges itself. These movements may probably be interpreted as beconing behaviour which provides the necessary optical stimulus to overcome the avoidance reaction of the female and render it receptive for courting.

Courtship: During courtship which follows beconing behaviour, the stimulus appears to shift from the earlier optical, to

tactile phase. The male touches the female with its feelers and strokes the telson with its pincers. If the female is still in the non-receptive stage, it separates away from the male, as it occurred in one instance. The male, then, encircles the female (Plate IA) with its second chelipeds, simultaneously brushing the cephalothoracic region with its first thoracic legs and periopods. Sometimes, when the female gets receptive much earlier, it approaches in between the fighting males.

Mounting and Sex Arousal: The courtship leads to mounting of the male first with its cephalothorax at right angles on the cephalothoracic portion of the female. Next abdomen is followed and ultimately the male occupies over the female longitudinally. In this posture, the pincers of the male are exhibited in the shape of <—>, while those of female lie parallelly straight. Sex-arousal in female is effected by the preliminary acts of male, of sex-play, which involve active brushing and rubbing of cephalothorax of female with its thoracic legs. The male presses its telson firmly on the abdominal end of female. The upper portion of the abdomen of female is rubbed by vigorous fanning of the pleopods of male. As soon as the female starts responding, the male turns the cephalothoracic part of female to

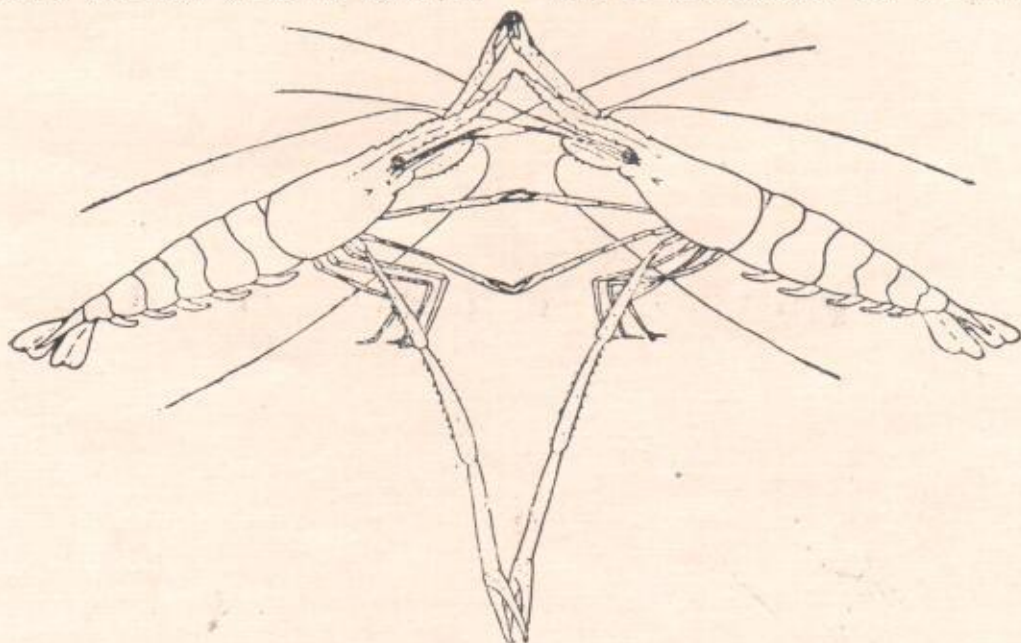


Figure 1 Fight for the establishment of territory in males.

a lateral side with the first cheliped and periopods. Subsequently the abdomen of the female is also turned laterally with the last two thoracic legs aided by telson and pleopods of male. This, in a way, is to get the genital operculum of female opposed to one of the first thoracic legs of the male. In this position, male will be on the female longitudinally with the female completely turned lateral to one side. The first thoracic leg vigorously probes the genital operculum of female. After an interval of half to two minutes the male turns the female to the opposite side making it lie lateral again. It continues rubbing and caressing with its thoracic appendages and fanning of pleopods. Sex-arousal, comprising these tactile stimuli is repeated four to five times lasting for two to ten minutes.

Homosexual Behaviour in Males: In one instance an unusual behaviour was observed, which, most probably, has not been recorded in *M. rosenbergii*. When two males were released in the presence of a ripe female, instead of fighting among themselves, one of them mounted (Plate 2A) the other male and started caressing it with its first pair of chelipeds and thoracic legs (Plate 2B). After

one of them was taken out, the remaining male readily mated with the female. After this male was replaced by the other male, it also mated with the same female within about half an hour.

Copula: As soon as the female gets completely responded, the consummatory act, the copula follows. The female lies on its back beneath the male at an angle of 20-30°; with their bodies crossing each other in the manner of a scissor. The abdominal portion of male slightly bends over the ventral side of the cephalothoracic region of female. During this time, the male firmly holds the female (Figure 2) by its thoracic appendages. This condition lasts for 20 to 30 seconds, during which the sperm deposition takes place. There is a slight movement of the abdomen of the male, perhaps to aid the sperm transfer. Similar observations were made in *Palaemon squilla* (Höglund, 1943), *Sisyonia carinata* (Palombi, 1939) and other Natanians (Balse, 1955-56, Nouvel and Nouvel, 1937 and Hudinaga, 1942). A slightly deviated posture described below, in addition to this typical position, is also observed in the present investigation.

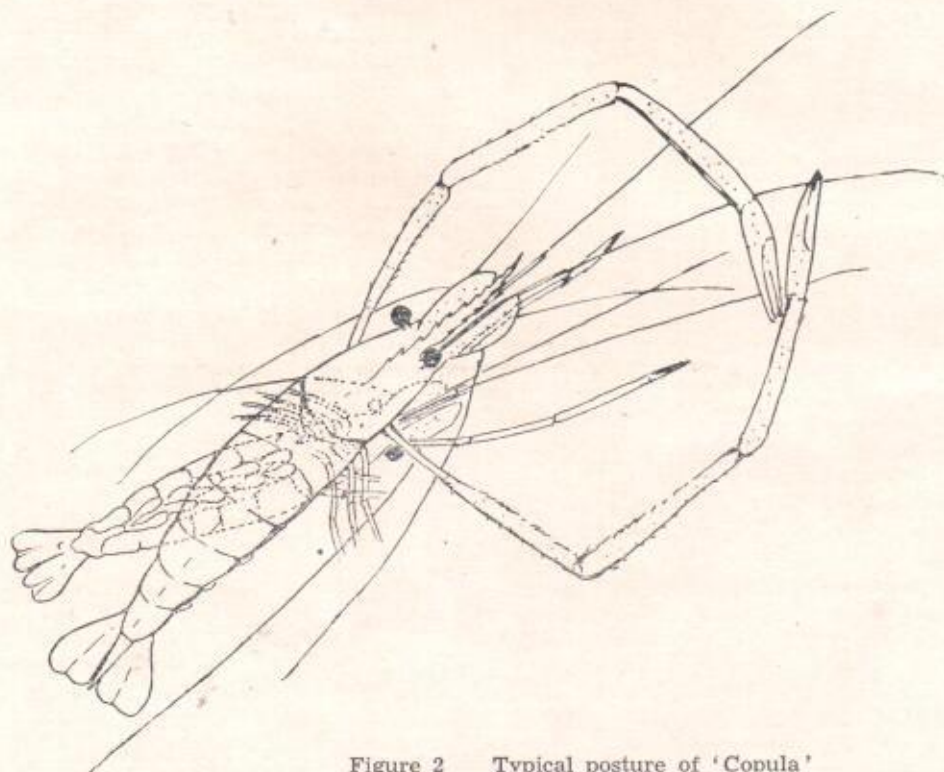


Figure 2 Typical posture of 'Copula'

Second type of copula: This type is essentially similar to the previous one, except that the female instead of lying on its back, assumes a lateral posture underneath the male (Plate IB, Fig.3) and thus the copula is effected.

Though the fight for territory and courtship among males takes about half an hour, the principal phases of mating behaviour — mounting, sex-arousal and copula — last for 2 to 10 minutes. In *Penaeus japonicus*, Hudinaga (1942) observed the duration of copula to be seven to ten minutes. In *Oronectes limosus* (Pieplow, 1938), the time taken is nine hours.

Copula is performed at the bottom of the cages or cisterns. Columnal mating is not observed. In two instances, the female is observed to mate within an hour for a second time with another male, which was replaced with the one previously mated, while the male is not found to mate for a second time as far as observed on the same day.

Post Mating Behaviour: Soon after mating the male relaxes beside the female (Plate IC) for five to ten minutes. Then, it

protects the female within its territory from other males by enclosing the female within its long chelipeds, and zealously guarding it. Male readily takes food, while female refrains from feeding after the completion of mating.

Spawning behaviour: Spawning of eggs on to the pleopods takes place within eight to twelve hours after copulation (Table II). During and after this act, the female leaves its bottom habit and comes to mid and surface waters. The time taken for the eggs to get deposited on to the pleopods is half to one hour. Spawning is observed to coincide with a phenomenon. Cephalothorax of unspawned ripe female will be orange-brown in colour. As the deposition of eggs occurs, a minute black patch appears on the posterior dorsal surface of the cephalothorax and gradually expands into a triangle, the tapering end pointing towards the rostrum; as is normally found in the non-breeding or bred females. The last thoracic legs help to orient the eggs to the ovigerous setae on the first 4 pairs of pleopods. Table II indicates the different conditions of water under which spawning took place.

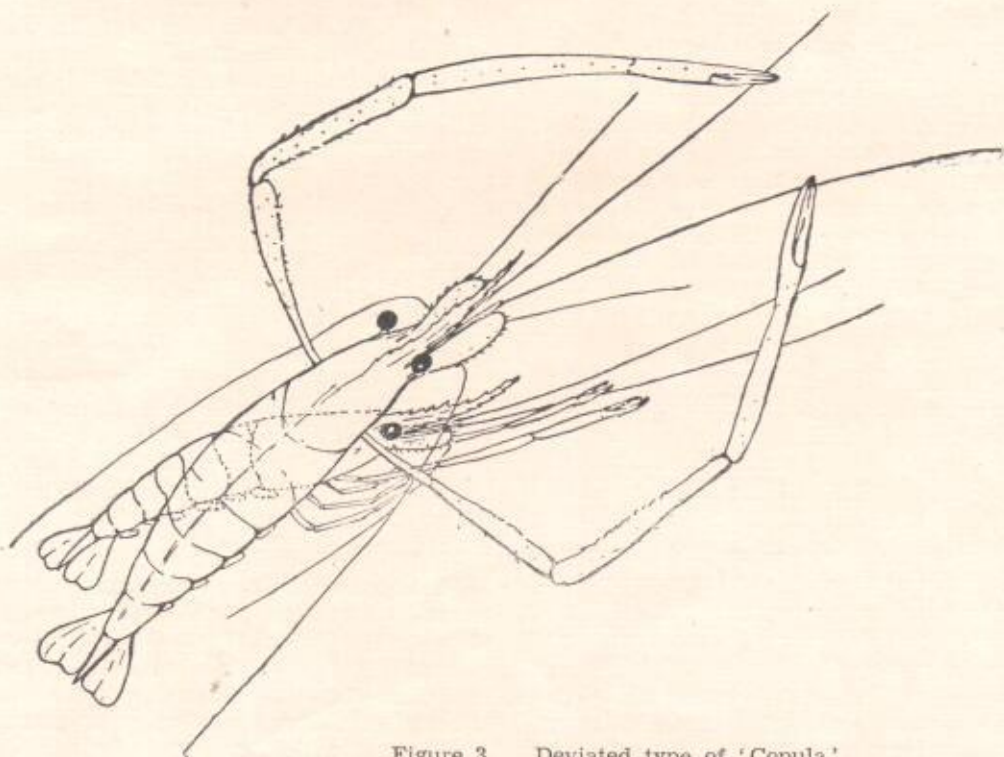


Figure 3 Deviated type of 'Copula'

TABLE — II CONDITION OF WATER MAINTAINED DURING SPAWNING

Sl.	Temperature 0°C	Salinity ‰	ppm.	D.O.	pH	Result
1.	26.2 — 27.0	2.70 — 5.84	4.04 — 5.04		8.3	Spawning observed 8 hrs. after mating
2.	26.0 — 27.8	6.15 — 6.49	3.32 — 3.83		8.0	Spawning observed 8 hrs. after mating
3.	26.4 — 28.0	0.20 — 0.20	4.63 — 6.43		8.5	Spawning observed 12 hrs. after mating

The females are observed to breed more than once, the interval between two successive puberty moults being 20 to 52 days.

Behaviour of Berried Females: The egg-bearing females start to consume the food given, as their ovaries, being shrivelled up, are no more obstruction to the gut. Vigorous movements of pleopods to aerate the eggs are observed throughout the period of incubation.

Incubation: Incubation period lasted for 19/20 days. The eggs hatched out into larvae when the water conditions were Temperature 27.8-28.3°C dissolved oxygen 2.6-6.0 ppm. and pH 8.5 and died within a day. Salinity was traces till the 14th day of incubation and by the time eggs hatched out, salinity was raised gradually to 6‰. Temperature ranged from 25.6-29.4°C, dissolved oxygen 2.6 to 6.0 ppm. and pH 8.4 to 8.6 during the whole period). Berried females with advanced stages of eggs when kept in 4-7‰ saline water (Temperature 26 - 36.2°C, dissolved oxygen 4 - 6 ppm. and pH 8.5 to 8.7) also hatched out successfully and lived for less than a day.

Discussion

Ling (1961) observed that it would be better to introduce a single male prior to the introduction of female, to induce mating. Here, on the contrary, male was introduced later. A single male released in the presence of a ripe female took much longer time to get responses from the female; whereas when an additional male was introduced, the one succeeding in the fight for the establishment of territory, thereby could court and arouse the female for mating more quickly.

Herman Schöne (1961) states that "appetitive behaviour is related to the releasing mechanism (RM), a mechanism in the Central

Nervous System which, at the arrival of a specific configuration of stimuli (sign stimuli) sets the final act, the 'consummatory act' into motion. With the completion of the last, appetance disappears. So after copulation, the females of various decapods are no longer ready for mating". However, in the present investigations, in two instances the female readily copulated with different males, for a second time. However, any male, as far as observed did not mate for a second time on the same day probably 'because the spermatophores, have already been deposited in one female (Hudinaga, 1942)'.

The behaviour aspects of mating follow in a definite chronological order — fight for the establishment of territory, becoming, courtship, mounting, sex-arousal and copula — in a sequential stereotyped fashion. Definite factors — releasers — in the environment steer the heirarchical system of behaviour patterns into the consumatory act (Hoar, unpublished). Presence of a ripe female in the vicinity invokes the male to establish the territory, or to fight with another male, in case of its presence, for the same purpose. Freshly moulted female emanating definite chemical-mechanical stimuli (Burkenroad, 1947) or some secretary substances (Ling, 1961) is the releasive factor for the rest of the behaviour patterns in male for exhibiting sign and tactile stimuli to reach ultimately the goal situation of copulation. Homosexuality in males, as reported, appears to be a result of mere inappropriate movements which are not normal, of appetitive behaviour.

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* As referred to by Herman Schöne (1961).
There was no discussion on this paper.

Recommendations :

1. It is therefore suggested that high priority should be given to intensive research on a planned basis, with proper sequence on delimiting spawning grounds, mortality, age and growth, raciation, migration and other aspects of the dynamics of prawn population.
2. In view of the extensive resources for development of culture-fisheries in brackish water and in fresh water areas which are at present not utilised or under-utilised, intensive research has to be carried out for prawn production.
3. The present research set-up for prawn investigations in the country is very inadequate. Such action as may be necessary to achieve the targets of research should be undertaken.