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Breeding Cycle of *Thalamita crenata* (Latreille, 1829) at Gazi Creek (Maftaha Bay), Kenya

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Abstract—*Thalamita crenata* (Latreille, 1829) is a crustacean decapod that occurs in inter- and sub-tidal environments in the main water channels of the eastern Africa coast. The sandy pools at Gazi creek are areas for artisanal crab fishery. For this study, crabs were collected during low tide from April 1990–March 1991, sexed and measured (carapace width). Females were examined for ovary maturity which was recorded in four classes. It was found that there was no significant difference in male to female ratio between months (χ^2 = 16.83; d.f.= 11; P > 0.05), but the overall sex ratio was significantly different from 1:1 (χ^2 = 19.577; d.f.= 1; P < 0.05). Size heterogeneity between sexes was also significantly different (χ^2 = 112.2; d.f. = 12; P < 0.05). The existence of continuous breeding was inferred from the percentage of ovigerous female crabs. In addition, the relative abundance of ovigerous female crabs in relation to carapace width, percentage frequency of maturity stages of all mature female crabs as well as the mean monthly carapace width of all female crabs obtained during the study period was also taken into account.

INTRODUCTION

The presence of extensive mangrove areas along the Kenyan coast supports crab, prawn and lobster fisheries. The edible portunid crabs of Kenya belong to three genera (*Scylla, Thalamita* and *Portunus*) and are specifically *Scylla serrata* Forsskål, 1755, *Thalamita crenata* Latreille, 1829, and *Portunus pelagicus* Linnaeus, 1758. Mutagyera (1981) observed that crustacean fishery is potentially the most profitable of the fishery activities off the East African coast, and proposed that the biology of valuable East African decapods required further study.

Studies on portunid crabs in various areas of the Indo-Pacific region have included methods of capture (Mutagyera, 1984), distribution in mangrove ecosystems (Onyango, 1995; Cooper, 1997; Kyomo, 1999 and Ravichandran et al., 2001), studies of yolk and larvae (Godfred, 1997; Kannupandi et al., 1999; Kannupandi et al., 2000), food categories (Williams, 1981) and blood and muscle proteins (Kannupandi & Paulpandian, 1975).

Thalamita crenata is a relatively small-sized crab species collected by artisanal fishermen only for local consumption as a source of protein. There is little scientific information on its breeding in eastern African coastal waters. The work reported here was undertaken to generate information on the breeding cycle of *T. crenata* in relation to seasonal changes in the environment.

MATERIALS AND METHODS

Study area

Gazi (4º 25' S and 39º 30' E) is a mangrove creek located on Maftaha Bay on the Kenya south coast

(Fig. 1). This creek has a small lagoon, which holds water at low tide. The surrounding area has no industrial development or discharges, neither is sewage discharged into the creek. It supports an artisanal fishery that includes fin fishes, prawns and crabs during the long rainy seasons.

Sample collection

Crabs were collected using a scoop net over a sampling distance of 2 km during low tide for a week each month from April 1990 to March 1991. All crabs were collected alive and taken to the laboratory and placed in a deep freezer which both killed and preserved them until further analysis. For each crab, carapace width (mm) and sex were recorded. The number of ovigerous (with extruded ovaries) female crabs was also recorded and all female crabs had their carapace opened for observation of the maturity stages of the ovaries.

Samples analysis

Ovarian maturity stages

Observations of the ovaries were made with a binocular microscope. The maturity stages of ovaries were grouped into four main classes following the procedure adopted by Pillay & Ono (1978). Ovarian development was arbitrarily distinguished by size and colour of ovary as follows:

Stage 0 – Virgin / Resting. Ovary very thin (< 2 mm) and transparent (colourless). No initiation of gametogenesis.

Stage 1 – Developing. Ovary is approximately 2 mm thick and creamy white in colour.

Stage 2 – Well developed ovary, approximately 5 mm thick, broad, yellow and contains medium-sized oocytes.

Stage 3– Ripe. Ovary is dark brown and practically fills the body cavity, pressing

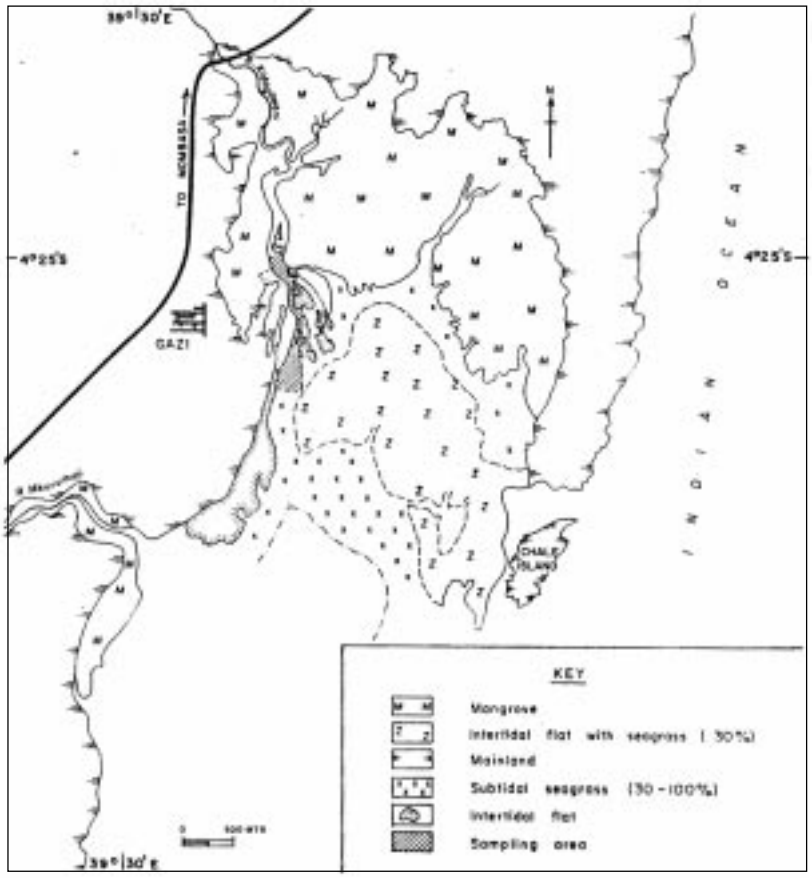

Fig. 1. Study area—Gazi creek at the Kenya south coast

against the hepato-pancreas and the stomach. The ovary is highly lobulated and has large oocytes. After this stage the eggs are extruded onto the pleopods.

Sex ratio

The ratios of males to females of *T. crenata* were determined in the monthly catches.

The overall sex ratio was calculated using the formula (Snedecor & Cochran, 1989):

$$\chi^2 = \sum(f - F)^2 / F \qquad (1)$$

F = expected f = observed.

A variance test of homogeneity of the binomial distribution was performed on the monthly samples to verify whether there was a significant difference in sex variation using the formula (Snedecor & Cochran, 1989):

$$\chi^2 = (\sum p_i a_i - \bar{p}A)/(\bar{p}\bar{q}) \qquad (2)$$

where $p_i = a_i/n_i$, a_i = proportion of males or females in a size class or monthly sample, n_i = total number of males and females in a size class or monthly sample, $\bar{p}$ = A/N, $\bar{q}$ =A/N, A = total number of a_i, N = total number of n_i.

$\bar{p}$ = Totals of males (A) / overall total (N);

$\bar{q}$ = Totals of females (A) / overall total (N).

A variance test of homogeneity of the binomial distribution was performed on the samples to determine the size–frequency distribution of males and females using formula (2). The overall mean sizes were compared using the *t*-test (Snedecor & Cochran, 1989).

Breeding cycle

This was established from the:

(a) percentage of ovigerous females in each month;
(b) relative abundance of ovigerous crabs in relation to carapace width;
(c) percentage frequency of maturity stages of ovaries of all mature female crabs; and
(d) monthly mean carapace width of all mature female crabs obtained during the period of study.

RESULTS

Ovarian maturity stages

All the four stages of ovarian development were observed in *T. crenata* in this study (Fig. 2). Stage 0 of ovarian development had the fewest crabs

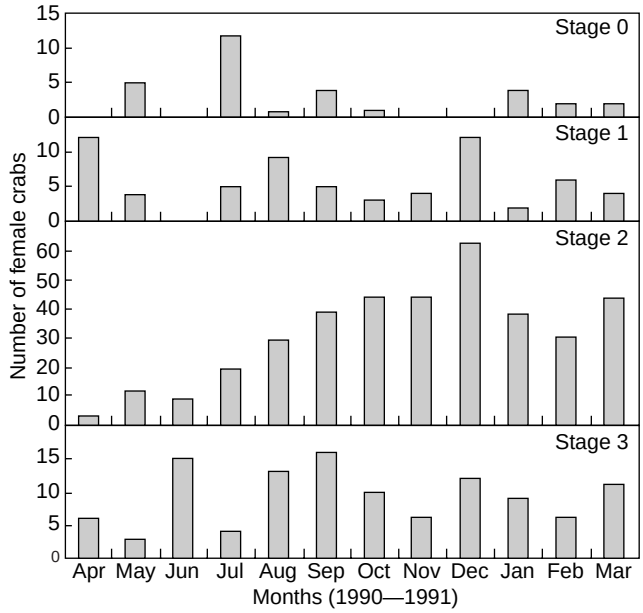

Fig. 2. Maturity stages 0–3 of ovaries of *Thalamita crenata* from Gazi Creek

overall; in April, June, November and December no crabs in this stage were observed. The number of crabs with ovaries in Stage 1 was higher than that with ovaries in Stage 0 and only June had no Stage 1 individuals. Crabs with ovaries in Stage 2 of development were abundant in each month, throughout the sampling period. There was a grey mass which was thought to be a peri-ovarian fatty body over a bright yellow Stage 2 ovary. Because of the variable crabs' sizes, it was difficult to group the fatty body into sizes. The number of crabs with ovaries in Stage 3 tended to be low, though occurring throughout the sampling period. Crabs in this maturity stage also had a grey mass over the ovary.

Sex ratio

The highest female-to-male ratio was recorded in June (Table 1). The other months with high female ratios were May, October, January, February and March. The females dominated the catch in most months during the sampling period. A variance test showed that there was no significant difference in the monthly binomial distribution of the sex ratio during the sampling period, ($\chi^2 = 16.83$; d.f. = 11; $P > 0.05$).

The overall sex ratio was significantly different from 1:1 as shown by the chi-square test ($\chi^2 = 19.577$; d.f. = 1; $P < 0.05$).

Table 1. Sex ratios of *Thalamita crenata* during the sampling period (Pooled sex ratio 1:1.31; $\chi^2 = 16.83$; d.f. = 11; P > 0.05)

Month	Males	Females	Total	M:F
1990				
Apr	32	21	53	1 : 0.66
May	16	24	40	1 : 1.50
Jun	12	24	36	1 : 2.00
Jul	30	40	70	1 : 1.33
Aug	40	52	92	1 : 1.30
Sep	51	64	115	1 : 1.25
Oct	36	58	94	1 : 1.61
Nov	62	54	116	1 : 0.87
Dec	67	86	153	1 : 1.28
1991				
Jan	31	53	84	1 : 1.71
Feb	30	44	74	1 : 1.47
Mar	37	61	98	1 : 1.65
Total	444	581	1025	1 : 1.31

It can also be observed that in smaller size classes with carapace width ranging from 40.5 – 55.44 mm females were more numerous than males (Table 2). On the other hand, males dominated the catch in the larger size classes (55.5–80.44 mm). The unimodal distribution of this species in relation to the different size classes is shown by percentage of totals column with a peak at size class 45.5–50.44 mm. The variance test of homogeneity of the binomial distribution of sex in relation to size showed a very significant evidence of

Table 2. *Thalamita crenata* sex ratio in relation to size (width) of carapace

Carapace width (mm)	Males	Females	Total	M:F	% of total	χ^2	P
15.5–20.44	3	3	6	1:1	0.6	0	> 0.05
20.5– 25.44	16	18	34	1:1.13	3.3	0.058	> 0.05
25.5–30.44	42	42	83	1:0.98	8.1	0.006	> 0.05
30.5–35.44	50	70	120	1:1.40	11.7	1.167	> 0.05
35.5–40.44	60	88	148	1:1.47	14.4	2.648	> 0.05
40.5–45.44	50	108	158	1:2.16	15.4	10.646	< 0.05
45.5–50.44	49	112	161	1:2.29	15.7	12.326	< 0.05
50.5–55.44	41	87	128	1:2.12	12.5	8.266	< 0.05
55.5–60.44	47	39	86	1:0.83	8.4	0.372	> 0.05
60.5–65.44	39	14	53	1:0.36	5.2	5.896	< 0.05
65.5–70.44	28	1	29	1:0.036	2.8	12.569	< 0.05
70.5–75.44	16	0	16	16:0	1.6	8.0	< 0.05
75.5–80.44	3	0	3	3:0	0.3	1.5	> 0.05
Total	444	581	1025	1:1.31	100	9.156	< 0.05

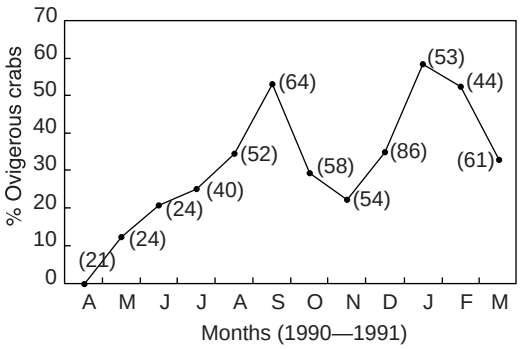

Fig. 3. Percentage of ovigerous *Thalamita crenata* females obtained during the study period (Total number of female crabs in each month in parentheses)

heterogeneity (χ^2 = 112.20; d.f. = 12; P < 0.05). When the overall mean sizes for males and females were compared using the *t*-test, a very significant difference between the sexes in the different size classes (t = 3.745; d.f. = 24; P < 0.05) was found.

Breeding cycle

The percentage by month of ovigerous female *T. crenata* is plotted in Fig. 3. These crabs breed throughout the year. There were two breeding peaks in September and January, when the percentages of ovigerous crabs are high.

Figure 4 shows the monthly relative abundance of ovigerous crabs, from which it is evident that

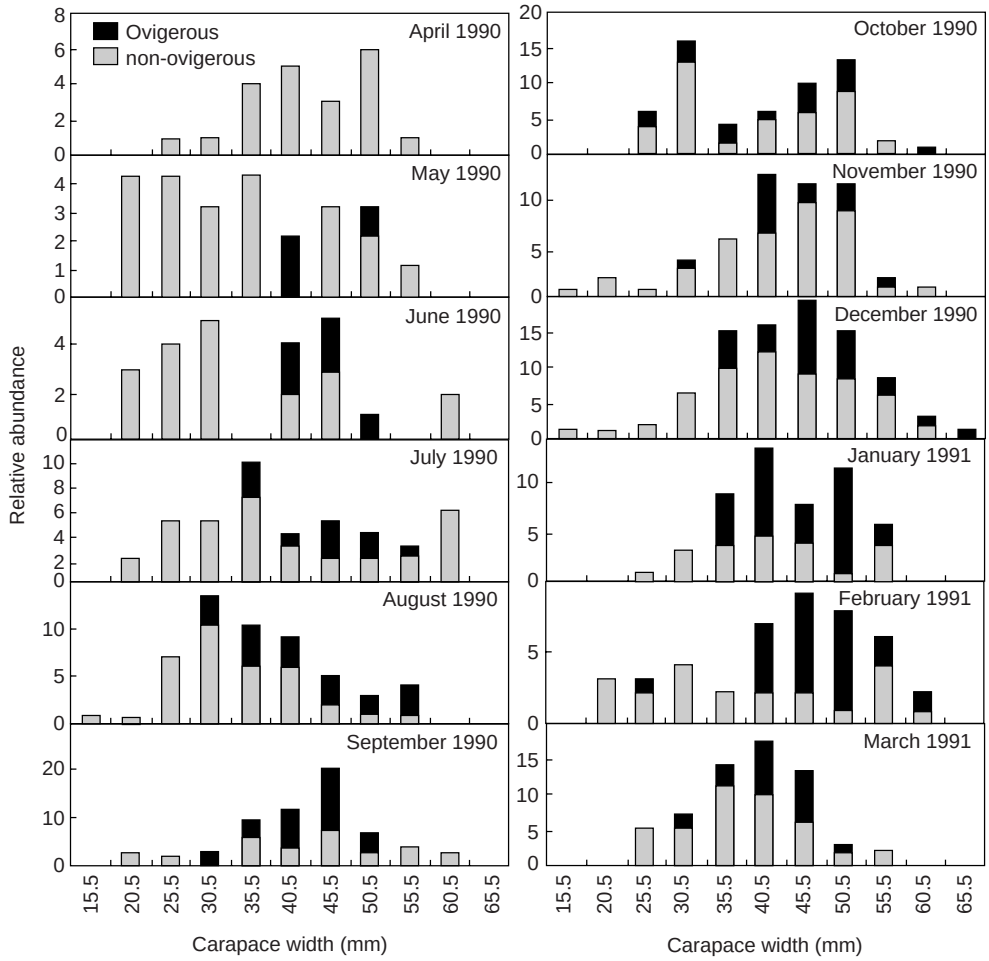

Fig. 4. Size frequency distribution of ovigerous and non-ovigerous female *Thalamita crenata*

female crabs of carapace width 40.5 mm initiate egg laying in May. During the first breeding peak (Fig. 3) in September, they are joined by younger crabs of carapace width 30.5 mm and older crabs of carapace width 60.5 mm. The second breeding peak (Fig. 3) in January has crabs of carapace width between 35.5 mm and 55.5 mm being ovigerous. Egg laying starts to decline in February, during which a few young crabs of carapace width 28.9 mm are recruited into the breeding population. By April no ovigerous crabs are available in the population. During all the months, ovigerous crabs with carapace width between 40.5 mm and 45.5 mm were obtained, and in September, December, January, February and March, that size class had a larger number of ovigerous crabs.

Figure 5 shows the percentage frequency of maturity stages of all female crabs collected during the sampling period. The number of ovaries in Stage 0 of development was higher during May (20.8 %) and July (30 %) only. August–October and January–March had very low percentages in that stage. Maturity Stage 1 and above occurred

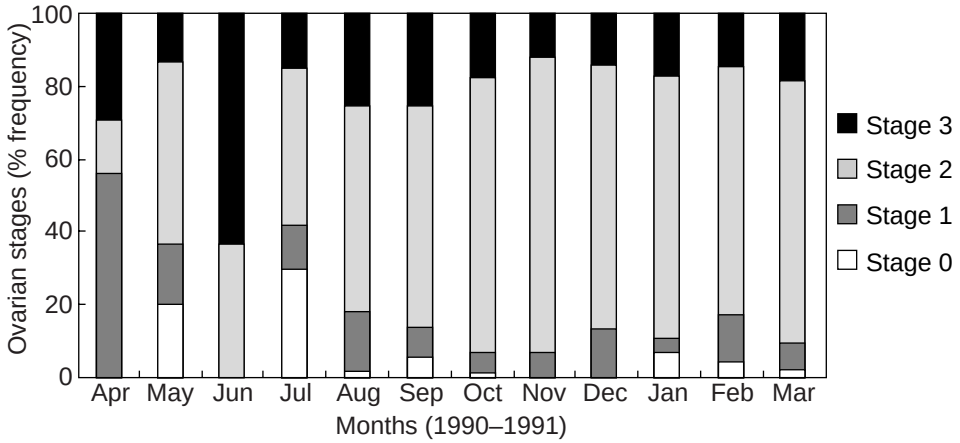

Fig. 5. Percentage frequency of ovarian maturity stages of all female *Thalamita crenata* obtained during the sampling period

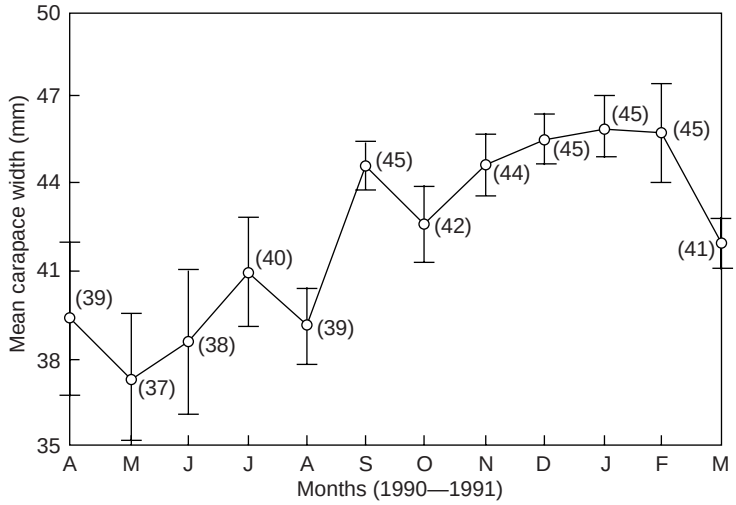

Fig. 6. Variation in the mean monthly carapace width of mature female *Thalamita crenata.* Numbers in pooled monthly sample means are given (bars indicate standard errors of the means)

throughout the year indicating that mature females were actively breeding throughout the year, hence continuous ovarian development. April had the highest percentage of individuals in maturity Stage 1 (57 %) yet there were no ovigerous crabs, while June had none in Stage 0 and 1. Maturity Stage 2 occurred in high percentages except in April (14 %) while November had the highest percentage (83 %) in this stage, though there was reduced spawning activity. June had the highest percentage (63 %) of crabs in maturity Stage 3 while July had the lowest percentage (10 %) in maturity Stage 3 despite the presence of this stage throughout the year.

The mean monthly carapace width of all mature female crabs obtained (Fig. 6) was low between April and August. It peaked in September and February then started to decline thereafter.

DISCUSSION

Ovarian maturity stages

Crab ovaries are bilobed structures with two antero-lateral lobes which fuse posteriorly with paired reproductive oviducts connecting the ovary to a pair of external genital openings on the crab's sixth thoracic sternite (Wild, 1983). The ovaries undergo colour changes as they mature (Spencer, 1932 [in Wild, 1983]) and also increase in mass, as has been observed in *Cancer magister*. Ovarian size and colour are related to histological changes in *Callinectes sapidus* and *Geryon quinquedens* (Wild, 1983). Prasad & Neelakantan (1989) identified four developmental stages of the ovary in *Scylla serrata* which were recognised using colour changes in the ovary and the oocyte diameter. Pillay & Ono (1978) grouped the developing ovaries of grapsid crabs into four classes based on colour and size of the ovaries observed with the naked eye. In this study, increase in mass and colour changes in the *T. crenata* ovaries similar to that observed by Pillay & Ono (1978) were observed.

Sethuramalingam et al. (1982) identified three stages of ovarian development in *Portunus sinipes* (Miers) and in *Thalamita chaptali* (Aud-et-Savign) in Porto-Novo. At Gazi, maturity stages of *T. crenata* ovaries were based on colour changes which ranged from creamy white to yellow to brown, as observed in *S. serrata.* The ovary also increased in mass and the grey mass over the ovary in Stages 2 and 3 of development was identified as the peri-ovarian fatty body accumulation (Onyango, 1995). Because of the crab's size it was difficult to group the fatty body into sizes and colours. Maturity Stage 0 was absent in only four months and this could have been due to the fact that crabs store sperm for fertilisation, which promoted ovary development immediately after spawnings (Erhirarasi & Subramanium, 1980 [in Prasad & Neelakantan, 1989]). Maturity Stage 1 occurred in low numbers but was completely absent in June. Maturity Stage 2 was abundant throughout the study period. The presence of maturity Stages 2a and 3 confirms that *T. crenata* is a continuous breeder.

A few ovigerous crabs with carapace width above 35 mm had ovaries in Stage 0 of development. This could have been because they had no sperms in store to stimulate ovarian development immediately after spawning. This observation concurred with observation of Prasad & Neelakantan (1989) that even larger crabs had to be impregnated more than once for development of ovary.

Sex ratio

The size frequency distribution of a population is a dynamic characteristic that can change throughout the year as a result of reproduction and rapid recruitment from larvae. In several species of *Uca*, unimodal population size structures have been observed (Thurman II, 1985). The author also reported that unimodal distributions are observed in populations which reproduce continuously while bimodal distributions are observed where a species reproduces seasonally. Sethuramalingam et al. (1982) reported that in *T. chaptali*, males and females alternately dominated the population during the sampling period. In the data pooled for the whole year, the males were found to be slightly more than the females and the chi-square value deviated significantly from the expected 1:1 ratio in the first year of sampling although data pooled for both years conformed exactly to the expected 1:1 ratio.

In *T. crenata*, a preliminary test for the homogeneity of variance of the binomial

distribution showed that there was no significant variation in the monthly binomial distribution (χ^2 = 16.83; d.f. = 11; P > 0.05). The overall sex ratio was significantly different from the expected 1:1 ratio (Table 1) being 1:1.31 males to females (χ^2 = 19.577; d.f. = 1; P < 0.05).

The size frequency distribution of both male and female *T. crenata* was unimodal, typical of continuous breeders (Thurman II, 1985). The ratios (Table 2) show that females dominated the catch from carapace width 40.5–55.44 mm while males dominated larger carapace width classes. The variance test for the homogeneity of the binomial distribution showed that there was a very significant variation in the classes (χ^2 = 112.20; d.f. = 12; P < 0.05). The overall mean sizes for males and females were compared using a *t*-test and there was a significant difference between the sexes (t = 3.163; d.f. = 24; P < 0.05). This significant evidence of heterogeneity could have resulted from differential mortality, whereby ovigerous female crabs were being fished out of populations, leaving mostly males.

Breeding cycle

The life cycle of many animals is timed by environmental factors so that the young are produced at a period favourable for their survival (Giese, 1959). Booloottian et al. (1959) suggested that the ultimate aim of research on reproductive cycles is to correlate them with environmental factors such as temperature, light, tidal variation and food availability, observing there are both continuous and synchronised seasonal breeders. They concluded that synchronised breeding in semi-terrestrial crabs and continuous breeding in lower inter-tidal and swimming crabs may be related to seasonal changes in temperature, day length and availability of food resources which are more sharply defined on land than in the aquatic environments.

Sethuramalingam et al. (1982) reported that *T. chaptali* breeds from February to September when the ovigerous female crabs were obtained. At Gazi, *T. crenata* is a continuous breeder because ovigerous crabs were obtained throughout the year except for April (Fig. 3). The peak months for spawning were September and January which were not apparently related to temperature because the sampling site had high temperatures throughout the year with an annual range of 26.1 ± 2.2 ºC. These peaks also fall outside long or short rains and this may be significant in that fluctuations in salinity are minimised during the dry periods (Hill, 1974). The observations made by Booloottian et al. (1959) that lower inter-tidal crabs re-berry immediately after the escape of zoeae, is confirmed in the present study for *T. crenata* because observations made on ovaries of some ovigerous crabs show that the crabs had their ovaries in maturity Stage 3 ready for spawning after the escape of zoeae.

From Fig. 4 it can be observed that female crabs with a carapace width of between 40.5 to 45.44 mm form the bulk of the breeding population in every month. This therefore is the most reproductively active size. Figure 5 shows that activated ovaries (Stages 1 to 3) were obtained throughout the sampling period, indicating that they are continuous breeders. This concurs with the findings of Booloottian et al. (1959) that intertidal crabs are continuous breeders. The percentages on Table 2 show the unimodal distribution characteristic of continuous breeders. Figure 6 shows that the breeding population was composed of younger female crabs and was later joined by older female crabs in April to August. The older crabs berry between September and February, after which they either migrate out of the inter-tidal area or are fished out, hence a decline from March during the breeding season.

Various crab species are used as food by the local communities, and future research should focus on establishing their nutritive food value, biology and ecological relationships in their mangrove habitats.

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