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REPRODUCTION IN *UCA (CELUCA) TRIANGULARIS BENGAL* CRANE, 1975 INHABITING THE ADYAR ESTUARY AND BACKWATER, MADRAS, INDIA.

S. KRISHNAN

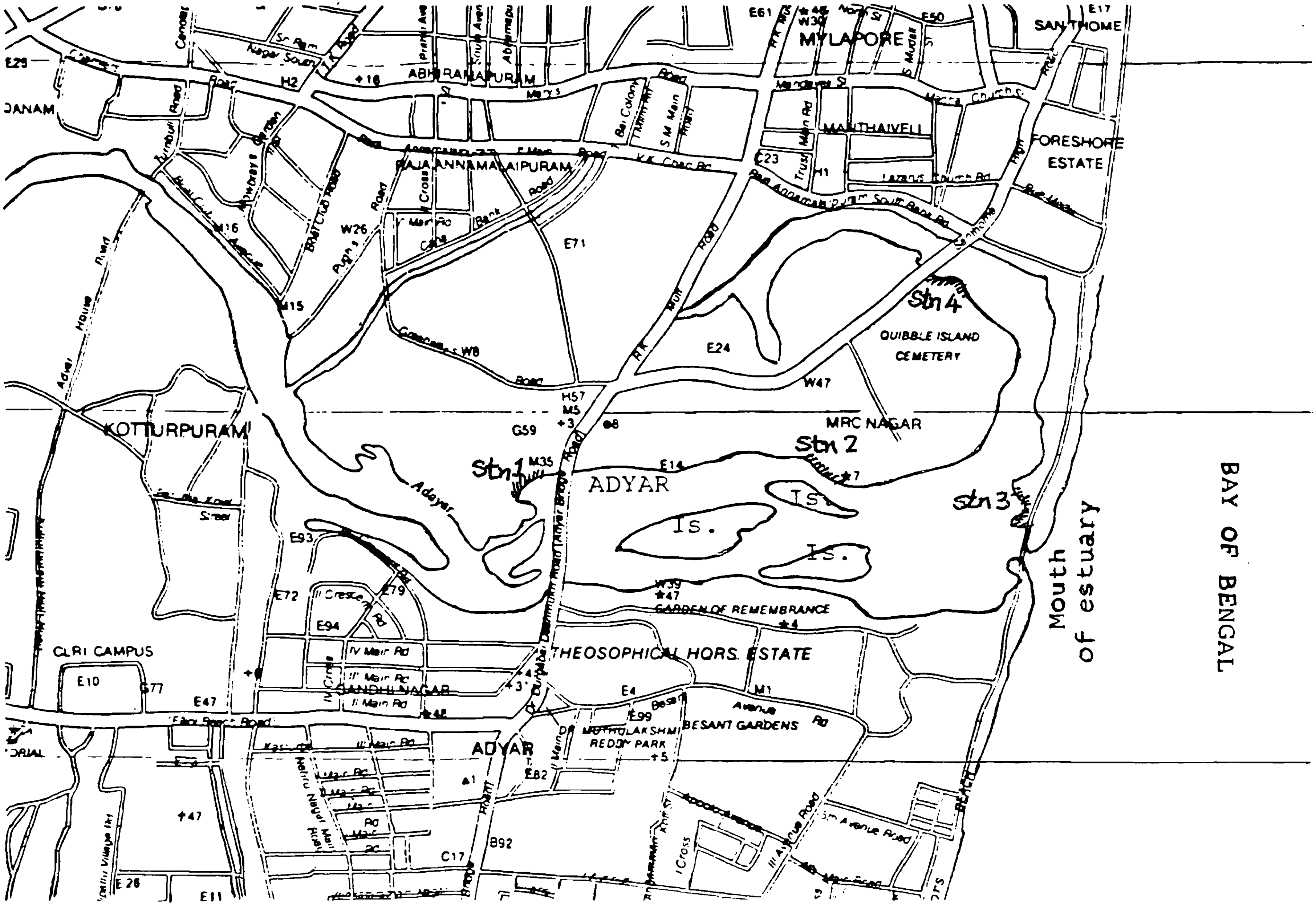
Marine Biological Station,
Zoological Survey of India,
100, Santhome High Road,
Madras-600 028.

AND

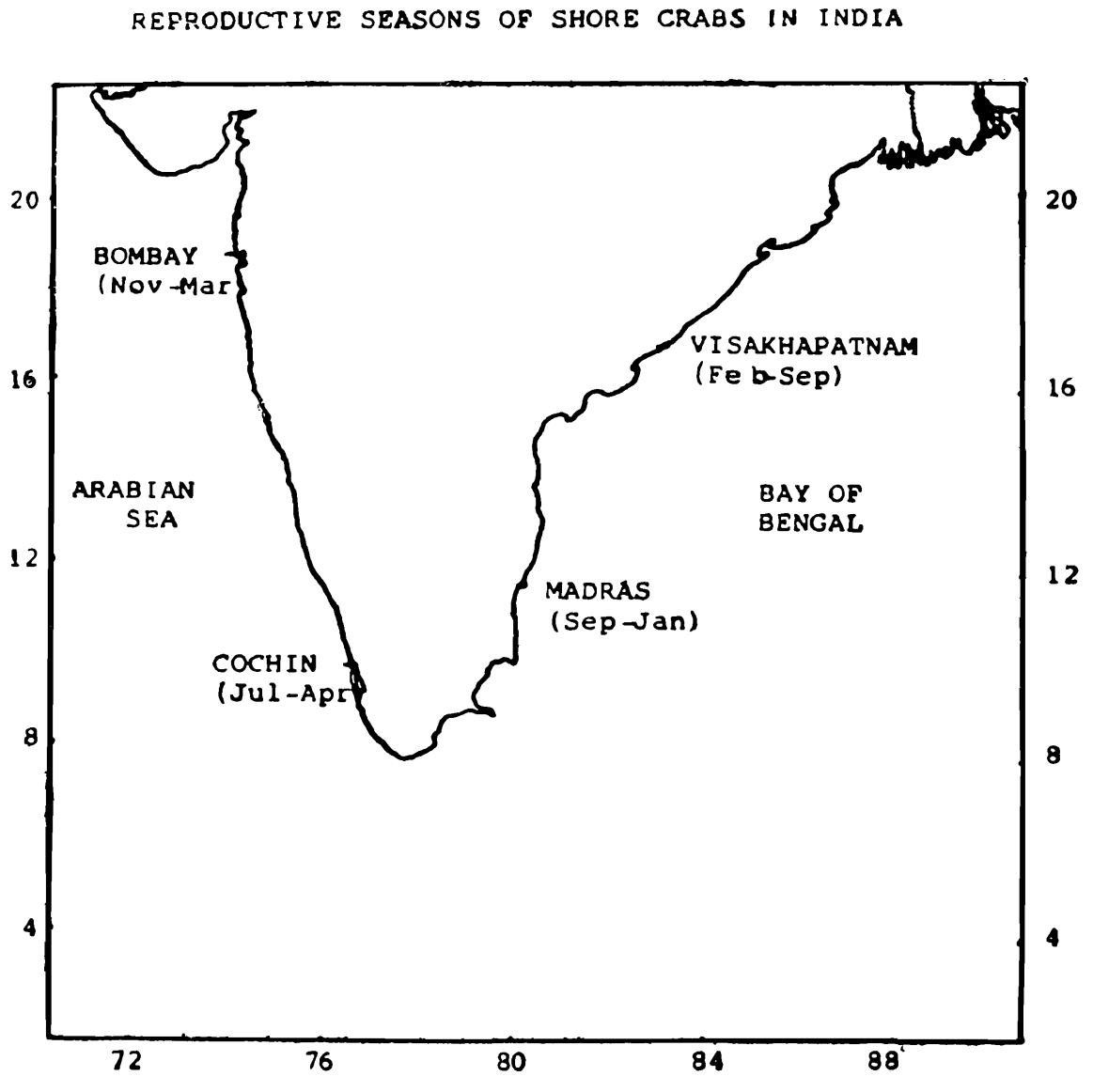
V. RAMACHANDRAN
Department of Statistics,
Annamalai University,
Annamalai Nagar, Tamilnadu.

INTRODUCTION

The annual reproductive cycles of estuarine crustaceans vary in periodicity and intensity in the East and West coasts of India due to differences in the "monsoon rains" (Panikkar and Jayaraman, 1966). Semi-annual breeding patterns have been reported for a number of species in the East coast (Giese and Pearse, 1974) where the South-west monsoon brings little rain during summer months and its receding phases telescope into the North-east monsoon regime which produces considerable rain (Hu-Cheng, 1967). Quite a number of species exhibit breeding activities round the year (Panikkar and Aiyar, 1939 ; Subramoniam, 1977 ; Varadarajan and Subramoniam, 1982). Chhapgar (1959) indicated that the majority of shore crabs breed during November-March on the West coast at Bombay while Nair and Pillay (1975) observed that the maximal breeding activity occurred during the post-monsoon (South-west) though the breeding season extended for several months at Cochin on the West coast. They observed that the gonad index remained high in the female *U. annulipes* from July to April


MYLAPORE
SAN THOME
ABHIRAMAPURAM
MANTHAIVELI
FORESHORE ESTATE
RAJA ANNAMALAIPURAM
Stn 4
QUIBBLE ISLAND CEMETERY
MRC NAGAR
Stn 2
Stn 1
ADYAR
Stn 3
Is.
Is.
Is.
KOTTURPURAM
Adayar
GARDEN OF REMEMBRANCE
THEOSOPHICAL HQRS. ESTATE
CLRI CAMPUS
GANDHI NAGAR
BESANT GARDENS
ADYAR
Mouth of estuary
BAY OF BENGAL
Map No. 2

with a peak in December indicating the ability of the crab to breed for a period of ten months at a stretch in a year. Panikkar and Aiyar (1939) concluded that the shore crabs breed mostly from September to January along the Madras coast (East coast). Rao *et al* (1986) found that the shore crabs breed from February to September at Visakhapatnam on the east coast (Map 1).



Map 1

Occasionally the summer monsoon results in more rainfall in the Madras coast, the waning period of which is continued as the setting period of the winter monsoon and during these years, there is a possibility of continued reproduction in the fiddlers. Altevogt (1957) studied the physiology of reproduction, waving seasons and patterns in two species of

fiddler crabs from South India. Feest (1969) established that the females of *Uca triangularis* breed during the two monsoons in South-India. Reproductively active males could be located through out the year but courtship activities were considerably more after the first rainfall. The occurrence of berried females becomes scarce during summer months when atmospheric temperature maxima shoot up beyond 38°C and the relative humidity percentage dips below 60 accompanied by the failure of the summer monsoon. Little information is available on the breeding activities and reproductive cycles of the fiddlers of the Madras coast and specifically no literature is available on *Uca* (*Celuca*) *triangularis bengali* inhabiting the Adyar estuary and backwater and hence this work.

MATERIAL AND METHODS

The experimental material *Uca* (*Celuca*) *triangularis bengali* was collected at random from four different stations located in the Adyar estuary and backwater (Map-2). A minimum of ten females were collected from each station once every fortnight following the procedures of Boolootian *et al* (1959). The samples were brought to the laboratory and wet weights were taken in a single pan electrical balance. Females were sacrificed and ovaries were removed by thin stainless steel blade and needles. The ovaries were either preserved in 5% formaldehyde (Anal R Grade) or utilised for experimental procedures afresh. Following the procedures of Gray (1942) the egg diameter was estimated with an ocular micrometer mounted on a Meopta stereomicroscope by placing a 1 mm grid graph paper under a Corning petridish containing either fresh or preserved eggs. Clutch sizes were calculated by counting the number of ova attached to a single pleopod of an egg bearing female under a dissection microscope and the resultant number was multiplied by the number of pleopods to estimate the total number of eggs per female. Gonad index was calculated by dividing the wet weight of the gonad by the wet weight of the whole female and multiplying this factor by a hundred. Courtship activities were observed through a pair of low power Super Zenith optical binoculars

and a limited number of still photographs were taken using 400 ASA colour film loaded in a Zenith TTL camera during day light.

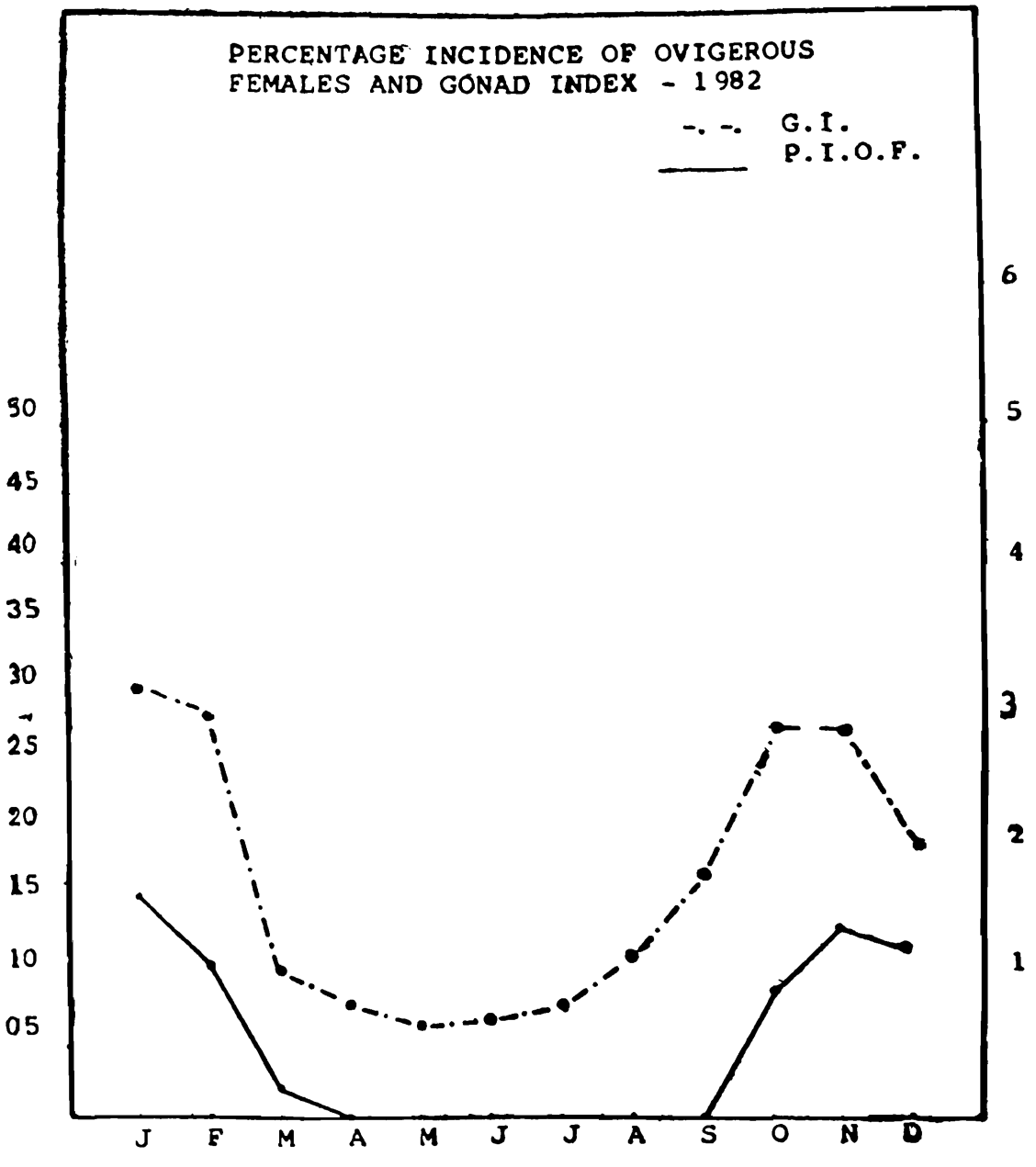


Fig. 1

Releasing of developed eggs for hatching has been observed during nocturnal high tides of the full and new moon. Such observations were restricted to July and November, 1983 ; October, 1984 and January, 1985. Statistical analyses were carried out with the aid of a HCL fourth generation computer at the Statistics Department of Annamalai University.

RESULTS

Fluctuations in the mean gonad index over a period of

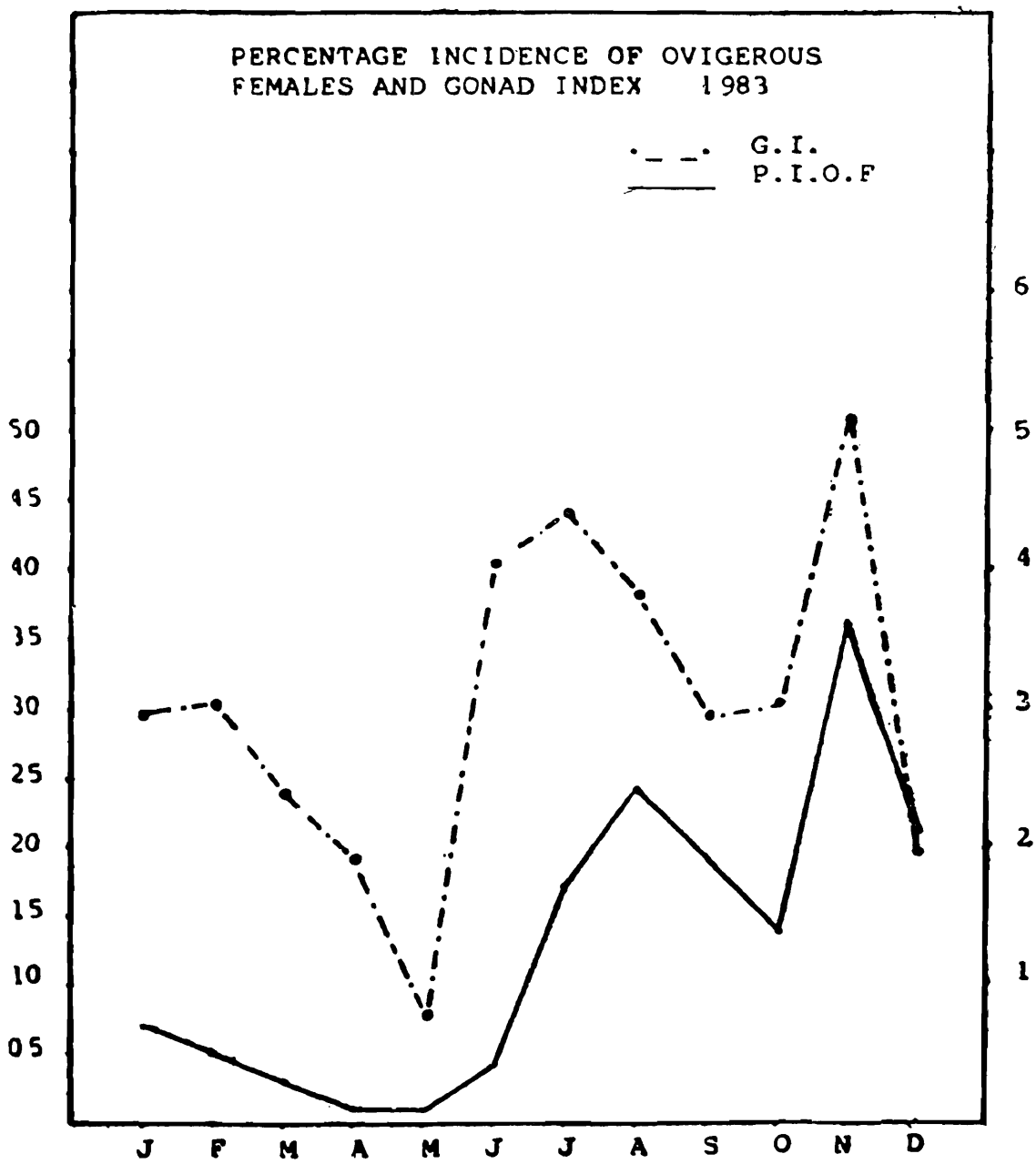


Fig. 2

four years indicate that the monsoons have pronounced effect on breeding (Figure 1, 2, 3 & 4 and Table 1, 2, 3 and 4).

During 1982, both the monsoons failed resulting in drought condition. The Adyar river upto four kilometers from the coast line dried up except for the streams of sullage and stagnated high saline ponds near the Maraimalai Bridge

and the tenements located on one side near Sathya Studios and Kotturpuram. No male courtship activity could be

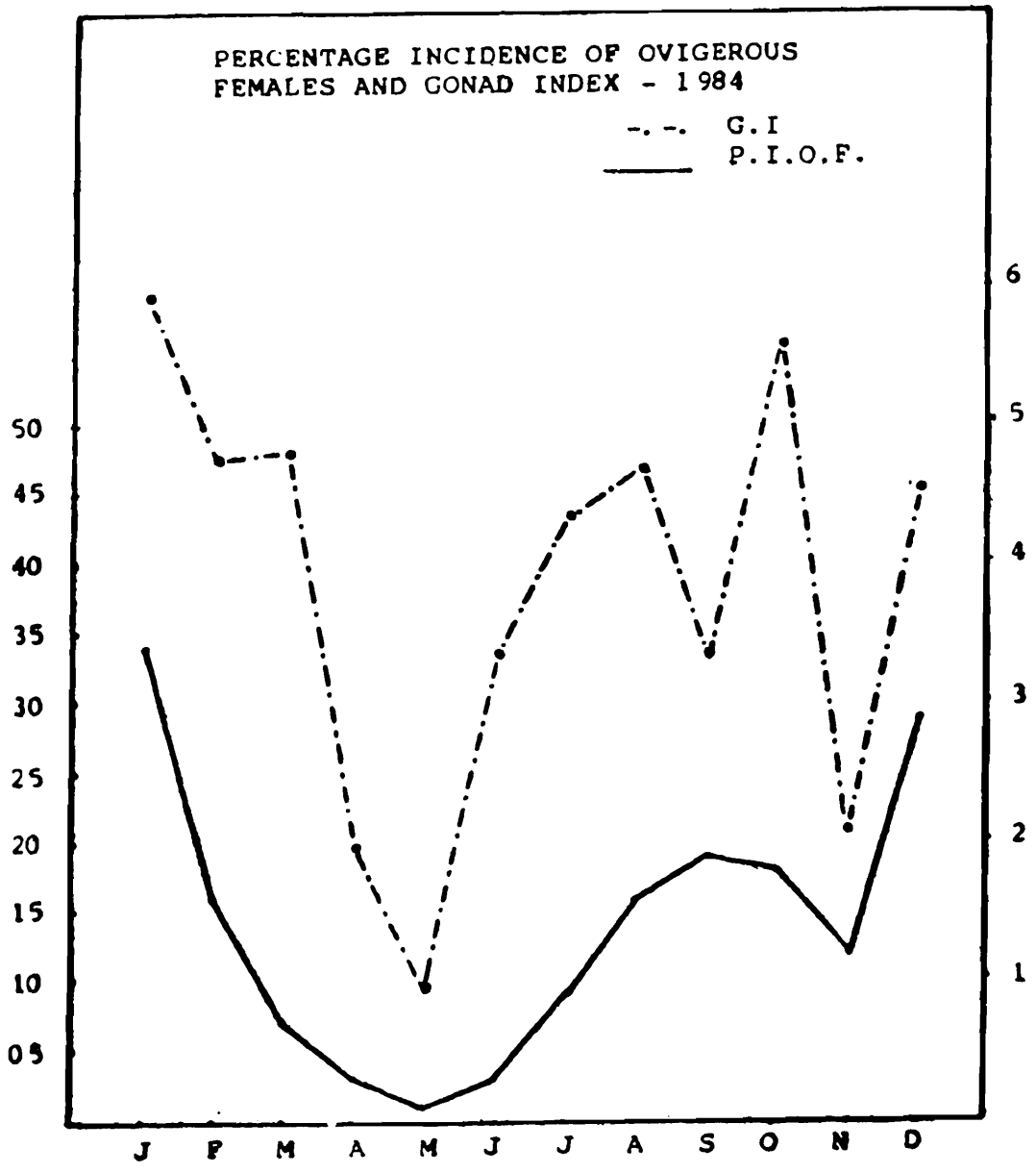


Fig. 3

observed from March to August. Berried females were scarcely available between February and August. However, during September-October a short spell of male courtship activity occurred possibly due to the decline in atmospheric temperature and increase in relative humidity. The highest female gonad index for the year was recorded during October November, which fell in December.

During 1983, ovigerous females were scarce from January

to July and the female gonad index dipped to the minimum in May. In June, the few females collected during the last

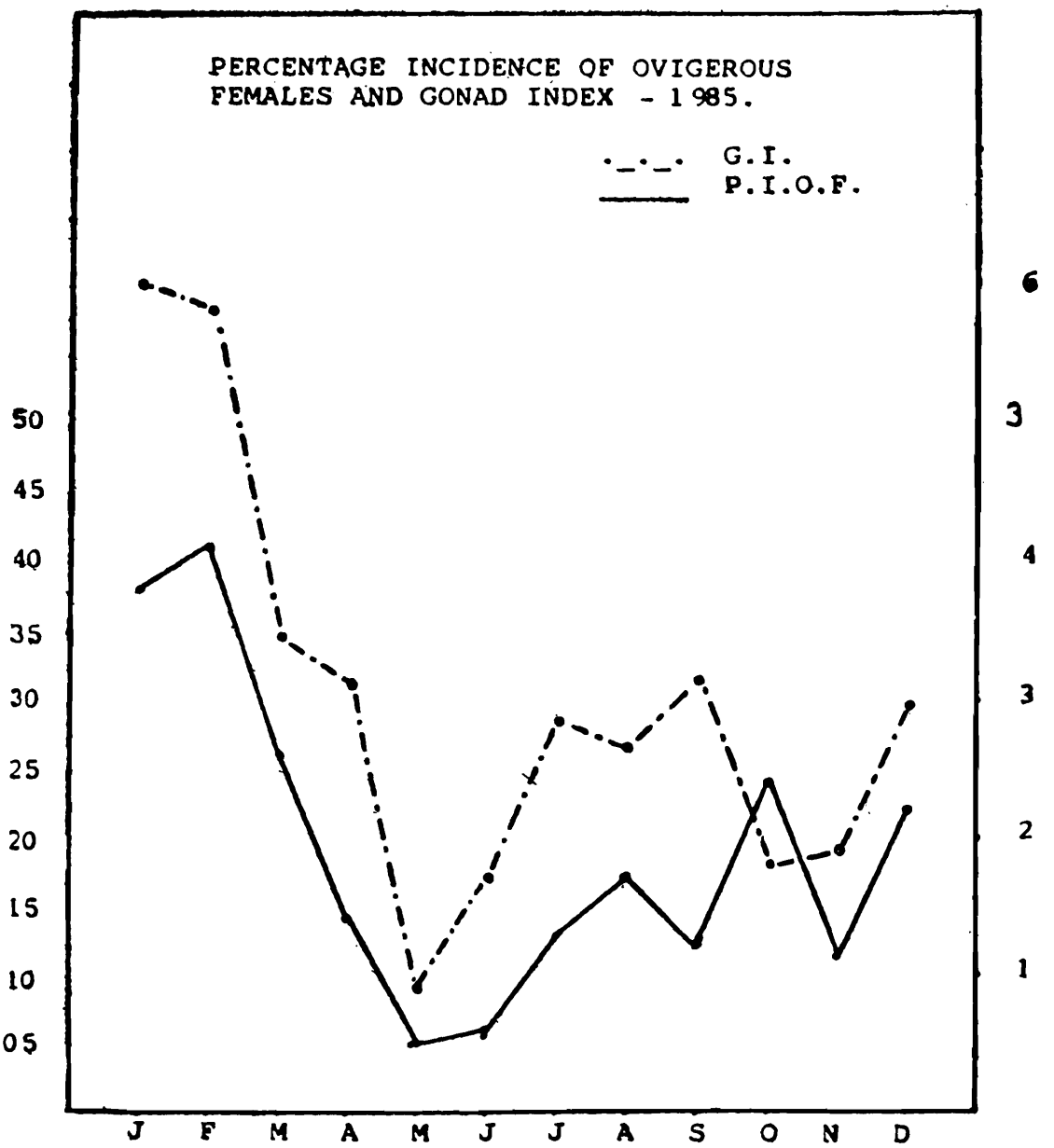


Fig. 4

week were all ovigerous. A peak in the gonad index was recorded in July. Madras experienced heavy rainfall during August-October and in this period majority of the females were not in berry. However, the females occupying burrows farther from the banks high on clay exhibited the presence of ripe ovaries. No male courtship activity could be noticed during this period. The maximum of gonad index was recorded in November, possibly due to the interplay of optimal rainfall, lower humidity and atmospheric temperature.

TABLE 1. Climatic factors in relation to reproduction in *Uca (Celuca) triangularis bengali.*

Months	Average Atmospheric Temperature Maximum °C	Minimum °C	Relative Humidity Percentage	Monthly Rainfall in mm	Percentage Ovigerous females	Gonad Index
1982						
January	28.8	20.1	74.0	—	16	3.08
February	31.1	21.5	71.5	—	11	2.91
March	33.0	23.6	68.5	—	2	1.03
April	35.8	26.3	68.5	—	—	0.82
May	36.9	27.6	62.5	—	—	0.68
June	37.3	27.0	54.5	—	—	0.70
July	35.6	26.3	62.5	—	—	0.82
August	35.0	25.9	64.5	—	—	1.14
September	34.8	25.5	65.5	—	—	1.78
October	32.5	24.4	72.5	—	9	2.83
November	30.2	23.2	77.0	—	13	2.78
December	29.1	21.0	70.0	—	11	2.01

TABLE 2. Climatic factors in relation to reproduction in *Uca (Celuca) triangularis bengali.*

Months	Average Atmospheric Temperature Maximum °C	Minimum °C	Relative Humidity Percentage	Monthly Rainfall in mm	Percentage Ovigerous females	Gonad Index
1983						
January	29.3	19.7	67.0	—	7	2.96
February	32.6	23.1	72.0	—	5	3.01
March	34.9	24.1	66.0	—	3	2.67
April	35.9	25.9	65.5	—	1	1.92
May	38.0	27.7	62.5	—	1	0.78
June	38.2	28.1	52.0	71.4	9	4.04
July	35.0	26.7	64.5	93.4	17	4.66
August	34.1	25.1	73.0	194.4	24	3.81
September	32.8	24.1	78.5	248.7	19	2.96
October	31.9	24.5	78.0	401.6	14	3.02
November	30.1	22.3	70.0	119.9	36	5.08
December	27.9	22.2	80.5	400.5	21	1.94

TABLE 3. Climatic factors in relation to reproduction in *Uca (Celuca) triangularis bengali.*

Months	Average Atmospheric Temperature Maximum °C	Minimum °C	Relative Humidity Percentage	Monthly Rainfall in mm	Percentage Ovigerous females	Gonad Index
1984						
January	28.7	21.9	77.0	38.8	34	5.96
February	28.6	22.6	78.0	283.8	16	4.73
March	32 2	23.5	73.0	2.2	7	4.81
April	34.9	26.0	68.5	1.4	3	1.99
May	38.5	27.8	60.5	—	1	0.97
June	37.9	27.4	51.5	78.6	3	3.34
July	33.8	24.7	69.0	182.1	9	4.34
August	35.8	26.3	60.0	39.2	16	4.69
September	33.7	25.2	71.0	295.9	19	3.33
October	31.7	24.3	75.0	125.4	18	5.61
November	28.8	22.5	77 0	467.1	12	2.08
December	29.0	21.1	75.5	117.0	29	4.56

TABLE 4. Climatic factors in relation to reproduction in *Uca (Celuca) triangularis bengali*

Months	Average Atmospheric Temperature Maximum °C	Minimum °C	Relative Humidity Percentage	Monthly Rainfall in mm	Percentage Ovigerous females	Gonad Index
1985						
January	28.4	21.3	76.5	125.6	38	6.01
Febuary	31.2	21.6	72.5	NIL	41	5.83
March	34.1	24.1	70.0	NIL	26	3.46
April	36.5	26.6	68.0	26.4	14	3.10
May	38.4	27.9	58.5	6.0	5	0.91
June	36.6	26.8	58.0	68.1	6	1.70
July	33.9	25.0	65.5	200.7	13	2.83
August	34.3	25.1	68.0	108.4	17	2.66
September	33.5	24.7	75.5	342.8	12	3.12
October	32.1	24.2	71.0	132.5	24	1.82
November	28.4	21.9	77.5	1071.4	11	1.89
December	28.5	21.6	77.5	137.5	22	2.94

In December, due to floods, the Adyar river was in spate and the backwater extended considerably wiping off the habitats of *U.* (*C*) *triangularis*.

During 1984, the maxima of female gonad index were observed during January, October and December. The number of ovigerous females dropped drastically from January to June. Maximum male courtship activities could be seen during February, July and August and the maximum number of ovigerous females occurred in January and December only.

In 1985, the maximum number of ovigerous females occurred in February while the maximum in gonad index was recorded in January. Similar to the previous year the number of ovigerous females and gonad index fell deeply down to the minimum in May. Madras witnessed the worst floods during November and the populations were washed away leaving a few patches near the MRC Nagar, backyard of Andhra Mahila Sabha and the embankments at Kotturpuram area. The larger ovigerous females which survived showed a low gonad index and fewer eggs.

Mating and courtship behaviour as a rule were restricted to the burrows or the vicinity of the burrows of males. Peak of male courtship activity occurred between 0.930 hours and 1100 hours. Surface copulation right on the rims of male burrow was common. Mass waving was very rare and when seen, not more than 10-12 individuals exhibited synchronized waving. Aggressive wandering of sexually active males when compared to the congener *U.* (*C.*) *lactea* was very restricted and the number of wanderers was also limited. Only on one occasion courtship activities and consequent copulation could be observed during the full moon right near the female's burrow, between a wandering male and resident female. Lateral waving display though present was observed occasionally. Underground copulation could not be noticed. Females of more than 7 mm carapace width only respond to courtship display of males. Copulations between larger males and more or less equal sized females were numerically more and sexual activity involving larger female and a smaller

male (female carapace width 14.5 mm ; male 9.5 mm) was also seen. In every case, courtship display preceded copulation. The approximate time taken to complete copulation varied from 2 to 4 minutes. Male courtship display normally occurred either before the first showers or coinciding with the setting of it and the peaks were recorded only during the second half of the year, either twice or thrice when atmospheric conditions were favourable.

The number of ova carried by ovigerous female increased with the size of the crab. Larval release occurred during the night time spring tides of full and new moon. During the entire period of study, not more than one third of the female population was found to be in berried condition at any point of time excepting during February, 1985 when it touched the 40% mark. The total number of eggs carried by the female in berried condition varied from 2,800 to 4,100, the minimum in crabs inhabiting the MRC Nagar backwater area and the maximum in the populations of the Adyar estuary near the Maraimalai Bridge. Similar to the observations of Pillay and Nair (1973) in *U. annulipes*, development of a new brood occurs within 15 days after shedding the first batch of eggs. Colonisation of new areas by settlement has not been seen as the young ones choose the clay substratum with undulating or irregular margins on a steeper incline of the shore unlike *annulipes* inhabiting the same estuary.

DISCUSSION

The shore living crabs including the fiddlers have been recorded to breed at different times of the year in the East and West coasts of India by Chhapgar (1959), Nair and Pillay (1975), Panikkar and Aiyar (1939) and Rao *et al* (1986) (Map 1). In *U. annulipes* the breeding period extends from July to April with three distinct periods of gonadal activity in the West coast at Cochin (Pillay and Nair, 1971) while in the East coast Panikkar and Aiyar (1939) recorded that the shore living crabs including the fiddlers breed mostly from September to January. Some shore living carbs like hermit crabs (Varadarajan and Subramoniam, 1982) breed continuous-

ly throughout the year with dispersed breeding peaks indicating that the breeding seasons of shore living carbs vary much and that a generalization will be meaningless. Feest (1969) indicated that in *triangularis* breeding seasons occur twice a year and that the seasons depend on the monsoons. This study confirms that the breeding of *triangularis* is tied to the monsoons and that there need not be two seasons in a year should one of the monsoons fail. Panikkar and Aiyar (1939) stated that discontinuously breeding brackish water forms of Madras concentrate their reproductive activities mainly to the rainy seasons while Nair and Pillay (1975) concluded that the rainy season is essentially a period of inactivity on the West coast. In the present observation it is evident that if the rains consequent to the monsoons are of milder intensity activate and if heavy deter breeding and hence it is the intensity of rain that matters rather than the season.

Nair and Pillay (1975) inferred that medium and high saline conditions of pre and post monsoon seasons are the most favourable for breeding activity in the West coast while in the East coast at Madras the low saline periods upto March (Muthu, 1956) are the periods of up welling increasing the availability of food to the planktivores. The present study-results tend to deviate from that of Nair and Pillay (1975) and conform to that of Muthu (1956) since *triangularis* breeds during the lowsaline periods of upwelling. In the case of *triangularis* which is found on the clayey areas near the high saline water ponds in the estuary and back water, lowering of salinity appears to trigger reproductive activities rather than an increase. Should the South-west monsoon rains of moderate intensity follow similar rains of North-east monsoon, reproduction may occur continuously for a period of 7 to 9 months. High summer temperatures at times shooting upto 42°C in May arrest continuity of reproduction since the crabs spend most of their time in choosing a better habitat nearer to the source of water and for other survival activities. The reproductive seasons of *triangularis* differ from *rapax* and *cumulanta* of other tropical areas (Ahmed, 1976) which reproduce continuously throughout the year and

U. (*C.*) *lactea annulipes* of the Adyar estuary at Madras itself (personal observation) which reproduces similar to its relatives on the West coast.

Tropical shore crabs do not reach 100% berried condition while in temperate regions it is common (Boolootian *et al.*, 1959). Nair and Pillay (1975) could locate only 67% berried females in the sample collected during the peak season in *U. lactea annulipes* in the west coast and Varadarajan and Subramoniam, (1982) 66% in *Clibanarius clibanarius* of the East coast. In *U.* (*C.*) *triangularis* less than 45% of the females only were in ovigerous condition during the peak breeding season. Its courtship components are also limited when compared to its congener *lactea annulipes.* It is a well known fact that *triangularis* is a lethargic species in every activity.

Wear (1974) observed the presence of ovigerous females active on the surface daily even toward the end of incubation period, while Christy and Salmon (1984) reported that the ovigerous females were seen rarely moving about or feeding on the surface. In *triangularis* also active females in berried condition could be located foraging near the burrow area farther from the low tide mark on the clayey mud. Similar to *lactea annulipes,* in *triangularis bengali* males defend the breeding burrows and the mating occurs near the male's burrow as observed by Altevogt (1957) and Crane (1975) but in contrast to Yamaguchi's (1971) *Uca lactea* in Japan. Christy and Salmon (1984) expressed that the reversal in Yamaguchi's observation may be due to low population density. In *triangularis bengali* which populate the estuary and backwater with less than 40 burrows per square meter did not indicate any copulation activity near the female's burrow, and even in *lactea annulipes* such a phenomenon does not occur in the Madras coast.

Thurman (1985) observed that egg diameter is independent of female size in *U. subcylindrica.* It appears to be a universal phenomenon and in *triangularis* the egg diameter did not significantly differ in females from 9 mm carapace width. von

Hagen (1970 a, b) found that mating of fiddlers occurred on the new and full moon days suggesting the release of larvae after two weeks. In *triangularis* courtship activities and copulation occurred during day time low tides of the pre-monsoons predominantly and no such restriction of copulation to these two days of the lunar month has been seen. The release of larvae occurred during nocturnal spring tides of the full and new moons similar to the other fiddlers (von Hagen, 1970 a, b ; wheeler, 1978 ; Bergin, 1981 ; Christy, 1982 b and Salmon and Hyatt, 1983). In *lactea annulipes* the ovigerous females forage farther on the land from water line and in *triangularis bengali* the berried females and young ones remain farther from the waterline and forage on the trapped material in the puddles filled during high tides.

A statistical analysis on the model

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + E$$

where Y = percentage of ovigerous females

X_1 = Maximum temperature

X_2 = Minimum temperature

X_3 = Relative humidity

X_4 = Rainfall

X_5 = Gonad index

Yields a fitted regression

$$Y = 7.012 + 0.8232X_1 + 0.1943X_2 + 0.2212X_3 +$$

SE = (0.359223) (1.3348) (1.5271) (0.2643)

T = (0.1951) (0.6169) (0.1225) (0.8407)

$$0.00063X_4 + 4.4066X_5$$

(0.00656) (0.7300)

(0.096) (6.036)

for which $R^2 = 0.6602$.

The F ratio for testing the regression was 16.31 with 5, 142 d.f. This value being significant, it can be inferred that all the dependent variables under study, X_1 through X_5 have a combined predictive capacity of 48%. But a closer look reveals all coefficients except that of X_5 (Gonad index) were not significant. Gonad index has a positive coefficient.

Hence, a fresh analysis was done using X^5 (Gonad index) as the explanatory variable, the results of which are

$Y = -0.3079 + 0.5423X_5$

SE (0.2310) (0.7045)

T (1.333) (7.6976)

indicating $R^2 = 0.5599$

The increase in R^2 due to inclusion of X_1, X_2, X_3 and X_4 is about 10% which is not quite significant because the ratio corresponding to the decrease in residual sum of squares due to the additional variables was found to be only 1.85 which is not statistically significant.

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