OBSERVATIONS ON THE BIOLOGY AND FISHERY OF *METAPENAEUS BREVICORNIS* (M. EDW.) IN THE HOOGHLY ESTUARINE SYSTEM

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Several species of Penaeid prawns ascend the Hooghly estuarine system, as juveniles, where they contribute considerably to the commercial catches. Such of those juveniles that enter ' bheris' and paddy fields constitute the varieties that are cultured widely in deltaic Bengal. Amongst these various species *Metapenaeus brevicornis* (M. Edw.) locally known as 'Dhanbone chingri' is the 'commonest Penaeid of Bengal occurring very plentifully in the delta of Ganges' (Chopra, 1939 and 1943; Panikkar and Menon, 1955). Alcock (1906) has recorded the distribution of the species as in India, Mauritius and Borneo. He has also recorded that the species rarely attains a length of 3". In the present studies also the largest female recorded is 120 mm (4.75"). Considering the commercial importance of this species a knowledge of various aspects of its biology has been considered essential both for a proper management of its fishery in the estuaries as well as for recommendation of its large-scale culture, and hence this study.

Several workers from other countries have investigated into various aspects of the biology of prawns, both Carideans and Penaeids. (Gurney, 1923; Hoglund, 1943; Lloyd and Yonge, 1947; Forster, 1951 a and b and 1959; Kubo, 1951 and 1955; Pike, 1952; Lindner and Anderson, 1956; Dall, 1958 and Cole, 1958). However, contributions to the knowledge of the biology of prawns from Indian waters are few. Among others Menon (1951, 1953, 1955 and 1957), and George (1959) have studied certain aspects of the life-history and biology of several species of Penaeids, whereas Kunju (1955) worked on the biology of *Leander styliferus*.

**MATERIAL AND METHODS**

Material for this study stems from the commercial catches of the Hooghly estuarine system, collected fortnightly from thirteen randomly selected sampling centres (3 along Roopnarain, one on Matlah and nine on Hooghly) (Text-Fig. 1). The entire stretch of the estuary can be divided, based on the
pattern of fluctuations in salinity, into three zones: an upper zone corresponding to freshwater zone, where salinity is in traces throughout the year; a middle zone corresponding to the gradient zone, where salinity fluctuates
from traces to 11.42 parts per thousand, and a lower zone corresponding to the tidal zone where salinity fluctuations are in the range of 6.32-29.89 parts per thousand (unpublished records of the Institute). The samples are drawn mostly from Bagnets (Bhinjals) and barrier nets (Kalpatajals).

The total length of the individuals was measured from the tip of rostrum to tip of telson. Weights were taken to the nearest gram, in a trip type of double-pan balance. Lengths at ages were calculated separately for males and females. Separation of sexes by external examination was possible in specimens measuring more than 20 mm., since the rudiment of the petasma on the protopodite of the first pleopod of male is not generally clearly visible in specimens smaller than that size. The individuals examined for this study ranged between 15 and 115 mm. Smaller specimens were not available even in the ½ meter tawnet (made of muslin cloth) catches made in the estuary. For age studies the different size groups in the polymodal length-frequency distributions of males and females for 1959, 1960 were separated by the use of probability paper (Harding, 1949; Cassie, 1954 and Pantulu, 1962). Probability plot analysis was found to be a useful tool in the separation of different age-groups and in the determination of specific and seasonal growth of the species. However, there are certain limitations to this method, and as observed by Pantulu (op. cit.) “one of the serious limitations of this method was found to be the diagnosis of points of inflexion in the cumulative percentage curve . . . .” “However, by trial and error a fairly accurate choice of inflexion points was found possible in such cases.”

**AGE AND GROWTH**

Estimation of age has been done only in respect of a few species of Indian prawns (Menon, 1951, 1953 and 1955; George, op. cit. and Kunju, op. cit.) by the modes of length-frequency distributions. This method, which is commonly known as ‘Peterson’s method’, has been demonstrated to be inadequate particularly in respect of species which have a prolonged spawning season. Further, non-representation of certain year classes in the commercial catches and increasing overlap of distribution of older size groups is likely to yield erroneous results. Hence in this study, as mentioned earlier, the probability plot method (Harding, 1949; Cassie, 1954) of separating the polymodal length-frequency distribution has been used to find out the modal lengths of different year classes. Further, in the absence of alternative methods of estimation of age such as the use of periodic markings on hard parts, as in fishes, testing validity of the conclusions based on length-frequency analysis becomes difficult. Hence in this study estimates
of "length at age" as made independently by seasonal growth studies and progression of modal lengths in the length-frequency distribution during different months of the year have been used to verify the accuracy of the conclusions arrived at.

Table I shows the modal lengths and standard deviations of the component modal values of the polymodal length-frequency distributions during the years 1959 and 1960 separately of males and females. Normal curves fitted to the length-frequency distributions based on the probability plot analysis are illustrated in Text-Fig. 2. It is evident from these that both males and females are represented in the commercial catches by five approximately normally distributed size groups. The successive modes separated along the length axis have not been assigned to different age-groups in this case, as is usually done. The earliest mode has been assigned to the zero-group, since experiments on mesh selectivity of bagnets, from which these samples have been drawn, have indicated that the mean selection size of the species by bagnets is 22.7-11 mm. (Rajyalakshmi, unpublished). This observation lends support to the conclusion that the earliest mode does not represent the modal size of 1 year group. Of the subsequent modes two consecutive modes have been considered to represent one-year class because of the reasons given below.

1. The occurrence of females in advanced stages of maturity in the months January and February, and the availability of impregnated, soft-shelled females in the months of July-August coupled with the occurrence of young prawns having modal sizes of 23 mm. in July and 23-26 mm. in October-November probably indicates that the species has two spawning seasons, one in the early summer, viz., March-April and the other in the monsoon months, viz., July-August.

2. The availability of smallest modal sizes, viz., 24.5-26.4 mm. in the months July and October-November tends to confirm the above observation, since the growth trends in zero-group individuals indicate that approximately 3-4 months time is required to attain a length of 24-26 mm.

The monthly progression of (Text-Figs. 3 and 4) modal sizes of the 0-year class indicates that, after the post-larval phase, the prawn grows approximately at a rate of 3 mm. for month. This, coupled with the occurrence of mature and soft-shelled females in the catches, indicate that the July and October-November earliest modal sizes are probably the results of previous March-April and July-August spawnings respectively.
TABLE I

Modal lengths of different age-groups of *M*. brevicornis as estimated by length-frequency analysis of samples from commercial catches of Hooghly, Matlah and Roopnarain estuaries

<table>
<thead>
<tr>
<th>Calendar year</th>
<th>Males</th>
<th></th>
<th>Females</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Monsoon brood</td>
<td>Summer brood</td>
<td>Monsoon brood</td>
<td>Summer brood</td>
<td>Monsoon brood</td>
</tr>
<tr>
<td>1959</td>
<td>26.8 ± 3.8</td>
<td>40.0 ± 5.6</td>
<td>54.5 ± 7.3</td>
<td>69.0 ± 4.6</td>
<td>82.0 ± 4.3</td>
</tr>
<tr>
<td>1960</td>
<td>24.8 ± 3.4</td>
<td>37.2 ± 4.6</td>
<td>49.6 ± 5.8</td>
<td>66.0 ± 3.5</td>
<td>79.0 ± 4.97</td>
</tr>
<tr>
<td>Average</td>
<td>25.8 ± 3.8</td>
<td>38.6 ± 4.6</td>
<td>52.05 ± 3.5</td>
<td>67.5 ± 4.97</td>
<td>80.5 ± 2.9</td>
</tr>
</tbody>
</table>
TEXT-FIG. 2. Histograms of length-frequency distribution of *M. brevicornis* (males and females) for 1959 and 1960. The polymodal frequency curves are dissected into their normal components by probability plot analysis.
In view of the facts mentioned two consecutive normal curves (Text-Fig. 2) have been taken to represent the size classes resulting from early and late spawning.

Text-Fig. 3. Histograms of monthwise frequency distributions of males of *M. brevicornis*. Data are pooled for 1959 and 1960.
TEXT-FIG. 4. Histograms of monthwise length-frequency distributions of females of *M. breviceps*. Data are pooled for 1959 and 1960.
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late spawnings each year. The average lengths attained at different ages by females of these two broods are presented in Table II. The close agreement in the estimates of length at different ages made by tracing monthly progression of modal values in the length-frequency distributions (Text-Figs. 3 and 4) is taken to indicate the accuracy of these estimates.

**Table II**

*Seasonal pattern of growth (females)*

<table>
<thead>
<tr>
<th>Season</th>
<th>Month</th>
<th>Summer brood</th>
<th>Monsoon brood</th>
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<tr>
<td></td>
<td></td>
<td>Average modal size (mm.)</td>
<td>Specific Increment in length</td>
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<td></td>
<td></td>
<td>Average modal size (mm.)</td>
<td>Specific Increment in length</td>
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<td></td>
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<tr>
<td>July</td>
<td>24.5</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Monsoon</td>
<td>38.9</td>
<td>11.507</td>
<td>14.4</td>
</tr>
<tr>
<td>November</td>
<td>26.5</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Winter</td>
<td>43.8</td>
<td>2.966</td>
<td>4.9</td>
</tr>
<tr>
<td>March</td>
<td>34.95</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Summer</td>
<td>59.0</td>
<td>7.448</td>
<td>15.2</td>
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<tr>
<td>July</td>
<td>47.85</td>
<td>..</td>
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<tr>
<td>Monsoon</td>
<td>6.015</td>
<td>16.0</td>
<td>..</td>
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<tr>
<td>November</td>
<td>58.1</td>
<td>..</td>
<td>..</td>
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<tr>
<td>Winter</td>
<td>3.187</td>
<td>7.9</td>
<td>..</td>
</tr>
<tr>
<td>March</td>
<td>66.0</td>
<td>..</td>
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</tr>
<tr>
<td>Summer</td>
<td>21.8</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Monsoon</td>
<td>96.8</td>
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<td>..</td>
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</tbody>
</table>

The rate of growth in females appears to be faster than that of males, indicating that sexual differences in growth rate exist in the species. Similar differences in allied species of prawns was noticed by Menon (1957). Text-Figures 3 and 4 show the apparent growth rate curves of male and female *M. brevicornis*. As is well known growth in size in crustaceans is essentially discontinuous since increases in the linear dimension take place abruptly at ecdysis and length, within the rigid exoskeleton, in the interval between molts remains constant (Teissier, 1960). In *M. brevicornis* the
growth of males and females is comparable during the first year of their life. One-year old males and females measure about 45.8 and 47.4 mm, respectively. Later the females appear to grow at a faster rate than males and at the age of 2 females and males attain lengths of 89.0 and 80.5 mm, respectively.

Text-Figures 5 and 6 represent the approximate growth rate of males and females respectively. The increments in length shown in the figures are derived from the seasonal growth studies. Increment in the length for both the broods separately in comparable durations of time, irrespective of season, have been plotted (dots) and their average values (circles) were connected by broken lines.

SEASONAL PATTERN OF GROWTH

To ascertain the seasonal pattern of growth the length-frequency distribution of samples obtained during the months March, July and November were analysed separately by the probability plot method. The three months
represent the commencements of the three principal seasons in this part of the country, viz., summer, rainy season and winter. The increments in lengths attained between March and July, July and November and November and March are taken to indicate the growth during summer, rainy and winter seasons respectively. During the summer season, the temperature and salinity of the water in the estuary are high (ranging from 30.45–30.82°C and salinities 4.3–29.1 parts per thousand). The rainy season is characterised by low salinity (traces to 9.47 parts per thousand) and fairly high temperature (30.08–30.8°C) whereas, the winter by fairly high salinity (1.62–19.78 parts per thousand) and low temperature (21.85–23.7°C). The growth of the sexes and broods was traced separately. Since growth is multiplicative and logarithmic expressions express it more adequately (Brown, 1957), specific growth rate 'G' during different seasons was taken as an index for comparison:

\[ G = 100 \times \frac{\log e l_T - \log e l_t}{T - t} \]

(where \( l_T \) and \( l_t \) are lengths at times \( T \) and \( t \), \( T \) being later than \( t \)).

Text-Figure 7 shows the seasonal fluctuations in specific growth rates for females. Estimates of 'G' in respect of males have not been made due to paucity of data for different seasons for the I and II year groups. It appears
that except in the zero-group individuals where the specific growth rate is high, the growth is fastest during summer, low during winter and medium during rainy season. Specific growth rate is observed to be highest in the young and later declining with age. This agrees with Medawar's fifth law of growth that "the specific growth rate declines more and more slowly as the organism increases in age" (Brown, 1957) and Minot's (1908) observations that for most animals the specific growth rate is highest early in life and that it typically decreases with increasing age.

**SEX RATIO**

The proportion of males to females during each month is shown in Table III. The observed differences in the sex ratio during different months were found to be significant, the significance point at 2% level being 22.618. The ratio of males to females during all the months combined was found to be 1:1.2.
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TABLE III

Distribution of males and females in the samples during different months

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<td>Sex</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>187</td>
<td>210</td>
<td>118</td>
<td>330</td>
<td>224</td>
<td>289</td>
<td>367</td>
<td>545</td>
<td>337</td>
<td>1357</td>
<td>913</td>
<td>494</td>
<td>5371</td>
</tr>
<tr>
<td>Female</td>
<td>297</td>
<td>267</td>
<td>138</td>
<td>427</td>
<td>263</td>
<td>352</td>
<td>390</td>
<td>634</td>
<td>401</td>
<td>1483</td>
<td>1060</td>
<td>671</td>
<td>6383</td>
</tr>
<tr>
<td>Total</td>
<td>484</td>
<td>477</td>
<td>256</td>
<td>757</td>
<td>487</td>
<td>641</td>
<td>757</td>
<td>1179</td>
<td>738</td>
<td>2840</td>
<td>1973</td>
<td>1165</td>
<td>11754</td>
</tr>
</tbody>
</table>

LENGTH-WEIGHT RELATIONSHIP

The length-weight relationship for individuals ranging from 23–120 mm was estimated on the basis of 1968 observations. Sexes were not considered separately since a scatter diagram of weights on lengths (Text-Fig. 8) indicated that there was no sexual difference in length-weight relationship. The mean weights of all the individuals in any particular 3 mm length range was taken to represent the weight of the midpoint of the class interval. It has been observed that the relationship between length-weight for the species is linear in the logarithmic form and that different relationships exist for the 0-group (a) and other individuals (b). In both cases the relationship confirms to the general formula.

\[ W = al^n \text{ or } \log W = \log a + n \log L. \]

The relationships for the two groups a and b were found to be:

(a) \[ \log W = -5.0083 + 2.9810 \log L \]
(b) \[ \log W = -4.5407 + 2.6976 \log L. \]

The values of the constant \( a \) were found to be significantly different by the application of the 'F' test. However, the difference in the values of the exponent \( n \) (viz., 2.9810 in group a and 2.6976 in group b) were not found to be significantly different from each other by the same test. It has further been observed that the values of the exponent are not significantly different from 3, hence the species could be said to conform to the so-called cube law.
RELATIVE CONDITION

The relative condition factor \( K_n \) (Le Cren, 1951) which is a ratio between observed and the smoothed mean weight \((W/W)\) was calculated separately for each size group, and for all the length groups combined during different months of the year. Sexes of the individuals was not considered separately in the estimation of the \( K_n \) since a scatter diagram indicated that sexual differences in condition do not exist. \( K_n \) was estimated in preference to ponderal index \((K = 100 W/L^2)\) so as to eliminate the effects of length and correlated
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Factors on condition particularly since the length-weight relationship was found to vary in different size groups.

Fluctuations in \( K_n \) for different length groups indicated (Text-Fig. 10) that condition was high in the smallest size groups (21 mm.). Thereafter, a decline in condition was generally noticeable. Between 23 and 98 mm. moderate fluctuation in \( K_n \), more or less cyclic in nature, were observable. There appears to be abrupt cyclic increases in \( K_n \) followed by a slightly less abrupt decline in condition which may probably be attributable to the nature of growth pattern in prawns, where sudden spurts of increase in weight and length take place immediately after moulting and these dimensions remain relatively constant during inter-moulting period. The observed spurts of increase in \( K_n \) values indicate, probably, that weight increases, subsequent to moulting, are proportionately greater than increases in linear dimension.

At 98 mm, a marked decline in condition and subsequent recovery higher in magnitude than the fluctuations in earlier size groups, is observable. Such
a rapid decline and recovery are generally associated with the attainment of sexual maturity. It is interesting to note that in the case of *M. brevicornis* sexual maturity is usually attained when the prawn is about 100 mm long.

Studies on the monthly fluctuations (Text-Fig. 9) in \( K_n \) indicated that the condition is generally low during the winter months of November to March. The species appears to gradually gain in condition during the summer months till finally in June maximum condition is attained. This is followed by an abrupt fall in \( K_n \) during July and subsequent gradual recovery till October when the second maxima in \( K_n \) value is reached. It is interesting to note in this context that studies on the seasonal pattern of growth also indicate that growth rate is lowest in the winter months and high in summer and monsoon. A direct correlation between seasonal fluctuations in \( K_n \) values and rates of growth is thus evident. The sudden decline in \( K_n \) value in July might have been brought about by adverse environmental conditions in the form of sudden decline in salinity and resultant osmotic stress, consequent to the first floods.
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SPAWNING AND MIGRATION

Maturing females are represented in the catches only from the lower Sunderbans area (mouth of the estuary) during the months of January-March and the early monsoon period (June-July). Earliest zero-group individuals having modal lengths of 24.5 and 26.5 mm. are obtained in the catches during the periods July and October-November respectively. Soft-shelled females with two prominent white pads covering the surface of the telsonic in the catches during December to February and in July. All these evidences probably indicate that the species spawns during March-April once and again in July-August for a second time in the lower reaches of estuary and possibly in the inshore waters.

Generally, immature individuals belonging to the 0, I and II year groups only are represented in the catches in the upper zone and upper reaches of the middle zone of the Hooghly whereas the III year group individuals along with earlier groups occur in lower reaches. As mentioned, maturing and mature females in II to IV stage (Lindner and Anderson, 1956) of gonadial development are met with only in the lower Sunderban area. Larval forms of the species have not been found in the townet collections made at any of the sampling centres during any part of the year. These facts tend to show that spawning takes place in the marine zone of the estuary or inshore areas and the young ones either migrate or are pushed up the estuary by tidal action where they live till the attainment of maturity. Adults appear to migrate to the lower reaches of the estuary where they mature and spawn.

FISHERY

*M. brevicornis*, which contributes to over 30% of the total prawn catches in the Hooghly estuarine system, is one of the most commercially important species of prawns in Bengal. Bulk of the landings of this species is made in the lower zone of Hooghly and lower Sunderbans during the winter months of November-February. In the Matlah estuary, however, the fishery has a longer duration commencing from August and continuing up to next March. Text-Figures 3 and 4 represent the size composition in the commercial catches during different months of the year.

In the lower reaches of upper zone and upper reaches of the middle zone of Hooghly I and II year groups form the fishery, the I year class forming the dominant group, during all the months except August, September and October. In the lower middle zone (Fuleshwar to Nurpur) and lower zone of the Hooghly two additional size groups 0 and III contribute to the fishery.
during practically all the months of the year, the 0-group appearing only
during the period July-December. In the Roopnarain only 0, I and II
year groups contribute to the fishery whereas in Matlah III group also forms
the fishery (only during winter) in addition to other groups. The trend of
occurrence suggests that bigger size groups are more or less confined to areas
of higher salinity.

GEAR

Bagnets (Bhijnals and Thorjals), which form the main type of gear with
which the species is caught, account for nearly 90% of the total catches of
the species and small dragnets and dipnets account for the rest of the land­
ings. Bagnets are generally operated in the midstream either at the subsur­
face level or in slightly deeper waters. Prawns are known to be bottom
feeders inhabiting shallow areas and feeding on debris at the substratum.
Hence, it appears possible that operation of suitable prawn nets or traps will
enhance, considerably, the catches of bigger and commercially more desirable
size groups. Since the present study indicates that bigger size groups are
confined to areas of comparatively high salinity, the lower reaches of the
estuary might prove to be very profitable prawn fishing grounds provided
suitable types of gear, as suggested, are operated.

SUMMARY

The paper deals with growth, migrations, spawning and fishery of Meta­
penaeus brevicornis (M. Edw.) in the Hooghly estuarine system.

Estimates of age and seasonal fluctuations in specific growth rates of the
species have been made by the probability plot analysis of length-frequency
distributions. There appear to be two-year groups in the catches. Growth
in females appears to be faster than in males, during the second year. There
are two spawning periods, once in March-April and a second one during
June-July. Growth rate is fastest during summer, medium during rainy
season and low during winter, in females. Length-weight relationship and
relative condition factor \( K_n \) have been determined. The probable reasons
for the observed seasonal fluctuations and fluctuations in different size groups,
of relative condition have been discussed. An account of the distribution
of the various year groups in the estuary and migration and fishery of the
species is given.

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* Not referred to in original.