BIOLOGY OF THE LARGE SNAKE-HEAD *OPHICEPHALUS MARULIUS*; (HAM.) IN BHAVANISAGAR WATERS

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ABSTRACT

Length frequency distribution of *Ophicephalus marulius* (Ham.) from Poongar Swamp dissected out by probability plot technique produced four year classes. Von Bertalanfly’s growth equation adequately describes the growth of *O. marulius*. The mean length at first maturity is 460 mm in females and 550 mm in males. The Lm/L∞ value for the former is 0.47 and for the latter 0.45. A rapid fall in fecundity is observed in older fishes (4 year and above). Peak spawning occurs during November and December in the swamp but during June and July in the river and reservoir. Parental care ceases when the young ones are 4-month old. Fish less than 50mm long feed on zooplankton especially *Daphnia* but those 50 to 110mm long prey upon *Macrobrachium* and larger insect nymphs.

INTRODUCTION

*Ophicephalus marulius* (Ham.) known locally as ‘Pu Vera’ or ‘Avuri’ is the largest species of murrel normally restricted to large rivers and adjacent waters of submountainous stretches (800-2000 feet MSL). It is distributed in freshwaters especially rivers of India, E. Pakistan, Burma, Ceylon, Siam and China (Hamilton, 1822; Gunther, 1861; Day, 1876; Munro, 1955; Misra, 1959). According to Hamilton (1822) though this species is often found within the tideway, it never frequents salty waters. Munro (1955) reports its distribution up to an altitude of 1500 feet MSL. It is reported to grow to a length of 4 feet by Day (1878) and Misra (1959), 3 feet by Hamilton (1822) and Cuvier and Valenciennes (1831) and 2½ feet by Munro (1955).

Since *Ophicephalus marulius* from Ceylon differs from Indian specimens with regard to their dorsal and anal fin ray counts, Deraniyagala (1945) assigned the subspecific name *Ophicephalus marulius ara* to the former.

Earlier accounts on the bionomics of *O. marulius* include comments on nest building (Khan, 1923, 1924); detailed descriptions on development (Khan, 1926) description of fertilized eggs (Mookerjee, 1946); brief notes on culture in irrigation wells (Chacko and Kurian, 1947); bionomics (Chacko, 1956) and cultural possibilities

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No detailed investigation seems to have been made on the important biological aspects of this species although a comprehensive study has been made on the biology of an allied species *O. punctatus* by Qayyum and Qasim (1964) and Qasim and Bhatt (1965) and the age and growth of another species *O. striatus* by Bhati (1969; 1970).

**MATERIAL AND METHODS**

The present study is based on 4123 specimens of *O. marulius* collected over a period of three years from 1964 to 1966, mainly from the seasonal catches of an artificial, 250 ha weedy swamp lying close to the northern bank of the Bhavanisagar Reservoir in the Poongar Village. A few specimens of *O. marulius* grown in two wells which existed in this area formed the parent stock for the fishery that later flourished in the swamp. Stray specimens landed from the reservoir as well as the river immediately below the sluice gates were also studied. The fishes were caught by gill nets (rangoon-nets and 'uduvalai') from the reservoir and river and by cast nets from the swamp. They were measured to the nearest millimetre from the tip of the maxillary symphysis to the terminal point of the longest ray of the caudal fin. Weights were recorded in a single-pan balance of 10 gram precision in the case of adult fishes and to the nearest mg in a double-pan balance for fry and fingerlings.

The probability technique described by Harding (1949) and Cassie (1954) to separate the length groups in a polymodal length-frequency distribution has been found to be very useful in sorting out the different age-groups resulting from the contributions of different spawnings. The length data were grouped at every 40 mm interval and the pooled quarterly length frequency distribution of the sample for the third quarter from the swamp alone was dissected out into its component normal curves as samples of adult fish were much less during other periods.

The fishes were grouped into five maturity stages as adopted in *O. punctatus* by Qayyum and Qasim (1964). In fecundity study, which is based on 13 ovaries, the total number of eggs in each ovary was estimated based on the count of mature eggs in one gram of sample from the middle portion of the ovary. For ova diameter studies, 500 to 1000 eggs were measured from 19 ovaries in different stages of maturity with the aid of an ocular micrometer giving a magnification of 0.071 mm per division. The stomach contents of the fry and fingerlings, owing to the smallness of the food items were estimated by the numerical method.

**BIOLOGICAL STUDY**

*Age determination by probability technique*

The length-frequency distribution of the whole sample consisting of 4123 specimens collected during the entire period of observations is represented in Fig. 1C. The pooled quarterly length-frequency distribution of samples from the swamp is represented in Fig. 1A and that of the reservoir and river samples in Fig. 1B. The
Fig. 1. A. Pooled quarterly length-frequency distribution of *Ophicephalus marulius* in Poongar Swamp: B. pooled quarterly length-frequency distribution of *Ophicephalus marulius* in the reservoir and river; C. length-frequency distribution of *Ophicephalus marulius* in the samples from all sources during the years 1964-1966.
data has not been treated together as the spawning period of *O. marulius* has been found to differ in the two sources. Modal values in the pooled length frequency distribution of samples for the quarter, July-September from the swamp alone have been obtained by the probability technique (Fig. 2; Table 1) owing to inadequacy of samples during other periods and from other sources.

![Cumulative Percentage](image)

**Fig. 2** Probability plot of the length-frequency distribution of *Ophicephalus marulius* showing the method of separation into its theoretical normal curve components.

In a fish with single restricted spawning season, the modal lengths of different size-groups are usually taken to be yearly in nature. *O. marulius* breeds only once a year. Specimens from the swamp collected during July, August and September were in third or fourth stage of maturity and spawning has been found to last from October to February with peak in November and December. Since the peak spawning period lasted for two months during the NE monsoon rains, it may be possible to assign the modal lengths of different size-groups to those of yearly modes representing the lengths at different years. Hence, in the estimation of growth parameters modal lengths of different size-groups are taken to correspond to different years. The first modal length is at 106 mm which obviously is the O year class. The mean monthly increment in length based on experimental growth studies in nursery and farm-pond is 20.94 mm. If the mode at 386 mm represents the first year class the monthly growth is 32.2 mm. In view of the best feeding conditions, as
evidenced by the stomach contents of the young ones, higher growth rate could naturally be expected from the swamp. Khan (1926) observed a monthly growth of 28 mm during the first 17 week period since hatching.

TABLE 1. Length at age obtained by different methods, annual growth increments and growth rate in O. marulius

<table>
<thead>
<tr>
<th>Year class (age in years)</th>
<th>Mean length (mm) (Probability technique)</th>
<th>Standard deviation (mm)</th>
<th>Percentage of total</th>
<th>Length at age (mm) (Bertalanffy) (equation)</th>
<th>Duration between checks</th>
<th>Growth increment between checks (mm)</th>
<th>Growth per month (mm)</th>
<th>Relative growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>106</td>
<td>31.45</td>
<td>3.70</td>
<td>0 - I</td>
<td>280</td>
<td>23.33</td>
<td>42.42</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>386</td>
<td>39.51</td>
<td>18.30</td>
<td>I - II</td>
<td>147</td>
<td>12.25</td>
<td>22.27</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>533</td>
<td>52.15</td>
<td>68.00</td>
<td>II - III</td>
<td>120</td>
<td>10.00</td>
<td>18.18</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>653</td>
<td>38.44</td>
<td>9.00</td>
<td>III - IV</td>
<td>133</td>
<td>9.42</td>
<td>17.13</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>766</td>
<td>13.98</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fitting of von Bertalanffy growth equation

Mathematical expression in fitting growth curves is helpful in interpolation and extrapolation, besides their utility in production computations (Pantulu, 1962; Kamal, 1969). von Bertalanffy's growth equation based on the concept that growth is the net result of anabolism and catabolism, produces a growth curve in length that fits well the growth rates of many species of fish (Beverton, 1954; Beverton and Holt 1957). This equation gives a linear relationship between length at time t and at time t+x and is expressed as

\[ l_t = L_\infty (1 - e^{-K(t-t_0)}) \]

where \( l_t \) = length at age \( t \); \( L_\infty \) = asymptotic length; \( e \) = base of the Naparian or Natural logarithm; \( K \) = coefficient of catabolism; \( t \) = age of fish; \( t_0 \) = arbitrary origin of the growth curve. To fit this growth equation to the length at age data, the method developed by Ford (1933) and Walford (1946) of plotting \( l_{t+1} \) against \( l_t \) is used. The relation between \( l_{t+1} \) and \( l_t \) may be expressed as

\[ l_{t+1} = L_\infty (1 - k) + kl_t \]

where \( k = e^{-K} \).

A straight line is drawn which passes through almost all points. The value of the resultant slope \( k \) is 0.7982 from which \( K \) is calculated. The point of intersection of
this straight line with the bisector drawn through the origin gave the value of $L_0$ (Fig. 3). The values estimated for these parameters are

$L_0 = 1130$ mm; $K = 0.22565$

to was calculated by the following formula of Ricker (1958)

$$t_o = \frac{\log e L_0 + K t_o}{K} - \log e L_0$$

The value of $\log e L_0 + K t_o$ is the Y-axis intercept (6.85) in Fig. 4 where $\log e (L_0 - t_o)$ is plotted against age. Substituting the values to the above formula, $t_o = -0.7976$. Feeding the values of $L_0$, $K$ and $t_o$ to the von Bertalanffy's growth equation growth in $O. marulius$ could be expressed as

$$L_t = 1130 (1 - e^{-0.22565 (t+0.7976)})$$

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**Fig. 3** Ford-Walford plot of growth of *Ophicephalus marulius*.

**Fig. 4** $\log e (L_0 - t_o)$ plotted against age for estimation of $t_o$ in *Ophicephalus marulius*. 
The theoretical lengths at different ages as calculated by this growth equation showed a high degree of agreement with lengths at ages calculated by the probability plot technique of length-frequency analysis (Table 1; Fig. 5).

A comparison of lengths at different ages attained by three species of *Ophicephalus* reveals that growth in *O. punctatus* is the least rapid, in *O. striatus* moderately higher, but in *O. marulius* very rapid (Table 2). Growth rate of the latter is the highest during the first year; the 0 year class (106 mm) fish grows at the rate of 29.33 mm per month till it attains 1 year. The growth rate rapidly declines to 12.25 mm per month during the check between I - II but records 10.00 mm and 9.42 mm respectively during the checks between II-III and III-IV (Table 1). The higher growth of the fish during the first year may be attributed to the voracious feeding habit of the juveniles on plankton and macroinvertebrates. The decline in the growth coincides with the attainment of maturity during the second year and the change over to a piscivorous habit. From the second to the fourth year decline in growth takes place very slowly. Growth parameters of von Bertalanffy's equation for the three species are given in Table 3.

**Length-weight relationship.**

Data from 969 fishes were utilized for studies on length-weight relationship. A scatter diagram of weight vs total length (Fig. 6A) indicated that the relationship conforms to the general allometric formula.
<table>
<thead>
<tr>
<th>Method of length determination</th>
<th>Species</th>
<th>0</th>
<th>0+</th>
<th>1+</th>
<th>2+</th>
<th>3+</th>
<th>4+</th>
<th>5+</th>
<th>6+</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length frequency (cm)</td>
<td>O. punctatus</td>
<td>10.27</td>
<td>17.32</td>
<td>21.65</td>
<td>24.95</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>Aligarh (Ponds)</td>
</tr>
<tr>
<td></td>
<td>O. striatus</td>
<td>20.90</td>
<td>35.10</td>
<td>41.10</td>
<td>45.10</td>
<td>48.10</td>
<td>53.10</td>
<td>..</td>
<td>..</td>
<td>Aligarh (Rivers, Channels &amp; Ponds)</td>
</tr>
<tr>
<td></td>
<td>O. marilus</td>
<td>10.6</td>
<td>38.60</td>
<td>53.30</td>
<td>65.30</td>
<td>76.60</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>Poongar swamp</td>
</tr>
<tr>
<td>von Bertalanffy equation (cm)</td>
<td>O. punctatus</td>
<td>10.42</td>
<td>14.43</td>
<td>17.70</td>
<td>20.38</td>
<td>22.56</td>
<td>24.35</td>
<td>25.81</td>
<td>..</td>
<td>Aligarh (ponds)</td>
</tr>
<tr>
<td></td>
<td>O. marilus</td>
<td>19.30</td>
<td>32.40</td>
<td>40.80</td>
<td>46.20</td>
<td>49.80</td>
<td>52.20</td>
<td>..</td>
<td>..</td>
<td>Aligarh (rivers, Channels &amp; Ponds)</td>
</tr>
</tbody>
</table>

* Polymodal total length frequency histogram dissected on the basis of scale reading.

** Polymodal quarterly length frequency histogram dissected out by probability plot technique.

* Polymodal total length frequency histogram dissected on the basis of scale reading.

** Polymodal quarterly length frequency histogram dissected out by probability plot technique.
**Table 3. Growth parameters in von Bertalanffy's equation calculated for the different species of Ophicephalus**

<table>
<thead>
<tr>
<th>Species</th>
<th>$L_\infty$</th>
<th>$K$</th>
<th>$t_x$</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. punctatus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>32.35107</td>
<td>-0.3017</td>
<td>-1.9286</td>
<td>Aligarh (Ponds)</td>
</tr>
<tr>
<td>(Qasim &amp; Bhatt,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1966) Female</td>
<td>21.27663</td>
<td>0.4504</td>
<td>-1.2244</td>
<td>Aligarh (Ponds)</td>
</tr>
<tr>
<td><em>O. striatus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Bhatt, 1970)</td>
<td>56.50</td>
<td>0.420</td>
<td>-0.981</td>
<td>Aligarh (Rivers, Channels &amp; ponds)</td>
</tr>
<tr>
<td><em>O. marulius</em></td>
<td>113.0</td>
<td>0.22565</td>
<td>-0.7976</td>
<td>Poongar Swamp.</td>
</tr>
</tbody>
</table>

**Fig. 6** Length-weight relationship of *Ophicephalus marulius*. A, Scatter diagram of observed values; B, log-log transformation.
\( w = a l^b \)

or

\[ \log w = \log a + b \log l \]

where, \( w = \text{weight} \), \( l = \text{length} \) and \( a \) and \( b = \text{constants} \).

Plotting logs of weights on logs of total lengths revealed one linear regression for fishes of size above 80mm in total length (\( N = 954 \)) and another for fishes of size below 80mm in total length (\( N = 15 \)) (Fig. 6B). Test of significance by analysis of covariance between the two regressions indicated that the F value (13.09; d.f. 1 and 965) was highly significant at 1% level (6.66). Further, within the larger group, samples from swamp tested against those from farm showed only very slight significance in variance (\( F = 3.96 \); d.f. 1 and 877) at 5% level (3.85). The fishes for the farm were originally derived from the swamp. Test for samples of the larger group from the swamp, reservoir and river also showed only slight significance in variance (\( F = 3.68 \); d.f. 2 and 948) at 5% (3.00). Because of the very slight significance in the F value at 5% level, only one regression equation was derived for the larger group from all sources. The equation is

\[ \log w = -6.1192 + 3.3260 \log l \]

The correlation coefficient for this regression, 0.9926 shows a high degree of correlation between the two parameters.

Regression equation estimated for the smaller group of size below 80mm is

\[ \log w = -1.8398 + 1.1752 \log l \]

The correlation coefficient for this regression is 0.9714 which again shows a high degree of correlation between the two parameters.

The value of exponent \( b \) for both the groups was tested against the exponent in isometric growth, by the formula of Snedecor (1961).

\[ t = \frac{b - \beta}{S_{b}} \]

The \( t \) value for the larger group of above 80 mm long fish is

\[ \frac{3.3260 - 3.0000}{0.2402} = 1.3572 \]

which is found to be insignificant at 5% level. According to Beverton and Holt (1957), instance of important deviations from isometric growth in adult fishes are rare. Ricker (1958) observed that though weight is affected by time of year, stomach contents, spawning condition etc., a large number of species approach the isometric growth.
The t value for the smaller group of below 80 mm long fish is

\[
\frac{3.0000 - 1.1752}{0.07361} = 11.2049
\]

which is highly significant at 1% level. Hence it may be considered that there is a deviation from the so called cube law and it shows that the weight of the fish increases at a rate lower than the cube of the length in the smaller group.

The above observations indicate marked difference in the body form over the range under study. Another example is the cisco (Leucichthys) where 'b' values ranged from 1.38 to 3.68 in different lakes (Ricker, 1958).

Relative condition (Kn).

Relative condition factor is obtained by dividing observed weight (w) by calculated weight (\(\hat{w}\)) (Le Cren, 1951). The latter for each fish below 80 mm group and above 80 mm was derived from their respective length-weight equations. The average values of Kn for the different length-groups and for all length-groups combined for the different months are shown in Fig. 7 and 8 respectively. As fishes within the size-groups 340-379 and 620-659 mm were fairly well represented in the samples from reservoir, river and swamp, the Kn values for the above size-groups were tested by means of analysis of variance. It was found that the variation between centres (\(F=1.5203;\) d.f. 3 and 21) was insignificant at 5% level (3.07). Variation between size-groups (\(F=1.8430;\) d.f. 21 and 7), was also found to be insignificant at 5% level (3.44). Deviations of Kn from 1.0 explains all variations in weight that are not associated with length, in a manner that is impossible with the ponderal index K, unless 'b' actually equals 3.0 which is hardly the case (Blakburn, 1960; Pantulu, 1963).

It is interesting to note that at the planktonophagous stage (40 mm group), Kn

\[
\text{FIG. 7 Mean Kn values at different lengths of Ophicephalus marulius.}
\]
records the least value of 0.85 and reaches the maximum of 1.47 at 80 mm size-group at which sudden change over to larger invertebrate food takes place. The young ones of each brood remain together till they attain a length of about 110 mm after which they disperse themselves. The food mainly consisted of macro invertebrate fauna till now and a change over to piscivorous habit takes place after separation. This critical phase in the life history may account for the steep decline in the Kn from 1.43 at 120 mm to 1.14 at 160 mm. After this phase the Kn increases to 1.44 at the next size-group. With some fluctuations in the intermediate size-groups, the Kn again rises to the next peak of 1.44 at 360 mm when the fish is about an year old. The fish enters the maturing phase from now on with a steadily declining Kn that reaches 1.015 at 440 mm. The rise at 480 mm corresponds to the size at first maturity (z = 460 mm; g = 500 mm) and the trough at 520 mm to spawning. The next mode (560 mm) and trough (600 mm) may respectively represent second maturity and spawning when the age of the fish is 2+. The distinct fluctuations noticed in the Kn till 600 mm are no more seen in the subsequent size-groups where the Kn has always been less than unity. The faint modes at 720-760 mm and 840 mm and troughs at 800 mm and 880 mm correspond to the 3rd and 4th mode of spawning. After 840 mm, the Kn declines to a low level and never rises again. It may be noted from Fig. 13 that the highest fecundity attained by the fish at about 820 mm corresponds to the mode in the Kn at 840 while the decline in the fecundity corresponds to the downward trend in the Kn in size-groups beyond 840 mm. These observations lend support to the view of Pantulu (1961) that the number of 'peaks' and 'valleys' in the relative condition curve may well be an index of the number of spawnings during the life of the fish.

Higher values of Kn during November and from February to April may be attributed to the predominance of young ones in the samples. While the peak in July is partly due to young ones, it is also due to the developing gonads in the maturing adults from the reservoir and river. Higher values in August is exclusively due to advanced maturity stages. The decline after September could have been caused by the dominance of larger specimens from river and reservoir in the samples and also by the spent gonads.

**Stages of maturity**

Macroscopic examination of gonads revealed only five stages of maturity from stage I representing virgins to stage V representing spent condition in both sexes. However, ova diameter studies indicated transitional stages such as 11+ and 111+ which conformed to stages 1 and 111 respectively assigned by external examination of ovaries (Fig. 9).

**Maturity/length relationship**

Fig. 10 represents the relation between maturity and length for male and female *O. marulius*. In view of the fact that stage 11 comprises spent recovering
Fig. 8 Monthly fluctuations in the mean Kn values of *Ophicephalus marulius*.

Fig. 9 Ova diameter frequency in *Ophicephalus marulius*.
stages also, individuals since second stage have been considered mature. Maturity in both sexes begins at about 360 mm and the percentage of maturity steadily increases with length until, finally, all females and males over 560 mm and 660 mm in length respectively are mature. The 50 per cent levels in the maturity curves which may be

**Fig. 10** The relation of percentage maturity to length in male and female *Ophicephalus marulius*

**Fig. 11** The relationship between fecundity and total length of *Ophicephalus marulius*. 
taken to represent the mean length at which maturity is attained are 460 mm in females and 550 mm in males. The size at which maturity is attained is rather a constant proportion to the final lengths of a fish (Holt, 1962). In fishes the ratio of mean length of maturity to the asymptotic length \( \left( \frac{L_{m}}{L_{oo}} \right) \) ranges from 0.3 to more than 0.9 (Beverton and Holt, 1957). In \( O. \ marulius \) the above value for females is 0.41 and for males 0.49.

**Fecundity**

Fecundity estimation is based on the enumeration of mature eggs from 13 ovaries in third and fourth maturity stages, which are likely to be spawned in the ensuing season. Fecundity ranged from 2214 eggs in a fish, 500 mm in length to 18475 in another, 820 mm in length. The relationship between fecundity and total length is depicted in Fig. 11 which in the logarithmic form could be expressed as

\[
\log F = -0.7700 + 1.6038 \log L
\]

correlation coefficient \( r = 0.6953 \).

Since the exponential value is much less than that in length-weight relationship of adult fishes, fecundity seems to increase at a rate much lower than that of body weight in relation to length. Such a condition has been observed by Pantulu (1963) also in the catfish \( Osteoglanisus \ milius \). The regression of fecundity \( (F) \) on body weight \( (W) \) (Fig. 12) is

\[
\log F = 2.1665 + 0.4916 \log W
\]

correlation coefficient \( r = 0.7188 \).

![Fig. 12 The relationship between fecundity and weight of \( Ophiophorus \ marulius \).](image-url)
The relationship between ovary weight (Ow) and total length (L) is shown in Fig. 13. Only weight of ovaries in stages III and IV have been used to estimate the regression, the logarithmic form of which is

\[
\log \text{Ow} = 5.0876 + 2.2644 \log \text{L}
\]

correlation coefficient \(r = 0.8321\).

The value of exponent in this case indicates that ovary weight increases at a less rapid rate in relation to length than body weight (exponential value, 3.326), but more rapid than the rate of increase in fecundity (exponential value 1.6038).

The regression of fecundity (F) on ovary weight (Ow) is found to be

\[
\log \text{F} = 2.7900 + 0.7418 \log \text{Ow}
\]

correlation coefficient \(r = 0.8756\).

The exponential value which is less than unity also confirms the conclusion that fecundity increases at a rate less than body weight and ovary weight as compared to length. The rapid fall in fecundity noticed in \(O. \text{marulius}\) when the fish is above 4 years old, provides direct clue to this disharmony between the growth of the fish and the ovary that manifests added stress on the fish with increase in length. The occurrence of only two females over 900 mm (910 and 920mm) in length as against four males (910, 915, 925 and 940mm) in the samples may point to early mortality in the former imposed upon by the heavier stress of spawning.

![Fig. 13 The relationship between ovary weight and total length of \(Ophicephalus \text{marulius}\).](image-url)
Spawning cycle and periodicity

From the availability of advanced stages of III and IV from July to October and also from the occurrence in large number of young ones from October to April being specially abundant in November and December, it is inferred that spawning lasts from October to February in the swamp.

As pointed out earlier, some specimens from the river had fully developed gonads during April and May and spent condition in May and June (Fig. 14). Young ones, 54 mm in average length collected on 15th July could have been spawned in the second week of May. Juveniles, 97.4 mm in average length collected on 21-11-64 from the reservoir appear to have been spawned during late July. It becomes thus evident that the population from the river and reservoir spawns during May-July at the time of the SW monsoon period when the reservoir and river begin to be flooded by rains in the catchment, whereas in the swamp spawning could take place only during the NE monsoon period (October-December) when it swells up due to local rains (Table 4). The monthly average inflow rate in rivers Bhavani and Moyar draining into the Bhavanisagar Reservoir and the monthly rain fall during 1966 represented in Fig. 15. show that Bhavanisagar is mainly under the influence of the NE monsoon rains and the initial floods during July is only due to rains in the catchment and not due to local rains. Consequent on the initial floods the fishes

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![Diagram](image-url) - Fig. 14 Percentage of different maturity stages of *Ophicephalus marulius* in different months.
<table>
<thead>
<tr>
<th>Date of Collection</th>
<th>Locality</th>
<th>Number</th>
<th>Range Length (mm)</th>
<th>Average Length (mm)</th>
<th>Weight (g)</th>
<th>Probable month of spawning</th>
<th>Spawning season</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-7-1964</td>
<td>River</td>
<td>60</td>
<td>40-63</td>
<td>54</td>
<td>1.38</td>
<td>May, 1964</td>
<td>During SW monsoon</td>
</tr>
<tr>
<td>21-11-1964</td>
<td>Reservoir</td>
<td>165</td>
<td>82-110</td>
<td>97.4</td>
<td>5.57</td>
<td>July, 1964</td>
<td>-do-</td>
</tr>
<tr>
<td>21-11-1964</td>
<td>Swamp</td>
<td>465</td>
<td>38-44</td>
<td>41</td>
<td>0.39</td>
<td>October, 1964</td>
<td>During NE monsoon</td>
</tr>
<tr>
<td>22-12-1964</td>
<td>Swamp</td>
<td>547</td>
<td>45-49</td>
<td>47</td>
<td>..</td>
<td>November, 1964</td>
<td>-do-</td>
</tr>
<tr>
<td>18-2-1965</td>
<td>Swamp</td>
<td>275</td>
<td>39.43</td>
<td>40.4</td>
<td>..</td>
<td>January, 1965</td>
<td>-do-</td>
</tr>
<tr>
<td>19-4-1965</td>
<td>Swamp</td>
<td>198</td>
<td>50-75</td>
<td>62</td>
<td>..</td>
<td>February, 1965</td>
<td>-do-</td>
</tr>
<tr>
<td>1-4-1965</td>
<td>Swamp</td>
<td>..</td>
<td>29-47</td>
<td>37</td>
<td>..</td>
<td>February, 1965</td>
<td>-do-</td>
</tr>
</tbody>
</table>
in the reservoir and river undergo spawning. But the water level in the swamp reaches the lowest level during this period and swells up only in October after the NE monsoon rains.

The percentage frequency of ova in different size-groups is shown in Fig. 9. In all, ova samples from 19 ovaries of different maturity stages were measured and those which were like-moded clubbed together producing ultimately six stages including the transitional stages II+ and III+. Except the one stage IV ovary which was from the reservoir, others were from the swamp. It is evident, that in all stages, there is only one well defined group of maturing or ripe ova as the case may be. They ranged in size from a minimum of 0.071 mm in the first stage ovary to a maximum of 3.57 mm in the fourth stage ovary. In the fully ripe stage, the mode is at 2.70 mm and all ripe ova would be evidently shed out in a single act of spawning. Mookerjee (1946) reported that the fertilized eggs of *O. marulius* are oval and 1.5 x 1.7 mm size.

Chacko (1956) reported spawning of *O. marulius* in south Indian rivers during March to June and October to December. Qasim and Qayyum (1961) observed two batches of oocytes in the maturing ovary of *O. marulius* from Northern India and inferred that their withdrawal from the ovary may involve more than one spawning act. They were of opinion that murrels may have two spawning seasons a year in South India coinciding with the two monsoons but each fish spawns repeatedly during its only one spawning season in Northern India where the NE monsoon rains are lacking. Khan (1924) reported restricted breeding season for Ophicephalidae in Punjab lasting from the middle of April to the end of July. Since in the present study the ripe ovaries of every female, both from the swamp and the

![Fig. 15 Rate of discharge in Bhavani and Moyar rivers and rainfall at Bhavansagar.](image-url)
reservoir, contained only one distinct group of ova, there is no likelihood that a single fish spawns more than once either in a season or year; but spawning season in a particular habitat seems to be determined by the type of monsoon rain that influences it.

Sex ratio

42 specimens from the reservoir contained 14 males and 28 females, the sex ratio being 1:2. In the river samples consisting of 28 specimens, there were 17 males and 11 females giving a ratio of 1.5:1.0. 743 specimens from the swamp were composed of 279 males and 464 females in the ratio of 1.0:1.7. Thus the ratio of females is found to be more in the lacustrine system (reservoir and swamp) but less in the fluviatile habitat.

Parental care

Nest building in *O. marulius* which is merely a receptacle formed among weeds has been reported by Khan (1924) and Chacko (1956). In the present study, on one occasion in November, an adult fish was seen resting in a saucer-shaped concavity in the bottom near the water margin of the farm-pond, partly covered with the submerged weed, *Hydrilla verticillata*. The scared fish left the spot never to return in spite of repeated search. The maximum number of young ones collected from a single brood under parental care in the present study is 701 and at least half of this number would have escaped. The average size of fry in this brood is 40 mm i.e., they are approximately one and a half month old. In another brood where parental care has ceased, there were 165 young ones, 97.4 mm in average length i.e., they are approximately four months old. The smallest size at which a juvenile was seen singly was 125 mm. While on certain occasions both the parents are noticed with their young ones especially during early stage of brood care, at other times only one could be seen. One of the parents guarding a brood of 60 mm average length caught and examined was found to be a male. The degree of vigilance seems to be inversely proportional to the size of the young ones. The parents cease to care for their young ones when the latter is about four months old and the young ones separate themselves when they are about four or five months old. Chacko (1956) also observed that both parents take equal share in brood care and they abandon their young ones when the latter has grown to a size of 4 inches (nearly 100 mm). However, Khan's (1926) observation that the fry begin to scatter about after six weeks since hatching is not in agreement with the present observation. In *O. punctatus*, Qayyum and Qasim (1962) found both parents guarding the young ones for about 15-20 days until they reach about 35 mm in length.

Food and feeding habits

The degree of fullness of the stomachs of young ones in each sample is given in Table 5. In all months, except March, the combined percentage of 'gorged' and 'full' conditions was much higher than the others. Only in the winter months
**Table 5.** Condition of feed of young *O. marulius* (figures in parenthesis give percentage)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Gorged</th>
<th>Full</th>
<th>$\frac{1}{2}$ full</th>
<th>$\frac{1}{3}$ full</th>
<th>$\frac{1}{4}$ full</th>
<th>Trace</th>
<th>Empty</th>
<th>Total</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-7-64</td>
<td>2.00 pm</td>
<td>15 (30)</td>
<td>14 (34)</td>
<td>6 (12)</td>
<td>5 (10)</td>
<td>3 (6)</td>
<td>3 (6)</td>
<td>1 (2)</td>
<td>50</td>
<td>River</td>
</tr>
<tr>
<td>21-11-64</td>
<td>2.30 pm</td>
<td>8 (13.3)</td>
<td>8 (13.3)</td>
<td>9 (15)</td>
<td>10 (16.6)</td>
<td>5 (8.3)</td>
<td>9 (15)</td>
<td>11 (18.3)</td>
<td>60</td>
<td>Swamp</td>
</tr>
<tr>
<td>22-12-64</td>
<td>10.00 am</td>
<td>3 (11.5)</td>
<td>8 (30.8)</td>
<td>5 (192)</td>
<td>5 (19.2)</td>
<td>3 (11.5)</td>
<td>2 (3)</td>
<td>..</td>
<td>26</td>
<td>Swamp</td>
</tr>
<tr>
<td>18-2-65</td>
<td>2.30 pm</td>
<td>4 (9)</td>
<td>10 (22.2)</td>
<td>13 (28.6)</td>
<td>5 (11.1)</td>
<td>4 (9)</td>
<td>6 (13.2)</td>
<td>3 (6.6)</td>
<td>45</td>
<td>Swamp</td>
</tr>
<tr>
<td>19-2-65</td>
<td>12.00 am</td>
<td>6 (22.2)</td>
<td>1 (3.7)</td>
<td>1 (3.7)</td>
<td>3 (11.1)</td>
<td>..</td>
<td>2 (7.4)</td>
<td>14 (5.8)</td>
<td>27</td>
<td>Swamp</td>
</tr>
<tr>
<td>1-4-65</td>
<td>11.00 am</td>
<td>19 (38)</td>
<td>18 (36)</td>
<td>5 (10)</td>
<td>1 (2)</td>
<td>2 (4)</td>
<td>..</td>
<td>5 (10)</td>
<td>50</td>
<td>Swamp</td>
</tr>
<tr>
<td>19-4-65</td>
<td>11.00 am</td>
<td>18 (38.3)</td>
<td>15 (31.9)</td>
<td>6 (12.8)</td>
<td>2 (4.3)</td>
<td>6 (12.8)</td>
<td>..</td>
<td>..</td>
<td>47</td>
<td>Swamp</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>73</td>
<td>77</td>
<td>45</td>
<td>31</td>
<td>23</td>
<td>34</td>
<td>305</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
of November and December there was a fall in the 'gorged' condition; but since the decline was compensated in the corresponding 'full' category, the effect may not be due to the season, though however, a remarkable effect of winter on the drift rate of aquatic invertebrates of Cauvery and Bhavani rivers has been observed. The percentage of different levels of fullness of all the months combined, also indicated dominance of 'gorged' and 'full' categories.

Since the nature of the gut contents is governed by selectivity in feeding in the various size-groups, seasonal variation observed in the qualitative composition of the food items would not reflect their relative abundance in the habitat. In general, while crustaceans dominated the food items during November, December, February and April, insects formed the bulk during July and March (Fig. 16A). The number of various food items encountered are presented in Table 6 and their percentage occurrence in Table 7. Most abundant items only are discussed below.

During the period November to April, samples of young ones were collected from the swamp.
### Table 6. Relative proportion of the important food items of fry and fingerlings of *O. marulius* expressed as number in total number of items (Percentage given in parenthesis).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirudinid worm</td>
<td>2 (0.62)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>2 (0.04)</td>
</tr>
<tr>
<td><em>Macrobrachium</em></td>
<td>8 (2.5)</td>
<td>15 (1.88)</td>
<td>14 (1.76)</td>
<td>1 (0.06)</td>
<td>4 (18.18)</td>
<td>144 (13.55)</td>
<td>186 (5.87)</td>
</tr>
<tr>
<td><em>Daphnia</em></td>
<td>6 (1.87)</td>
<td>317 (30.92)</td>
<td>516 (64.9)</td>
<td>1346 (85.35)</td>
<td>...</td>
<td>705 (66.38)</td>
<td>2890 (80.19)</td>
</tr>
<tr>
<td>Other crustaceans¹</td>
<td>7 (2.18)</td>
<td>339 (35.64)</td>
<td>7 (0.87)</td>
<td>1 (0.06)</td>
<td>...</td>
<td>10 (0.94)</td>
<td>364 (7.58)</td>
</tr>
<tr>
<td><em>Baetis</em> (nymphs)</td>
<td>6 (1.87)</td>
<td>25 (3.14)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>31 (0.65)</td>
</tr>
<tr>
<td><em>Caenis</em> (nymphs)</td>
<td>...</td>
<td>80 (10.05)</td>
<td>72 (9.05)</td>
<td>106 (6.72)</td>
<td>2 (9.09)</td>
<td>41 (3.86)</td>
<td>301 (6.26)</td>
</tr>
<tr>
<td><em>Trichorythodes</em> (nymphs)</td>
<td>6 (1.87)</td>
<td>39 (4.90)</td>
<td>52 (6.54)</td>
<td>37 (2.34)</td>
<td>...</td>
<td>3 (0.28)</td>
<td>137 (2.85)</td>
</tr>
<tr>
<td><em>Macromia</em> (nymphs)</td>
<td>...</td>
<td>...</td>
<td>16 (2.01)</td>
<td>38 (2.40)</td>
<td>...</td>
<td>1 (0.09)</td>
<td>55 (1.14)</td>
</tr>
<tr>
<td><em>Lestes</em> (nymphs)</td>
<td>152 (47.50)</td>
<td>39 (4.90)</td>
<td>6 (0.75)</td>
<td>20 (1.26)</td>
<td>...</td>
<td>16 (1.50)</td>
<td>233 (4.85)</td>
</tr>
<tr>
<td><em>Tholymis tillarga</em> (nymphs)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Corixid (unidentified)</td>
<td>73 (22.81)</td>
<td>129 (16.20)</td>
<td>51 (6.41)</td>
<td>...</td>
<td>...</td>
<td>3 (0.28)</td>
<td>256 (5.32)</td>
</tr>
<tr>
<td>Other insects²</td>
<td>59 (18.41)</td>
<td>42 (5.18)</td>
<td>27 (3.39)</td>
<td>27 (1.69)</td>
<td>...</td>
<td>56 (2.23)</td>
<td>211 (3.72)</td>
</tr>
<tr>
<td><em>Danio</em></td>
<td>...</td>
<td>...</td>
<td>32 (4.02)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>32 (0.67)</td>
</tr>
<tr>
<td><em>Rana</em> (larvae)</td>
<td>...</td>
<td>...</td>
<td>2 (0.25)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>2 (0.04)</td>
</tr>
<tr>
<td>Algal bunch (<em>Oedogonium</em>)</td>
<td>1 (0.31)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>1 (0.02)</td>
</tr>
</tbody>
</table>

| Total                      | 320            | 1025           | 795            | 1577           | 22            | 1062            | 4801        |

¹ Explanation as in Table 7

² Explanation as in Table 7
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Hirudinid worm</td>
<td>2.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macrobrachium</td>
<td>16.32</td>
<td>2.44</td>
<td>38.46</td>
<td>22.38</td>
<td>30.77</td>
<td>51.08</td>
</tr>
<tr>
<td>Daphnia</td>
<td>4.08</td>
<td>59.18</td>
<td>76.92</td>
<td>92.85</td>
<td></td>
<td>39.13</td>
</tr>
<tr>
<td>Other crustaceans (^1)</td>
<td>14.28</td>
<td>95.91</td>
<td>15.38</td>
<td>2.38</td>
<td></td>
<td>8.68</td>
</tr>
<tr>
<td>Baeotis (nymphs)</td>
<td>8.16</td>
<td>34.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caenis (nymphs)</td>
<td></td>
<td>55.10</td>
<td>80.77</td>
<td>64.28</td>
<td>15.38</td>
<td>29.34</td>
</tr>
<tr>
<td>Trichorythodes (nymphs)</td>
<td>12.24</td>
<td>46.93</td>
<td>65.38</td>
<td>52.38</td>
<td></td>
<td>2.17</td>
</tr>
<tr>
<td>Macromia (nymphs)</td>
<td></td>
<td></td>
<td>34.61</td>
<td>59.52</td>
<td></td>
<td>1.08</td>
</tr>
<tr>
<td>Lestes (nymphs)</td>
<td>87.75</td>
<td>42.85</td>
<td>23.07</td>
<td>38.09</td>
<td></td>
<td>16.30</td>
</tr>
<tr>
<td>Tholymis tilluga (nymphs)</td>
<td></td>
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<td></td>
<td></td>
<td>84.61</td>
<td>48.91</td>
</tr>
<tr>
<td>Corixid (unidentified)</td>
<td>69.38</td>
<td>71.42</td>
<td>92.84</td>
<td></td>
<td></td>
<td>3.25</td>
</tr>
<tr>
<td>Other insects (^2)</td>
<td>81.60</td>
<td>57.13</td>
<td>50.00</td>
<td>57.13</td>
<td></td>
<td>25.81</td>
</tr>
<tr>
<td>Danio</td>
<td></td>
<td></td>
<td></td>
<td>7.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rana (larvae)</td>
<td></td>
<td></td>
<td></td>
<td>7.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algal bunch (Oedogonium)</td>
<td>2.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Consist of Cyclops, Cypris, nauplius larvae and eggs of *Daphnia*
2 Consist of nymphs, larvae or adults of stonefly, *Pseudagrion, Ilypura,* *Cryptocricos, Pelocoris, plea, Micronecta,* caddisfly, *Dytiscus, Hydrophilus, Calos, Chaoborus, Chironomus,* ceratopogonid and ants.
In November, crustaceans and insects formed 55.53% and 44.47% respectively. Numerically, *Daphnia* formed the bulk of food components (42.08%).

In the month of December, crustaceans contributed 67.53%, insects 20.15%, fishes 4.02% and amphibians 0.25%. *Daphnia* was numerically important (64.9%).

During February, while crustaceans formed 85.48%, insects contributed the rest. *Daphnia* reached a peak contributing to 1346 number (85.35%).

In March, crustacean was exclusively composed of *Macrobrachium* (18.18%). Among insects, *Tholymis tillarga* dominated (72.72%).

During April, crustaceans were more dominant (80.85%) than insects (19.15%). The major items were *Daphnia* (66.38%) and *Macrobrachium* (13.55%).

Sample from the river was available only in the month of July. During this month, the total number of food items was composed of *Hirudinea* (0.62%), *Crustacea* (7.17%), *Insecta* (92.47%) and *Alage* (0.31%). Among insects Odonata and Hemiptera were the dominant groups forming 50.31% and 28.12% respectively. The former contained 152 nymphs of *Lestes* sp. (47.5%), 8 unidentified dragonfly nymphs (2.5%) and 1 unidentified damselfly nymph. Hemiptera included 17 *Plea* sp. (5.31%) and 73 corixids (22.81). *Lestes* and corixids occurred in 87.75% and 69.38% of stomachs respectively (frequency occurrence).

The variation of food according to different size-groups of young ones is as follows: The larvae, 30 to 49 mm in length are predominantly planktonophagous, *Daphnia* forming 81.4% and 70.75% respectively of the total number of food consumed. Small insects such as nymphs of *Caenis, Lestes* and *Tholymis* and larvae of *Chaoborus* and other culicids formed the rest of the major items. In the fingerlings, 50 to 109 mm in length *Daphnia* is almost completely replaced by *Macrobrachium* which accounts for 69.23% to 86.15% of the food. Among insects only larger nymphs of Ephemeroptera (2.38—4.61%) and Odonata (16.66—23.07%) formed the major part. Hemiptera was insignificant and Diptera totally absent (Fig. 16B).

Volume and weight of gut contents from each sample were also recorded. In Fig. 17 the total number of food items, their volume and weight converted to 100 stomachs (bars) and the volume of contents for 1000 number of food components (curve) in each sample are represented. It may be seen that the number and volume (or weight) are inversely proportional to each other, evidently due to the relative size of the major food items in the two categories.

In the present study none of the 45 adult fish (over 350 mm) from the reservoir and 28 adults from the river contained food in their stomachs. In the swamp also, out of 787 adults examined only 3 (morning sample) had food. All samples were from fish netted in the course of the night and landed early morning except on certain occasions. The food in these fishes was represented by *Barbus mahecola* and *Chela malabaricus* indicating that the adults are piscivorous.
Fig. 17 The total number, volume and weight of all food items converted to 100 stomachs and the volume of gut contents equivalent to 1,000 number of food items in each sample of young *Ophicephalus marmoratus*.

**Acknowledgement**

I am thankful to Dr. S.Z. Qasim, Director and Dr. R.V. Nair, Deputy Director, Central Marine Fisheries Research Institute for their critical comments in the manuscript. Mgr. Leonard Ejsymont, Katedra Ichtiologii, Polska, Poland rendered valuable suggestions during the preparation of the paper. Shri G. Venkataraman and Shri. K. Rangarajan, Scientists of the Central Marine Fisheries Research Institute and Shri. V. Natarajan, Assistant Director of Fisheries of the Department of Fisheries, Tamilnadu, helped me at various stages during the preparation of the manuscript and my thanks are due to them.
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BIOLOGY OF THE SNAKE-HEAD


