ASPECTS OF THE REPRODUCTIVE BIOLOGY OF MUGIL CEPHALUS (LINNAEUS, 1857) IN BONNY ESTUARY

Department of Zoology,
University of Port Harcourt
Port Harcourt, Nigeria.

ABSTRACT

Aspects of the reproductive biology of Mugil cephalus in the Bonny estuary were studied between January and December, 1996. Males were observed to be more slender than females while the females have deeper bodies than the males. The male:female ratio (1:0.95) was not significantly different. There was no significant size and month related variation in sex ratio but age related variations in sex ratio were significantly heterogenous. The minimum size at maturity was 16.6cm (0.5yr). Fish matured at 24.3cm TL (1.76yr) with median maturity size of 19.5cm TL (0.71yr). Median maturity for male and female fish were 16.4cm TL (0.41) and 18.2cm TL (0.60yr) respectively. Breeding occurred once a year between September and December, from late rainy season to early dry season. Mean absolute fecundity was 1,403,808 eggs (range 107,729-4,445,423 eggs) for fish of 17.0-29.5cm TL (mean 22.5cm TL). Fecundity correlated positively with fish total weight, length, ovary weight and age.

INTRODUCTION

The reproductive success of a fish population age. Appropriate behaviour and coordination with seasonal temperature regimes and other environmental factors interplay to achieve successful reproduction.

Fecundity estimates are useful in egg and larval survival studies, stock size estimation, stock discrimination, stock discrimination, induced spawning and egg incubation in aquaculture (Aluarez-Lajonchere, 1982) and its exploitation and management rationale (Adebisi, 1987). Absolute fecundity estimates of 1,275,000-2,781,000 (Kesteren, 1942) and 4,000,000-6,000,000 eggs (Shehadeh, 1973a) have been reported. Spawning season has been reported as varying from one locality to another (Kuo, et al, 1974b: Grant and Spain, 1975).

This study is intended to provide information on sexual maturity, breeding seasonality, fecundity and fry availability for stocking of ponds.

STUDY AREA

The Bonny river estuary system is located between latitudes 4o25'1 and 4o50'N and longitudes 7015'E. The basin has a total area of about 66,000 hectares made up of elevated beach ridges, mangrove swamps rivers and creeks. The mean tidal range at Bonny town is 1.35m (Wokoma & Ezenwa, 1982) and the river is tidal over its whole length. The climate is characterised by two season, dry (November-March) and wet (April-October). Annual rainfall in Bonny town is between 355.6cm and 469.8cm (Udo, 1978).

The vegetation include Rhizophora spp, Arecenia spp, Laguncularia sp growing on water-logged deposits of soft mud and clay-silt sediment.

2.0 MATERIALS AND METHODS

Samples were collected between January and December, 1997b, with gillnets, beach
The nets used were between 30mm and 60mm mesh size. Specimens were collected twice a month and conveyed to the laboratory in thermos-cool boxes (Olatunde, 1989) where they were counted and other morphometric parameters measured.

The standard and total lengths were taken to the nearest 0.1cm. The standard length (SL) was measured from the most anterior extremity to the hidden base of the median tail fin rays, while the total length (TL) was measured from the most anterior extremity to the bifurcated tail fin tips.

The weight (Wt) were obtained by weighing samples on digital meltler balance to the nearest 0.01g after draining water from buccal cavity and blot-drying with filler paper.

Length-weight relationship were represented by the exponential equation:

\[ Wt = a(TL)^b \]

Where:
- \( Wt \) = Total weight (g)
- \( TL \) = Total length (cm)
- \( a \) = a constant
- \( b \) = a constant.

Least squares linear regression was used to estimate \( a \) and \( b \) after transforming the equation to the logarithmic form.

\[ \log Wt = \log a + b \log TL. \]

There were no clear annuli to facilitate ageing from sealimetry. An indirect length based ageing method involving length - frequency distribution was used on the assumption that discrete modes in length frequency distribution could indicate age-groups (Pauly, 1983).

Sex ratio and sexual maturity were established by examining the gonads. The median size at maturity was estimated from cummulative frequency distribution of male and female specimens (see Marcus and Kusemiju, 1984).

The fishes were dissected and the ovaries collected, weighed and the stage of maturity observed. Ripe ovaries were preserved in Gilson's fluid (Bagenal and Braum, 1978) for not less than four weeks before fecundity was estimated by gravimetric method (Barbiker and Ibrahim, 1979). Sections of each ovary were taken and weighed, the eggs in each cut section was counted and recorded. Fecundity was estimated from the relationship (Barbiker and Ibrahim, 1979):

\[ F = \frac{1}{2} (N1 + N2) \]

Where:
- \( W1 \) & \( W2 \) = Weights of subsamples from left & right ovaries.
- \( N1 \) & \( N2 \) = No of eggs in \( W1 \) & \( W2 \) respectively
- \( W \) = Total weight of ovaries.

Fecundity was related to age, total length and total weight of fish (see Roff, 1988).

**Results**

**Size Composition/Sex Ratio**

Specimens comprised of 12.5-27.9cm TL (23.91-205.5g Wt) males and 12.2-30.1cm TL (20.01-247.5g Wt) females. Of the 246 specimens of M. cephalus used for sex ratio, 126 (51.22%) were males and 120 (48.78%) females, giving a male: female ratio of 1:0.95. The variation in sex ratio with fish size is shown in table 1. Contingency X2 test showed that their was homogeneity (X2=18.16, df=18, P>0.05) in the sex ratio of the various classes.

Sex ratio showed significant variation with age (X2=19.17, df=4, P<0.001). Goodness of fit X2 test showed that meles were predominant over females in ages 0+ to 4+ except in age 2+ where the ratio was homogenous (table 2). Monthly variation in sex ration is presented in table 3. Contingency X2 test revealed that overall monthly male: female ratio was homogenous (X2=19.38, df=11, P<0.05). The seasonal variations in sex ratio showed homogeneity when tested (X2=0.00, df=3, P>0.05) with contingency X2 (table 3).
Sexual Maturity
Maturity was attained by fish (overall sex) at 17.0 cm TL. The smallest fish at maturity was 16.6 cm TL, estimated from Langi and Langi's (1987) model. The age of the smallest mature fish was estimated as 0.5 yr. The male and female median maturity sizes were estimated as 16.4 cm TL (0.41 yr) and 18.2 cm TL (0.60 yr) respectively. Maturation ratios were 0.677 and 0.646 for males and females respectively. The modified maturation ratio was 0.5878 (males) and 0.6026 (females).

Breeding Seasonality
Gonadal maturation stages observed (Table 4) showed that breeding had its peak in July, August, September. Mature ovaries appeared from May through September, spent specimens occurred from September through December, while developing ovaries were prevalent throughout the year. Immature gonads occurred between December and May, peaking around January and February (Fig. 1).

Fecundity
The mean fecundity of M. cephalus was 1,403,808 eggs (range, 107,729-4,445,423 eggs). Out of the 13 mature ovaries used for estimation, 4 (30.77%) had <500,000 eggs, 6 (46.15%) had between 800,000 and 1,000,000 eggs and 3 (23.08%) had >3,000,00 eggs (Table 5).

1. Relationship to total length
   Average fecundity relative to total length was 9,862 eggs/cm TL (range 2,039-21,658 eggs/cm TL) for fish of 17.0-29.5 cm TL (mean 22.5 cm TL). Fecundity increased significantly with total length (r = 0.8678, df = 11, P < 0.001) (Fig. 2) according to the exponential relationship
   \[ F = 0.0412 \times \text{TL}^{5.451} \]

2. Relationship to total weight
   The relationship between fecundity and total weight (r = 0.8566, df = 11, P < 0.001) (Fig. 3) shows that 73.38% of the variations in fecundity is accounted for by the difference in total weight according to the regression equation
   \[ F = 197.9703 \times \text{Wt}^{1.7898} \]
   This indicates that the relationship between fecundity and total weight is linear.

3. Relationship to ovary weight
   Fecundity and ovary weight were significantly correlated (r = 0.9057, df = 11, P < 0.001) (Fig. 4). This means that 82.03% of the variations in fecundity was explained by the changes in the ovary weight. The relationship is given by the exponential equation:
   \[ F = 22,532.0134 \times \text{Wo}^{1.5750} \]

4. Relationship to age
   Fecundity estimates for various age groups were, 107,729-482,359 eggs (age 0+), 801,467-3,102,101 eggs (age 1+), 3,712,472-4,445,425 eggs (age 2+) and reduced to 1,136,698 eggs (age 3+). Overall mean fecundity per year of life was 875,260eggs. Fecundity increased with age (r = 0.8677, df = 11, P < 0.001) (Fig. 5) with an exponential equation of the form:
   \[ F = 633,869.7113 \times \text{A}^{1.476} \]
   However, age accounted for 45.4% variation in fecundity. Roff (1986) equation relating fecundity at a given age to body size is given as follows:
$F_T = 8.1 \times 10^6 (1-e(0.5547T)) 5.451$ (for length)
$F_T = 6.6829 \times 10^6 (1-e(0.5447T)) 1.7898$ (for weight).

**Discussion**

The species did not show any marked sexual dimorphism, though the males were generally more slender than the females and the female specimens were deeper bodied than the males. No sex dominance was observed as the overall sex ratio was approximately equal. This agrees with reports of Peterson and Shehadeh, 1971) for Hawaiian population and Tamura (1981) in Tunisian lakes, where females were more abundant than males. Sex ratio was observed to favour the females as the size of the species increased. This may mean that the lifespan of the females is longer than the males. El. Zarka and El sedfy (1970) noted that segregation of sexes due to maturity in age and size affects sex composition of a fish population.

*Mugil cephalus* attained first sexual maturity at 17.0cm TL (0.5yr) meaning that the population in Bonny estuary attained sexual maturity prior to completion of one year cycle. This disagrees with the observations for other populations (Thompson, 1963; Farrugio, 1975). The population of *M. cephalus* is Bonny estuary may have attained sexual.
Table 1: Sex ratio (male: Female) of *M. cephalus* from Bonny river as a function of size.

<table>
<thead>
<tr>
<th>Total length (cm)</th>
<th>Number males</th>
<th>Number females</th>
<th>Sex ratio</th>
<th>X² test</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.0-12.9</td>
<td>10</td>
<td>1</td>
<td>1:0.10</td>
<td>7.36*</td>
</tr>
<tr>
<td>13.0-13.9</td>
<td>11</td>
<td>5</td>
<td>1:0.45</td>
<td>2.26</td>
</tr>
<tr>
<td>14.0-14.9</td>
<td>12</td>
<td>8</td>
<td>1:0.67</td>
<td>0.80</td>
</tr>
<tr>
<td>15.0-15.9</td>
<td>11</td>
<td>6</td>
<td>1:0.55</td>
<td>0.92</td>
</tr>
<tr>
<td>16.0-16.9</td>
<td>10</td>
<td>8</td>
<td>1:0.80</td>
<td>0.22</td>
</tr>
<tr>
<td>17.0-17.9</td>
<td>14</td>
<td>13</td>
<td>1:0.93</td>
<td>0.04</td>
</tr>
<tr>
<td>18.0-18.9</td>
<td>17</td>
<td>7</td>
<td>1:0.41</td>
<td>4.16*</td>
</tr>
<tr>
<td>19.0-19.9</td>
<td>12</td>
<td>12</td>
<td>1:1</td>
<td>0.00</td>
</tr>
<tr>
<td>20.0-20.9</td>
<td>6</td>
<td>9</td>
<td>1:1.5</td>
<td>0.60</td>
</tr>
<tr>
<td>21.0-21.9</td>
<td>8</td>
<td>15</td>
<td>1:1.88</td>
<td>2.14</td>
</tr>
<tr>
<td>22.0-22.9</td>
<td>7</td>
<td>7</td>
<td>1:1</td>
<td>2.00</td>
</tr>
<tr>
<td>23.0-23.9</td>
<td>3</td>
<td>5</td>
<td>1:1.67</td>
<td>0.49</td>
</tr>
<tr>
<td>24.0-24.9</td>
<td>3</td>
<td>4</td>
<td>1:1.33</td>
<td>0.14</td>
</tr>
<tr>
<td>25.0-25.9</td>
<td>1</td>
<td>1</td>
<td>1:1</td>
<td>0.00</td>
</tr>
<tr>
<td>26.0-26.9</td>
<td>0</td>
<td>6</td>
<td>0:6</td>
<td>6.00*</td>
</tr>
<tr>
<td>27.0-27.9</td>
<td>1</td>
<td>3</td>
<td>1:3</td>
<td>1.00</td>
</tr>
<tr>
<td>28.0-28.9</td>
<td>0</td>
<td>5</td>
<td>0:5</td>
<td>5.00*</td>
</tr>
<tr>
<td>29.0-29.9</td>
<td>0</td>
<td>3</td>
<td>0:3</td>
<td>3.00</td>
</tr>
<tr>
<td>30.0-30.9</td>
<td>0</td>
<td>2</td>
<td>0:2</td>
<td>2.00</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>120</td>
<td>1:0.95</td>
<td>0.14</td>
</tr>
</tbody>
</table>

\[ P = df-1 \]

*P<0.05
Table 2: Sex ratio (male: Female) for *M. cephalus* from Bonny river as a function of age.

<table>
<thead>
<tr>
<th>Age(Yr)</th>
<th>Number of fish</th>
<th>Sex ratio</th>
<th>$X^2$ test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td></td>
</tr>
<tr>
<td>0+</td>
<td>10</td>
<td>1</td>
<td>1:0.1</td>
</tr>
<tr>
<td>1+</td>
<td>93</td>
<td>68</td>
<td>1:0.7</td>
</tr>
<tr>
<td>2+</td>
<td>22</td>
<td>32</td>
<td>1:1.5</td>
</tr>
<tr>
<td>3+</td>
<td>1</td>
<td>14</td>
<td>1:14</td>
</tr>
<tr>
<td>4+</td>
<td>0</td>
<td>5</td>
<td>0:5</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>120</td>
<td>1:0.95</td>
</tr>
</tbody>
</table>

* P<0.05  **P<0.001  CL = Confidence limit (3.48).

Table: 3 Monthly variation in the sex ratio (Male :Female) of *M. cephalus* from Bonny river.

<table>
<thead>
<tr>
<th>Months</th>
<th>Number Males</th>
<th>Number Female</th>
<th>Sex ratio</th>
<th>$X^2$ test</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>14</td>
<td>5</td>
<td>1:0.36</td>
<td>4.26*</td>
</tr>
<tr>
<td>February</td>
<td>2</td>
<td>11</td>
<td>1:1.00</td>
<td>8.34*</td>
</tr>
<tr>
<td>March</td>
<td>11</td>
<td>8</td>
<td>1:0.73</td>
<td>0.48</td>
</tr>
<tr>
<td>April</td>
<td>16</td>
<td>8</td>
<td>1:0.50</td>
<td>2.66</td>
</tr>
<tr>
<td>May</td>
<td>12</td>
<td>10</td>
<td>1:0.83</td>
<td>0.18</td>
</tr>
<tr>
<td>June</td>
<td>6</td>
<td>9</td>
<td>1:1.50</td>
<td>0.60</td>
</tr>
<tr>
<td>July</td>
<td>9</td>
<td>6</td>
<td>1:0.67</td>
<td>0.60</td>
</tr>
<tr>
<td>August</td>
<td>10</td>
<td>10</td>
<td>1:1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>September</td>
<td>14</td>
<td>26</td>
<td>1:1.86</td>
<td>3.60</td>
</tr>
<tr>
<td>October</td>
<td>13</td>
<td>7</td>
<td>1:0.54</td>
<td>1.80</td>
</tr>
<tr>
<td>November</td>
<td>9</td>
<td>9</td>
<td>1:1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>December</td>
<td>10</td>
<td>12</td>
<td>1:1.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>120</td>
<td>1:0.95</td>
<td>0.14</td>
</tr>
</tbody>
</table>

*p<0.05  df=1 in each $X^2$ test
Table 4: The lengths, weights, ovary weights and gonosomatic index of specimens of *M. cephalus* examined for fecundity.

<table>
<thead>
<tr>
<th>Total length (cm)</th>
<th>Total weight (g)</th>
<th>Ovary weight</th>
<th>Fecundity</th>
<th>Relative fecundity</th>
<th>GSI</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.0</td>
<td>52.83</td>
<td>4049</td>
<td>107,729</td>
<td>2,039.16</td>
<td>8.50</td>
<td>0.47</td>
</tr>
<tr>
<td>17.0</td>
<td>60.00</td>
<td>3.02</td>
<td>279,111</td>
<td>4,651.85</td>
<td>5.03</td>
<td>0.57</td>
</tr>
<tr>
<td>20.0</td>
<td>84.54</td>
<td>9.69</td>
<td>451,217</td>
<td>5,337.32</td>
<td>11.46</td>
<td>0.85</td>
</tr>
<tr>
<td>20.3</td>
<td>76.35</td>
<td>8.17</td>
<td>482,359</td>
<td>6,317.73</td>
<td>10.70</td>
<td>0.90</td>
</tr>
<tr>
<td>21.0</td>
<td>90.60</td>
<td>9.46</td>
<td>827,500</td>
<td>9,133.55</td>
<td>10.44</td>
<td>1.02</td>
</tr>
<tr>
<td>21.0</td>
<td>92.72</td>
<td>9.79</td>
<td>801,467</td>
<td>8,643.95</td>
<td>10.56</td>
<td>1.02</td>
</tr>
<tr>
<td>21.0</td>
<td>81.40</td>
<td>9.18</td>
<td>895,165</td>
<td>10,997.11</td>
<td>11.28</td>
<td>1.02</td>
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<tr>
<td>22.1</td>
<td>105.14</td>
<td>12.11</td>
<td>816,678</td>
<td>7,767.53</td>
<td>11.52</td>
<td>1.23</td>
</tr>
<tr>
<td>23.5</td>
<td>126.15</td>
<td>14.64</td>
<td>1,191,580</td>
<td>9,445.74</td>
<td>11.61</td>
<td>1.55</td>
</tr>
<tr>
<td>24.5</td>
<td>143.23</td>
<td>19.79</td>
<td>3,102,101</td>
<td>21,658.18</td>
<td>13.82</td>
<td>1.81</td>
</tr>
<tr>
<td>26.2</td>
<td>194.53</td>
<td>21.50</td>
<td>3,712,472</td>
<td>19,084.32</td>
<td>11.05</td>
<td>3.21</td>
</tr>
<tr>
<td>28.5</td>
<td>237.50</td>
<td>26.80</td>
<td>4,445,423</td>
<td>18,717.71</td>
<td>11.28</td>
<td>2.17</td>
</tr>
<tr>
<td>29.5</td>
<td>257.50</td>
<td>8.72</td>
<td>1,136,698</td>
<td>4,412.13</td>
<td>3.38</td>
<td>3.60</td>
</tr>
</tbody>
</table>

GSI = Gonadosomatic index