Dynamics in the Reproductive Biology of *Heterobranchus longifilis* Val, (Pisces: 1840) in the Inland Wetlands of Cross River, Nigeria

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**Abstract:** Sex ratio, maturity size, maturity stages, fecundity, egg diameter and breeding season of *Heterobranchus longifilis* were studied monthly between January 2004 and December 2006 in the inland wetlands of Cross River, Nigeria. Male: female sex ratio was 1:0.6. Size at first maturity was 14.8cm total length (L<sub>T</sub>) and 102.4g body weight (W<sub>b</sub>) for male, 15.7cm (L<sub>T</sub>) and 92.0g (W<sub>b</sub>) for female. Gonadal ripe stage(VI) was highest in June and July while fish in spent condition(VII) increased from August to December then decreased progressively towards August. Eggs sizes varied from 0.5mm to 1.0mm diameter and 0.25 to 0.40mg weight (immature eggs), 1.0 - 1.5mm and 0.40 - 0.55mg (maturing eggs) and 1.5 - 3.2mm, 0.45 - 0.75gm (mature eggs). Absolute fecundity ranged from 5515 eggs [fish: 14.8cm (L<sub>T</sub>); 102.4g (Body weight: W<sub>b</sub>)] to 36,800eggs [(fish: 69.9cm (L<sub>T</sub>); 1625.5g (W<sub>b</sub>)], relative fecundity from 208-236 eggs cm<sup>-1</sup> and 25-33 eggs gm<sup>-1</sup>. Relationship between fecundity and total length and between fecundity and body weight was according to the logarithmic function; F = 2365.88 +560.22 log L<sup>-1</sup> and F = 5025.81 + 56.34 log W<sup>-1</sup>. F= fecundity, L = total length and W = body weight. Gonado-somatic index (I<sub>G</sub>) varied from 0.12 to 4.06 with a mean index of 2.34± 2.22 in female fish and from 0.06 to 1.67 with mean index of 0.91± 0.87 in male fish. Gonadal ripe stage, I<sub>G</sub>, fecundity and egg size were highest during months of May to July indicating that for captive breeding programs of *H. longifilis*, gravid fishes are available in the wild during April-August.

**Key words:** Inland wetlands, Cross River, Fecundity, Sexual maturity and *H. longifilis*.

**INTRODUCTION**

Clariid catfishes occur in most freshwater bodies of South East Africa where they constitute a significant component of the catches. Highest generic diversity is found on the African continent where some 14 genera have been reported<sup>[48]</sup> against two in South East Asia. In both continents Clariids are of great economic importance as food fish. Aluko and Shabal<sup>[47]</sup> stated that African catfish, *Clarias and Heterobranchus*, are widely cultured in Africa and Europe and of late, African catfish is being cultured in Asia. *Clarias anguillaris* (Line), *Clarias gariepinus* (Burcell) and *Heterobranchus longifilis* are the three species most readily acceptable in Nigeria among fish farmers and consumers alike and as such command good commercial value<sup>[30]</sup>. Qualities which make them suitable for culture include; ability to withstand handling stress, disease resistance, fast growth rate, high yield potential, fecundity and palatability.

Rational fisheries management in rivers should consider the values of basic biological parameters of the fish from various water bodies including their reproductive potential.

Knowledge of fecundity is important in stock assessment, stock discrimination<sup>[27]</sup> and rational utilization of stock<sup>[37]</sup>. Studies on breeding seasons and factors associated with it is needed to protect new recruits and predict recruitment variability<sup>[33]</sup>.

Because of the diversity of aquatic environment, the differences in amount of deposited eggs are observed not only in individual species but also in populations from various water bodies. Similar studies conducted on other species of catfish in Nigerian waters include the work on egg size of *Chrysichthys auratus* (Geoffrey Saint-Hilaire) in Lake Kainji<sup>[14]</sup>, *Chrysichthys walker* (Gunther) in Lekki Lagoon, reproductive biology of *Chrysichthys filamentosus* (Boulenger) in Oguta Lake<sup>[19]</sup>, sex ratio and fecundity of *C. gariepinus* in Opa Reservoir in Ile Ife<sup>[30]</sup>, variation of egg size with species<sup>[28]</sup> and their reproductive behavior<sup>[50-53]</sup>. No study had been conducted on the reproductive biology of *H. longifilis* in the inland wetlands of Cross River. This study examined sexual maturity, fecundity and egg size of *H. longifilis* in Cross River, Nigeria.
MATERIALS AND METHODS

Fish samples were taken monthly in 3 sampling stations (Iru, Ekor and Ikom) along the 200km water length of Cross River inland wetlands (Figure 1) located at South-Eastern part of Nigeria (Latitude 4º.25' - 7º.00', Longitude 7º 15' - 9º.30') between January, 2004 and December, 2006. Climate of the study area is defined by dry season, from November-March and wet season from April-October.

Fish were caught with hook and line, cast net, seine nets, gillnets and lifts nets from dug-out canoes and identified using FAO Species Identification Sheet. Sexes were determined according to Madu et al. The fish were measured to the nearest 0.1cm (total length) and weighed to the nearest 0.1gm using a triple beam balance. The length at first maturity was worked out by plotting the percentage of matured fish against their length. The length at which 50% of the females were matured (with developed ovary in their ovaries) was considered as their length at first maturity. Stages of gonadal development were determined by visual inspection and graded according to Bruton and Lamai scale. Gonadosomatic index (I_v) was expressed according to De Vlaming et al as:

\[ I_v = \frac{\text{Gonad weight} \times 100}{\text{Body weight}} \]

I_v was used to follow seasonal changes in the gonads. Matured ovaries with visible eggs (stages IV-VII) were preserved in modified Gilson fluid which help to hardened the eggs, break down ovarian tissues and liberate the eggs. The samples were later analyzed for fecundity, egg size and egg weight. Eggs were counted by direct enumeration. Number of eggs per gram weight was determined by counting number of eggs in 1-gram sub-sample. Counting was done for five similar subsamples. The mean number of the eggs in the five subsamples gave the number of eggs per gram of weight. Fecundity was calculated by multiplying total weight of eggs by number of eggs per gram weight. To determine the spawning and breeding periodicity, egg diameter (width) progression was recorded monthly according to Imevbore, Douglas and measured using ocular micrometer mounted on a binocular microscope. By plotting the mean percentage frequency of eggs of different diameter in matured ovaries, against different months. Egg weight was determined according to Peter using metler analytical balance to the nearest one thousand of a milligram. Fecundity- fish body length and fecundity- body weight relationships were described by the expression:

\[ F = aX^b \]

after Kings where F = fecundity, X= independent variables (body weight, total length and condition index). a = constant (intercept), b= regression coefficient (slope) both of which were evaluated by least squares regression analysis using log transformed based on the equation:

\[ \log F = \log a + b \log X \]

RESULT AND DISCUSSIONS

Results: Male dominance was observed in the species, as male: female sex ratio of H. longifilis over the entire study showed highly significant (Chi-square, P < 0.001) monthly variation from the expected sex ratio of 1:1 with males more numerous in all months of sampling except November 2004, January 2005, March and April 2005 (Table I).

The maturity curve plotted for the fish by direct observation of ovaries and testis and changes in the proportion of mature fish in the population with increasing fish length showed that 50% of the males matured at 14.8cm (size at first maturity for male) total length (L), and females at length 15.7cm (size at first maturity for female) (Figure 2). The smallest matured female was 10.6cm while the smallest matured male was 12.0cm. Highest proportion of gonadal ripe stage (VI) were in June and July while fish in spent condition (VII) increased from August to December then decreased progressively towards August (Figure 3). Development from the immature condition to ripe condition through well defined intermediate stages of maturation and ripening, and the percentage of each stage of gonadal development is shown in Table II. 54.8% of female and 70% of male fish were undergoing reproductive processes, during study period. I_v varied from 0.12 to 4.06 with a mean index of 2.34± 2.22 in female fish and from 0.06 to 1.67 with mean index of 0.91± 0.87 in male fish. I_v values were higher in the wet season (p< 0.05). The I_v changes in H. longifilis females and males in consecutive months are presented in Figure 4. Both the values were very low during October to January. It began to increase in January, and increased considerably in March. The highest value was in July, with lower values during August, and values decline further in October and remain unchanged until January.

Absolute (Individual) fecundity of the fish ranged from 5515 eggs [fish: 14.8cm (L)]; 102.4g (Body weight: W_d)] to 36,800eggs [(fish: 69.9cm (L); 1625.5g (W_b)]. While relative fecundity ranged from 208-236 eggs cm⁻¹ and 25-33 eggs gm⁻¹. The monthly variation in mean fecundity, calculated as mean of fecundities of monthly samples, is shown in Figure 5. Fecundity was high during May-July, which falls sharply during August-October and remains constant.
Fig. 1: Map of Cross River State showing study area (Inserted with map of Nigeria showing Cross River).

Fig. 2: Percentage occurrence of mature male - and female--- H. longifilis at different lengths.
until January. The regression models of the relationship of fecundity with total length and body weight of the fish (Figure 6 and 7) were F = 2365.88 + 560.22 log L ($r^2 = 0.74, P < 0.001$) and F = 5025.81 +56.34 log W ($r^2 = 0.71, P < 0.001$) respectively. Fecundity was directly proportional to length and weight of the fish.

The diameter of oocytes ranged from 0.5mm-1.0mm diameter and 0.25-0.40mg weight for immature eggs; maturing eggs ranged from 1.0-1.5mm diameter and 0.40-0.55mg weight while mature eggs from 1.5-3.2mm and weight from 0.45-0.75mg. The frequency of occurrence of eggs at different diameter plotted against different months showed that immature eggs were present in the ovaries during January- April; maturing eggs during April- May and mature eggs during May- July with peak in June- July. The frequency of mature eggs began to drop from August while these were completely absent during October- January. Then again from January- February their frequency began to build up (Fig 8).

### Table 1: Monthly variation in the sex ratio (male : female) of H. longifilis in Cross River inland wetlands

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Total Sample</th>
<th>Male</th>
<th>Female</th>
<th>Sex Ratio</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>January</td>
<td>22</td>
<td>18</td>
<td>4</td>
<td>1:0.3</td>
<td>6.00**</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>18</td>
<td>12</td>
<td>6</td>
<td>1:0.5</td>
<td>2.45</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>1:0.7</td>
<td>4.14*</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>10</td>
<td>7</td>
<td>3</td>
<td>1:0.4</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>68</td>
<td>50</td>
<td>18</td>
<td>1:0.4</td>
<td>27.5**</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>112</td>
<td>82</td>
<td>30</td>
<td>1:0.5</td>
<td>17.25**</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>96</td>
<td>59</td>
<td>37</td>
<td>1:0.6</td>
<td>8.64**</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>21</td>
<td>15</td>
<td>6</td>
<td>1:0.4</td>
<td>17.24**</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>12</td>
<td>9</td>
<td>3</td>
<td>1:0.3</td>
<td>19.41**</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>-</td>
<td>4.00*</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>86</td>
<td>31</td>
<td>55</td>
<td>1:1.7</td>
<td>4.30*</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>1:0.5</td>
<td>6.45*</td>
</tr>
<tr>
<td>2005</td>
<td>January</td>
<td>18</td>
<td>4</td>
<td>14</td>
<td>1:3.5</td>
<td>3.64</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>1:0.5</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>16</td>
<td>6</td>
<td>10</td>
<td>1:1.7</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>34</td>
<td>14</td>
<td>20</td>
<td>1:1.4</td>
<td>1.84</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>72</td>
<td>50</td>
<td>22</td>
<td>1:0.4</td>
<td>5.41*</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>96</td>
<td>66</td>
<td>26</td>
<td>1:0.4</td>
<td>17.29**</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>100</td>
<td>72</td>
<td>28</td>
<td>1:0.4</td>
<td>12.00**</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>42</td>
<td>32</td>
<td>10</td>
<td>1:0.3</td>
<td>22.41**</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>1:0.5</td>
<td>3.36</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1:0.3</td>
<td>1.86</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>56</td>
<td>39</td>
<td>17</td>
<td>1:0.4</td>
<td>8.64*</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>61</td>
<td>48</td>
<td>13</td>
<td>1:0.3</td>
<td>13.33**</td>
</tr>
<tr>
<td>Overall</td>
<td>1064</td>
<td>659</td>
<td>343</td>
<td>1:0.52</td>
<td>31.02**</td>
<td></td>
</tr>
</tbody>
</table>

Significant @ *p = 0.05 and **p = 0.001
Fig. 3: Relative percentage of matured gonads in the male -- and female- of H. longifilis

Fig. 4: Dynamics of Gonado-somatic Index (GSI) in H. longifilis male - and female --- in Cross River.

Fig. 5: Monthly variation in mean fecundity of H. longifilis in Cross River inland wetlands.
Discussion: Preponderance of the male specimens over the female as observed in Cross River inland wetlands has similarly been observed in populations of other catfishes in some Nigerian water bodies by Abayomi and Arawomo\textsuperscript{11} and Taiwo and Aransiola\textsuperscript{11}. Ham\textsuperscript{11} attributed this disparity to differential survival over certain environmental conditions while Fagade et al\textsuperscript{11} explained the phenomenon as a mechanism for population regulation. However, the dominance of male in Cross River can be attributed to the relatively few spawning females susceptible to catch. Generally in African water bodies it is common that population of males dominate because they present more growth than females without representing a risk situation for the
fishery\cite{19}. Also once fertilization of eggs had concluded, males emigrate from spawning grounds towards feeding grounds in shallow part (where they are easily captured) and females go towards submerged vegetation and rocky areas to avoid gear and carry out incubation and protection of offspring\cite{7}. There is an assurance that every mature female will always have a male to mate it.

Males (14.8cm) reach sexual maturity before females (15.7cm). Knowledge of the phases of gonadal development is important for understanding the dynamics of the gonads and to assess reproductive mechanism of a species. As ovaries develop, they present accentuated differences in size and form. The mature stage is evidenced by its largest volume. Variations in the form occur, starting from the filiform appearance of the immature stage, becoming lobular along the maturation process, and resulting wrinkled after spawning. Afterwards they become turgid and lobuled, characterizing the starting of the recovering stage. Reproductive cycles and gonad development stages in fish had been documented\cite{16,18,32} and all classified gonad maturation cycle in Clariidae into eight stages as observed in this study.

GSI has been used thoroughly as indicator of the spawning period in teleosts\cite{14} and its use in reproductive biology has been considered more appropriate when associated with other indicators of the reproduction as macroscopic observations\cite{11}. Peak of Iₘ for this species in June/July were confirmed by the largest frequency of the matured phases during this period; characterizing a single annual spawning, and synchronic ovarian development. This explained the inability of the species to sustain itself adequately in the habitat. Catfishes generally present a single annual spawning period corresponding to the warm season or associated with high water temperature\cite{13,54,41}. GSI for females was always higher than that for males probably due to heavier ripe female gonads.

Absolute fecundity between 5515 and 36,800 eggs recorded in this study was comparatively low compared to observation from other Clariid catfishes. Gaigher\cite{11} recorded 70,000 eggs for C. gariepinus in Hardap dam, south West Africa while 650,625 eggs was reported by Abayomi and Arowomo\cite{13} in C. gariepinus in Opaa reservoir, Nigeria. However, higher values of 510-2278 eggs by Gudkov\cite{23} for Teranet fish; Salvalinus teranetz at same size range and 400-500 eggs for Silver carp by Mekeyeva have been observed in other freshwater bodies. Variation in fecundity of individuals fish may be due to differential abundance of food. Nutritional resources are known to play critical roles in regulating variations in fecundity\cite{12,57}. Cross River being oligotrophic, produce fish of lower fecundity. Peak season in fecundity of these species which coincides with on set of rains and the rising flood (May to August) have been observed by Greenwood\cite{22} and Vanderwaals\cite{49}. Harding\cite{24} stated that most tropical fishes are adopted to breed on the rising flood thus allowing the juveniles to take full advantage of the floofed banks for feeding while protected from predation. The choice of a particular season in fishes for breeding is influenced by various factors among which is food supply, changes in water quality or level, interspecific interactions, availability of spawning sites\cite{24,26,31,55,51}. In literature, fecundity of fishes subjected to analysis of correlation and regression, to determine the nature of relations between variables (e.g. between absolute fecundity and length or weight of a fish). The above relation is usually formulated as a power function\cite{26,6} or a linear function\cite{45,3}. The result of the present work suggest that the relation between the absolute fecundity and the total length or weight can be formulated in both ways: as a power function.

![Fig. 8: Monthly variation in egg diameter of H. longifilis in cross river inland wetlands](Image 193x592 to 444x684)

Table 2: Percentage gonadal development stages for female and male H.longifilis in Cross River inland wetlands

<table>
<thead>
<tr>
<th>Gonadal stages</th>
<th>% Female</th>
<th>% Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Immature virgin stage)</td>
<td>0.2</td>
<td>2.2</td>
</tr>
<tr>
<td>II (Developing virgin stage)</td>
<td>0.1</td>
<td>2.8</td>
</tr>
<tr>
<td>III (Developing stage)</td>
<td>0.3</td>
<td>3.3</td>
</tr>
<tr>
<td>IV (Maturing stage)</td>
<td>6.0</td>
<td>11.6</td>
</tr>
<tr>
<td>V (Mature)</td>
<td>38.6</td>
<td>5.2</td>
</tr>
<tr>
<td>VI (Ripe stage)</td>
<td>14.3</td>
<td>50.0</td>
</tr>
<tr>
<td>VII (Spent stage)</td>
<td>33.5</td>
<td>9.5</td>
</tr>
<tr>
<td>VIII (Recovering stage)</td>
<td>7.0</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Fig. 8: Monthly variation in egg diameter of H. longifilis in cross river inland wetlands
or as a linear one. In both cases high determination coefficients were obtained. Demska-Zakes and Dlugosz[12] believed that fish with such relations show faster growth rate at the same tune with higher fecundity and that the parameters to a large extent depend on environmental conditions.

The growth of eggs has a course similar to that of the entire ovaries. Occurrence of eggs of varying sizes between individuals in this study confirms data of other authors[10] who have shown that older, and thus as a rule larger female produce larger eggs. The changes observed, both in Lg and egg diameter, in H. longifilis are characteristic of fishes of a cyclic, single, spawning season. The breeding period of a fish will be for a definite duration if the mature eggs are sharply separated from the stock of the immature eggs.

Observations in this study that ovaries carried immature (January-April) and mature eggs (May-July) separated from each other by maturing eggs (April-May) indicated that the fish has a long spawning period, which extends from April to August. It is likely that the egg size ranging from 1.0mm to 3.2mm are the stock of the eggs to be shed and the maturing stock will mature subsequently. By August the mature eggs started declining signaling the end of breeding season. These result indicated that for captive breeding programs gravid fishes are available in the wild during April-August. Egg diameter observed, were larger compared to other members of Claridae. Nawar and Yoakin[38] found egg size range of 0.9-1.25mm diameter in Clarias lazera (Valenciennes). Douglas[16], encountered size range of 0.3-1.2mm diameter for C. gariepinus eggs in Lake Kariba, South Africa. Sidhmunka[43], encountered egg size range of 1.3-1.6mm diameter for Macrolepatus sp. in Thailand.

The status of the ovary of the fishes caught during October to January revealed that most of the ovaries were spent. These results indicated that the most productive fishing period for the species in the inland wetlands of Cross River was October-January. Although the length at first maturity obtained for the fish was 15.7cm, the minimum length recorded for specimens with spent ovaries was 23.4cm. Hence closed and less intense fishing during April-September, would help conservation of the natural stock of the fish, by allowing the fish to breed at least once in their lifetime.

ACKNOWLEDGEMENT

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