Population Dynamics of Labeo senegalensis Valenciennes 1842
(Pisces: Cyprinidae) in the Oueme River, Benin

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Abstract: The present study was conducted to understand the population parameters of Labeo senegalensis in Benin. Growth and mortality parameters, exploitation rates and annual recruitment patterns were estimated from monthly length-frequency samples between April, 2005 and March, 2006 for Labeo senegalensis in the Oueme river. Total length of the sampled 1,436 fish ranged from 6.3-52.7 cm. The Von Bertalanffy Growth Function (VBGF) was fitted to the 12 consecutive month’s length-frequency data to obtain a VBGF with the following parameters: L∞ = 57 cm TL, K = 0.30 year⁻¹. The growth performance index (a') was calculated as 2.99. The total mortality estimates from the catch curve analysis was Z = 1.47 year⁻¹ with a natural mortality M of 0.68 year⁻¹ for a mean environmental temperature of 28°C. The fishing mortality F estimates was 0.79 year⁻¹. The maximum of recruitment was recorded in June to September, indicating recruitment of one cohort year⁻¹. The estimated potential longevity Tₚₑₑ was 10 years. The exploitation ratio was 0.55 indicating that the Labeo senegalensis stock is on the verge being overfished. The results are discussed and compared to previously available information on Labeo senegalensis in other rivers.

Key words: Growth, mortality, exploitation rate, von bertalanffy GF, Labeo senegalensis, rivers

INTRODUCTION

The fish family Cyprinidae displays a worldwide distribution in fresh waters from tropics to cold temperate zones (Leveque, 2003). In Africa, the Cyprinidae have a pan-African distribution and form the most widespread fish family from the Maghreb region in North-western Africa to the coastal streams of the Cape in the South (Skelton et al., 1991). The vast majority of African species are included in only two genera: Barbus and Labeo.

Fishes species of the genus Labeo are widely distributed throughout Africa and consist of at least 80 species which comprise 16.5% of the African Cyprinid ichthyofauna (Skelton et al., 1991). Most Labeo species are commercially important throughout the African continent having contributed significantly to various fisheries (Weyl and Booth, 1999; Delaney et al., 2007). The species, Labeo senegalensis is widely distributed throughout West Africa (Leveque, 2003). It attains a length of 65.0 cm TL, a maximum weight of close to 4 kg and a maximum age of 6 years (Leveque and Daget, 1984). Labeo senegalensis locally known as gjobe is one of two Labeo species present in the Oueme basin (Laleyé et al., 2004). It is the largest species of the Labeo genus in the Oueme basin. L. senegalensis is becoming increasingly an important commercial cyprinid fish in the Beninese fisheries and it is used as a popular food fish. The growing demand, the increased fishing intensity and technological advances in catching has allowed a high fishing pressure on this species (Montchowui et al., 2008).

Despite its commercial importance and possible use as an aquaculture species in the tropics (Omoregie, 2001), only very limited and disparate information exists on its reproductive biology, ecology and exploitation levels in Benin in general and the Oueme river in particular. With the Benin continuously increasing fishing effort on the fish stocks in the Oueme basin, L. senegalensis is in

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danger of being overfished unless baseline research data are provided for its rational exploitation and management. Among studies of fisheries stock assessment for rational exploitation and conservation of resources, growth studies are an essential instrument in the sustainable management of fisheries resources because these studies contribute to estimates of production, stock size, recruitment and mortality of fish population (Issac, 1990; Abohweyere and Falaye, 2008). These studies provide a background for the elaboration of management plans envisioning optimum long-term exploitation of natural aquatic resources (Hilborn and Walters, 1992; Nassar, 1999). In order to contribute to a proper understanding of the life history of *L. senegalensis* in the Oueme river, this study investigated several aspects of population parameters such as growth, mortality, exploitation rates and recruitment patterns. Estimates of these population parameters are lacking for *L. senegalensis* in the Oueme river.

**MATERIALS AND METHODS**

**Study site:** The Oueme river (Fig. 1) is the largest fluvial basin in Benin with a 50,000 km² catchment area and extends to about 510 km in length originating from the Taneka mountains in the North of the country. The major

![Figure 1: Map of the Oueme river showing the four sampling stations](image)
tributaries are the Okpapa river (200 km long) and Zou river (150 km long). Peak discharge is rapid and occurs in August and September. The Oume river goes through many agro-ecological zones and reaches the Eastern side of Lake Nokoue that is connected to the Atlantic ocean. It has an average slope of 0.9 m km⁻¹ except along the upstream area of the basin where it measures 20 m km⁻¹. The river is influenced by two distinct climates due to its geographic location. The Northern basin (near the springs), experiences a tropical trend of alternative dry and rainy seasons and highly varying temperature (10-40°C). From November to March, rains can be rare or turbulent. Furthermore, the harmattan wind which blows from November to April, accentuates the thermic and hygrometric amplitudes. The rainy season extends from May to September. The Southern basin is characterized by a sub-equatorial climate with two rainy and dry seasons. The great rainy season occurs from April to July with the greatest amount of precipitation in June. The second rainy season occurs in September. The magnitude of variations of the temperature is much lower than in the North and ranges from 18-35°C. Fish sampling took place on four stations (Fig. 1). The first sampling station which is situated at Betéko (09°11'N-02°16'E), on the Oume river is located along a coarse, rocky zone with swift water currents. The second sampling station at Atchakpa (08°04'N-02°22'E) on the Oume river is located in a rocky zone. Toou (07°12'N-02°17'E) is the third sampling station on the Zou tributary which marks the transition between the zones of swift water and the delta. The forth station at Agonin Lowe's village (06°35'N-02°28'E) is situated within the Oume delta.

**Fish sample and data analysis:** Monthly samples of *Labeo senegalensis* were obtained from artisanal fishermen between April, 2005 and March, 2006. The Total Length (TL) of each specimen was measured to the nearest 0.1 cm while weight was measured to the nearest 0.1 g. The Fish Stock Assessment Tool (FiSAT) software (Gayanilo et al., 2002) was used to analyse the monthly length-frequency data (Table 1). The ELEFAN procedure in FiSAT was used to sequentially arrange and restructure the monthly length-frequency data from which a preliminary L∞ value was seeded. The procedure was then used to fit the Von Bertalanffy Growth Function (VBGF) using the equation proposed by Pauly and Gaschutz (1979):

\[ L_t = L_{\infty} - [1 - \exp(-K(t-t_0))] \]

Where:
- \( L_t \) = Length at age \( t \) (in years)
- \( L_{\infty} \) = Asymptotic length (cm)
- \( K \) = The von Bertalanffy growth coefficient (year)\(^{-1}\)
- \( t_0 \) = Age of the fish at zero length

The growth performance index was calculated as
\[ \alpha = \log K + 2 \log L_{\infty} \] (Pauly and Munro, 1984). The empirical model of Pauly (1980) was used to estimate the natural mortality \( M \):

\[ \log M = -0.0066 - 0.279 \log L_{\infty} + 0.6543 \log K + 0.4634 \log T \]

Where, \( T \) is the water temperature (the mean annual surface temperature in the basin). In the case, we set the temperature to a value of \( T = 28^\circ C \). For estimation of total

**Table 1: Monthly length frequency data of Labeo senegalensis from the Oume river**

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**Table 1:** Monthly length frequency data of Labeo senegalensis from the Oume river

ML: Mid-length of class interval; \( n = 1436 \)
mortality ($Z$) using the length-converted catch curve method (Gayanilo et al., 2002), length-frequency data of all fishing methods were pooled together. Based on the estimated $L_\infty$ and $K$, the length-converted catch curve was built, the slope of which with the sign changed gave an estimate of $Z$. Having obtained $Z$ and $M$, fishing mortality was derived by subtraction ($F = Z - M$). A relative yield-per-recruit analysis was performed incorporating probabilities of captures computed as suggested by Pauly and Soriano (1986) and Gayanilo et al. (2002). For this purpose in $L. senegalensis$, the ogive selection estimated by detailed analysis of the left ascending part of the length-converted catch curve was used. The potential longevity of the fish was estimated according to Pauly (1980), $T_{max} = 3/K$.

**RESULTS AND DISCUSSION**

The parameters of the von Bertalanffy growth equation were estimated as $L_\infty = 57$ cm TL and $K = 0.30$ year$^{-1}$. The growth curve superimposed on the length frequency data is shown in Fig. 2. The growth performance index ($e^r$) was calculated as 2.99. The theoretical longevity $T_{max}$ was 10 years. From the length-converted catch curve (Fig. 3), total mortality ($Z$) was estimated at 1.47 year$^{-1}$ and the instantaneous natural Mortality rate ($M$) was estimated at 0.68 year$^{-1}$. Fishing mortality rate ($F$) was calculated by subtraction at 0.79 year$^{-1}$. The level of Exploitation ($E$) has been assessed by computing the exploitation rate (Fig. 4) as 0.55. The recruitment pattern of $L. senegalensis$ was plotted in relation to the percentage of recruitment versus (i.e., projecting a set of length-frequency backward onto a 1 year time axis) as shown in Fig. 5. The highest peak for recruitment was in June to September indicating recruitment of one cohort year$^{-1}$. This suggested a major maximum breeding activity from July to September during the beginning of the flooding pattern of

*Fig. 2: Growth curves of *Laboe senegalensis*, superimposed over total length frequency data

*Fig. 3: Length-converted catch curve for estimating the total mortality (only black dots were considered for the computation of $Z$) of *Laboe senegalensis* in the Oueme river, Benin*

*Fig. 4: Relative yield per recruit and relative biomass per recruit of *Laboe senegalensis* in the Oueme river, Benin

*Fig. 5: Recruitment patterns of *Laboe senegalensis* in the Oueme river, Benin*
the river. The size at the 1st capture $L_c$ (length at 50% capture) of *L. senegalensis* estimated by backward extrapolation of the straight portion of the right descending part (Fig. 6) of the catch curve was 8.2 cm TL. Effective management and conservation of any fishery resource requires considerable knowledge regarding population parameters such as growth, age, recruitment pattern, mortalities and exploitation level of the stock (Abohweyer and Falaye, 2008). Population parameters of *L. senegalensis* were not studied either in Benin. For the 1st time, a length frequency analysis was performed on *L. senegalensis* population of Oueme river.

The estimates of the growth parameters ($L_{oo}$ and $K$) in the present study for *Labeo senegalensis* are near those (Table 2) documented by Moreau et al. (1995) in the Senegal river in Senegal. On the other hand in Lake Kainji (Nigeria) and Niger-Benoue river (Niger), the values of growth parameters (Table 2) for the same species reported in previous studies (de Merona et al., 1988; Moreau et al., 1995) are different from those obtained in the present study.

This is probably owing to fishing pressure. According to Welcomme (1999), the strong tendency of fish length to decrease as fishing pressure increases means that length-linked changes occur in several demographic parameters. The value of the index of overall growth performance $\sigma'$ obtained in the present study is in

![Fig. 6: Probability of capture analysis](image)

Table 2: Estimates of growth parameters from this study and the values from previous studies

<table>
<thead>
<tr>
<th>Locality</th>
<th>$L_{oo}$ (cm)</th>
<th>$K$ (year$^{-1}$)</th>
<th>$\sigma'$</th>
<th>References</th>
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<tr>
<td>Oueme river, Benin</td>
<td>57.0</td>
<td>0.30</td>
<td>2.99</td>
<td>This study</td>
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<td>Lake Kainji, Nigeria</td>
<td>39.5</td>
<td>0.26</td>
<td>2.61</td>
<td>Moreau et al. (1995)</td>
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<td>Niger-Benoue, Niger</td>
<td>45.6</td>
<td>0.63</td>
<td>3.12</td>
<td>de Merona et al. (1988)</td>
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<tr>
<td>Senegal river, Senegal</td>
<td>55.0</td>
<td>0.19</td>
<td>2.76</td>
<td>Moreau et al. (1995)</td>
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In additional according to Welcomme (2001), the fish growth in a population reflects their ability to fulfill their own nutritional requirements and to adapt to the abiotic conditions of the environment. The fast growth ($\sigma' = 2.99$) of *L. senegalensis* population in the Oueme river can principally be attributed to food availability, the nutritional value of the food ingested.

Concerning mortality, natural Mortality ($M$) estimates, apart from showing the proportion of death caused by all factors except fishing were lower than the total mortality $Z$ and Fishing mortality ($F$). The high mortality rates can therefore be attributed to high fishing mortality. This indicates that exist a fishing pressure on *L. senegalensis* stock in the Oueme river. The predominant small fish in certain sampling stations such as Agonlin-Lowe may therefore explain partly the high fishing mortality.

The exploitation rate (0.53) is also slightly higher than the expected optimal exploitation level. This indicates that the *L. senegalensis* stock is on the verge being overfished and confirms the observations reported for the same species by Monchowui et al. (2008) in the Oueme river Delta. High fishing pressure on several fish stocks in Oueme river and others Beninese water bodies was previously indicated by Lalye et al. (2003, 2005) and Monchowui et al. (2008).

These researchers indicated the fishing captures were currently dominated by the small size fishes. By consequent, the big size fishes such as *Heterobranchus longifilis, Gymnarchus niloticus, Parachanna obscura, Chrysichthys nigrodigitatus, Labeo senegalensis*, etc., became rare in fish captures in the Oueme river.

In the present study, the size at the first capture $L_c$ (length at 50% capture) of *L. senegalensis* estimated by backward extrapolation of the straight portion of the right descending part (Fig. 6) of the catch curve was 8.2 cm TL.

This value is widely lower than the length at the first sexual maturity reported for *L. senegalensis* (29 cm TL for the females, 25.7 cm TL for the males) by Montchowui et al. (2010) in the Oueme river. Moreover, comparing the length-frequency distributions of captured
ACKNOWLEDGEMENTS

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REFERENCES


CONCLUSION

The recruitment pattern suggests that seasonal recruitment consists of one peak seasonal pulse between June and September. There are no published reports on L. senegalensis recruitment in Benin. However, it has been reported that the L. senegalensis spawn mainly during June-September (Albaret, 1982; Montchowui et al., 2010). Major spawning was observed in August in the Oueme river, Benin. The major recruitment peak (June-September) detected in this study correspond to the major spawning season. The kind of study could assist in correlating the spawning and recruitment cycles in the Oueme river. This is typical feature of many African fishes studied so far (Bajot et al., 1997; Rabour et al., 2003; King and Etim, 2004; Montchowui et al., 2009).

Fig. 7: Length frequency distributions of Labeo senegalensis caught from the Oueme river


