

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 1436 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: $L_{\infty} = 57$ cm TL, $K = 0.30$ year⁻¹. The growth performance index (ϕ') 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 T_{max} 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 others 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 gbogbe is one of two Labeo species present in the Oueme basin (Laleye *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

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; Abohweyer 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

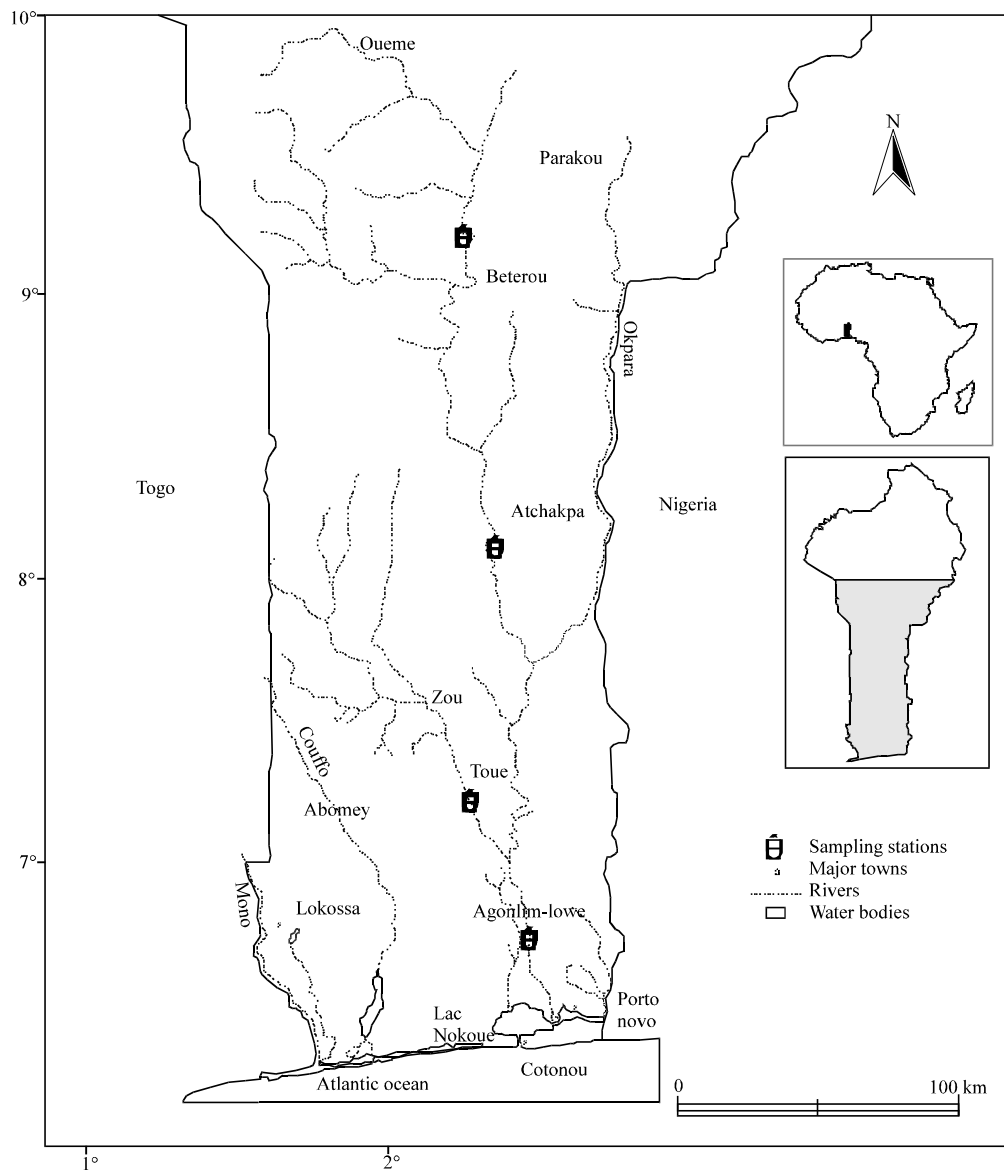


Fig. 1: Map of the Oueme river showing the four sampling stations

tributaries are the Okpara river (200 km long) and Zou river (150 km long). Peak discharge is rapid and occurs in August and September. The Oueme 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 ($10\text{-}40^\circ\text{C}$). 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 $18\text{-}35^\circ\text{C}$. Fish sampling took place on four stations (Fig. 1). The first sampling station which is situated at Beterou ($09^\circ11'\text{N}\text{-}02^\circ16'\text{E}$), on the Oueme river is located along a coarse, rocky zone with swift water currents. The second sampling station at Atchakpa ($08^\circ04'\text{N}\text{-}02^\circ22'\text{E}$) on the Oueme river is located in a rocky zone. Toue ($07^\circ12'\text{N}\text{-}02^\circ17'\text{E}$) 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 Agonlin Lowe's village ($06^\circ39'\text{N}\text{-}02^\circ28'\text{E}$) is situated within the Oueme 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_∞ = Asymptotic length (cm)

K = The von Bertalanffy growth coefficient (year)

t_0 = Age of the fish at zero length

The growth performance index was calculated as $\phi' = \log K + 2 \log L_\infty$ (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 $T = 28^\circ\text{C}$. For estimation of total

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

ML/Date	J	F	M	A	M	J	J	A	S	O	N	D
6	-	-	-	-	-	-	-	-	-	-	4	9
8	5	-	-	-	-	-	-	5	33	5	25	29
10	36	-	-	-	-	-	-	6	95	64	60	28
12	59	-	1	7	-	-	-	9	4	47	42	41
14	34	-	-	1	7	-	-	7	12	13	18	49
16	8	4	5	-	12	-	1	7	5	8	24	52
18	7	20	9	2	11	3	1	6	1	6	18	30
20	7	23	8	-	2	2	3	1	5	1	7	9
22	5	10	10	4	6	3	12	-	1	4	14	3
24	6	8	4	12	11	1	7	2	-	12	7	4
26	3	3	3	19	14	2	3	2	2	10	6	3
28	4	3	6	11	8	2	4	3	2	7	9	3
30	2	2	-	1	4	2	7	4	2	4	9	4
32	-	2	1	1	2	-	4	2	-	2	2	5
34	3	2	-	-	-	-	1	1	-	-	1	1
36	3	-	-	-	-	-	-	-	2	-	-	-
38	5	1	1	-	2	-	-	-	-	-	-	-
40	1	-	-	1	-	-	-	-	-	-	-	-
42	-	-	-	-	1	1	-	-	-	-	-	-
44	1	-	1	-	2	1	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-
52	-	-	-	-	-	-	-	1	-	-	-	-
Total	189	78	49	59	82	17	43	56	164	183	246	270

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_{∞} 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

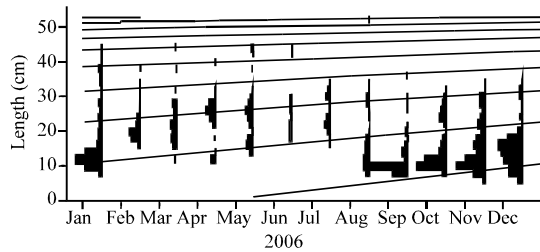


Fig. 2: Growth curves of *Labeo senegalensis*, superimposed over total length frequency data

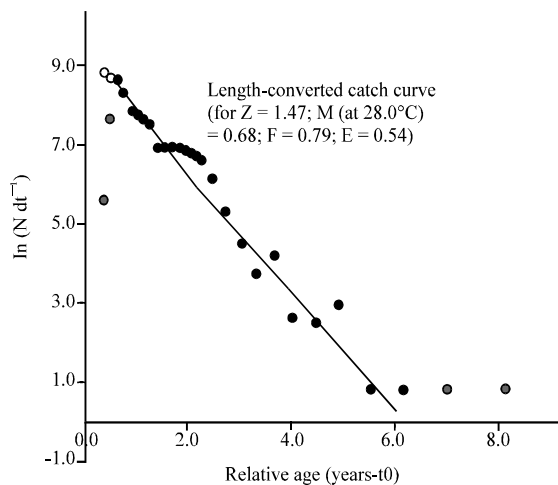


Fig. 3: Length-converted catch curve for estimating the total mortality (only black dots were considered for the computation of Z) of *Labeo senegalensis* in the Oueme river, Benin

$K = 0.30 \text{ year}^{-1}$. The growth curve superimposed on the length frequency data is shown in Fig. 2. The growth performance index (ϕ') 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

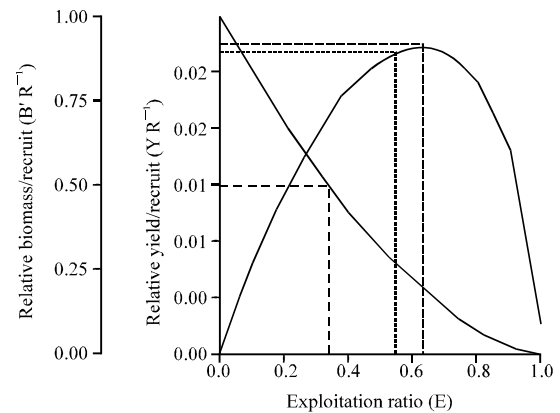


Fig. 4: Relative yield per recruit and relative biomass per recruit of *Labeo senegalensis* in the Oueme river, Benin

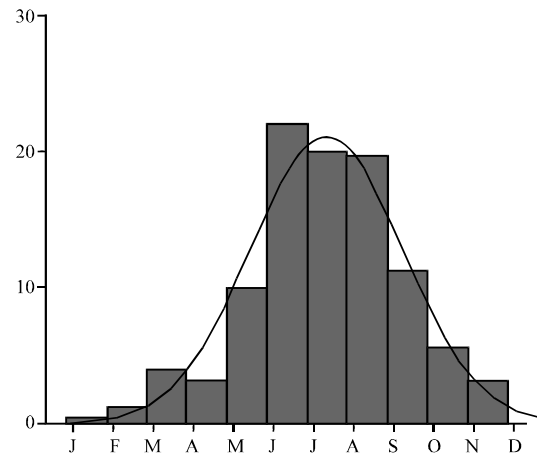


Fig. 5: Recruitment patterns of *Labeo senegalensis* in the Oueme river, Benin

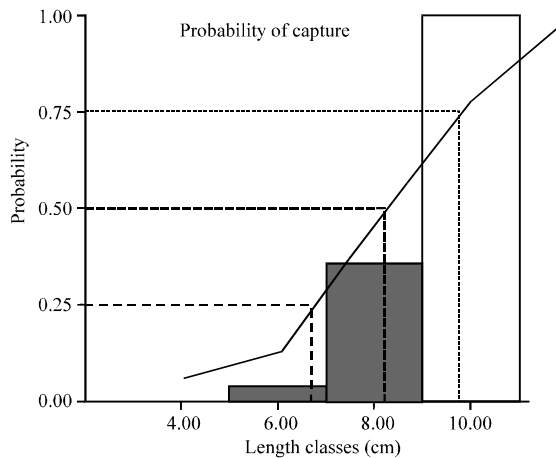


Fig. 6: Probability of capture analysis

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

Locality	Parameters			References
	L_{∞} (TL, cm)	K (year ⁻¹)	ϕ'	
Oueme river, Benin	57.0	0.30	2.99	This study
Lake Kainji, Nigeria	39.5	0.26	2.61	Moreau <i>et al.</i> (1995)
Niger-Benoue, Niger	45.6	0.63	3.12	de Merona <i>et al.</i> (1988)
Senegal river, Senegal	55.0	0.19	2.76	Moreau <i>et al.</i> (1995)

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_{∞} 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 ϕ' obtained in the present study is in

the range (2.65-3.32) recorded by Baijot *et al.* (1997) for the Western African fishes. These researchers consider that values in range (2.65-3.32) express a fast growth performance and potential. This result was in concordance with the results of de Merona *et al.* (1988) for the Niger-Benoue river, Moreau *et al.* (1995) for the Lake Kainji and Senegal river. This fast growth in the Oueme river population of *L. senegalensis* could allow for the attainment of fish large enough to migrate in the floodplains during the annual spawning migration as well as to maximise individual reproductive capacity.

In addition according to Welcomme (2001), the fish growth in a population reflects their ability to fulfil their own nutritional requirements and to adapt to the abiotic conditions of the environment. The fast growth ($\phi' = 2.99$) 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 (0.55) 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 Montchowui *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 Laleye *et al.* (2003, 2005) and Montchowui *et al.* (2008).

Those researchers indicated the fishing captures were currently dominated by the small size fishes. By consequent, the big size fishes such as *Heterobranchius 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

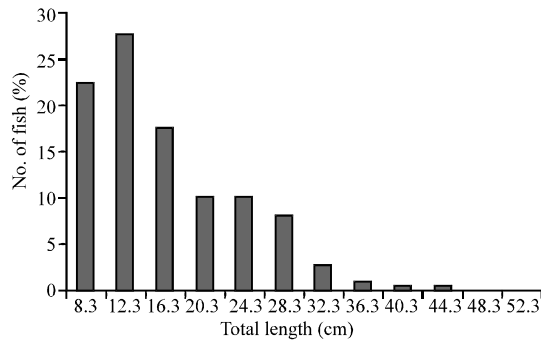


Fig. 7: Length frequency distributions of *Labeo senegalensis* caught from the Oueme river

fishes (Fig. 7) to the length of the sexual maturity, it comes out that for the examined sample about 87.5% of the caught fishes are <29 cm TL (L50 of females). It means that many individuals of *L. senegalensis* are captured before their first reproduction. It can then be considered that the population is heavily overfished and juveniles are the most captured in the Oueme river basin. It is therefore, necessary to ban certain fishing gears. Indeed, Montchowui *et al.* (2008) recently reported the negative impact of some fishing gears on *L. senegalensis* population in the low Oueme river valley. These gears are the small seine (Akpelou in local language) and bow-nets (Adja in local language) which catch all sizes. From the management point of view, this situation calls for a management strategy that will allow the escape of such sizes from the gear used in the resource exploitation. The L_c is very vital parameter that should be considered in the management of fisheries resource when used along with length at first maturity as it's indication of the health status of the resource.

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 (Baijot *et al.*, 1997; Rabour *et al.*, 2003; King and Etim, 2004; Montchowui *et al.*, 2009).

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