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Contribution to the Study of the Growth of the Bonga *Ethmalosa Fimbriata* (Bowdich) in Senegalese Coastal Waters

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Abstract

The Bonga (*Ethmalosa fimbriata*) is the third most abundant clupeid in Senegal after the round and flat sardines. This study allowed updating some growth parameters of *Ethmalosa fimbriata* witch can contribute to the management of the fishery.The size frequency distribution showed that bonga whose size range from 19 cm to 21 cm are more common in the landings of the estuary. At sea fisheries generally target individuals of average size from 18 cm to 22 cm with the dominance of class size from 19 cm to 20 cm. The study of the condition factor shows that the diet of *Ethmalosa fimbriata* is the best during the hot season also in estuary and at sea. This study also allowed estimating the growth parameters of marine and estuarine *Ethmalosa fimbriata* from size frequency by ELEFAN (Electric Length Frequency Analysis) software. Seasonal growth is faster in hot season in estuary and at sea.

Keywords: *Ethmalosa fimbriata*, Estuary, Sea, ELEFAN, Seasonal growth

1. Introduction

Senegal has a coastline of 718 km long, of an exclusive economic zone (EEZ) of 206,000 square kilometers. Its continental shelf is 23 800 square kilometers with particularly rich waters due to coastal upwelling (Roy, 1991).

The fisheries sector plays an important socio-economic role. It generates about 600,000 jobs and provides 70 % of animal protein for local populations. This sector is the main foreign exchange earner with 12.5 % of export earnings. It provides about 12% of primary sector GDP(GrossDomestic Product)and about 1.3 % of national GDP (Anonymous, 2010).

Most of the landings of the artisanal fisheries consists of small pelagic, including Bonga*Ethmalosa fimbriata*. This species is one of the most important inhabiting coastal and estuarine waters of Senegal small pelagic. In 2009, catches of *Ethmalosa fimbriata* were estimated at 6000 tons, about 2 percent of the total catch of small pelagic species in Senegal (FAO, 2011).

The Bonga (*Ethmalosa fimbriata*) is an estuarine and coastal clupeid that is abundant in the west coast of Africa between Mauritania and Angola. This fish is consumed in abundance in Senegal fresh or after undergoing transformations such as drying or partial cooking followed by drying. It plays an important role in income generation at the actors of the transformation through its export in the sub -region. The biology of this species has been studied in Senegal and other West African countries (Ivory Coast, Gambia, Nigeria,Sierra Leone, Cameroon, and Ghana). In Senegal, the first studies were from the 50s and 70s. The most recent study of this kind was made by Panfili et al. (2004) in the Saloum estuary. It focused on the influence of salinity on life history traits of the species. The estimation of growth parameters of a species is essential for the dynamic study of its population. These growth parameters are indispensable for an understanding of the general biology and population dynamics data. Knowledge of these parameters also allows some mathematical models of population dynamics and conduct demographic analyzes. Growth equations can also be used to compare populations of a geographically distant species (OuldYarba et al, 2004).

Furthermore, the determination of growth parameters from size frequency *Ethmalosa fimbriata* has not hitherto been made in Senegal. Thus, this study on the growth of the Bonga can help develop scientific evidence necessary for the implementation of management plans.

2. Materials and methods

2.1 Sampling Sites

Samples are collected in major landings centers Mbour (14 °24' 42"N and 16 °57' 57" W) and Joal (14 °10'00"N and 16 °49' 59" W) and the estuary of the Sine-Saloum (Foundiougne: 14 ° 07'59"N and 16 °28' 00" W). These samples were collected from the commercial scale fishing.

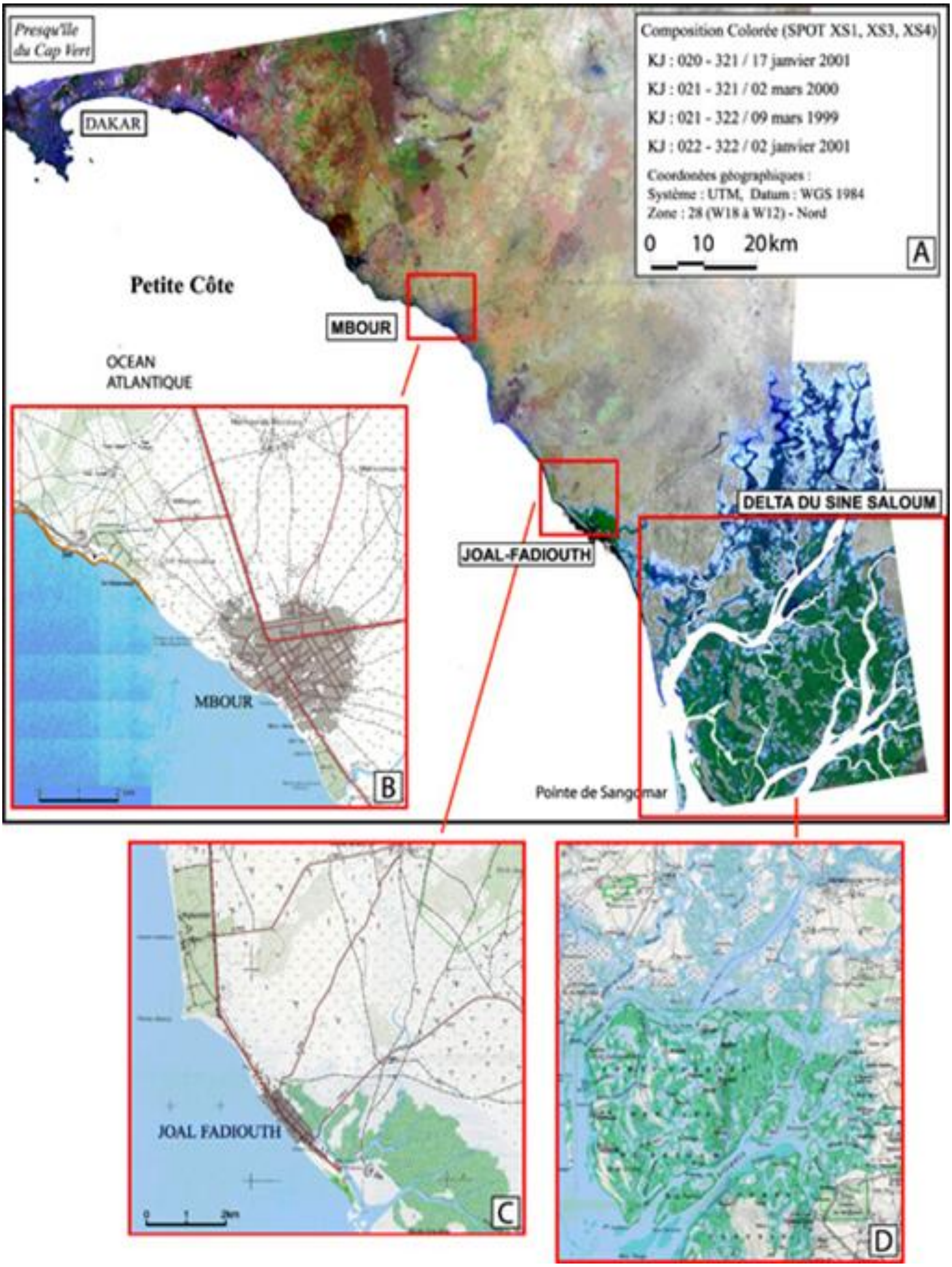

Figure 1. Location map of thesampling sites(Source:http://www.vertigo.revues.org/docannexe/image/2206/img-1.jpg)

2.2 Sampling Protocol

Samples arecollectedin majorlandings centersof MbourandJoal(Sea)and Sine-Saloum(estuary) andfromcommercialcatches ofartisanal fisheries.Sampling wasdone on amonthly basisfrom March 2012 to February 2013. For eachfish, the following morpho-metric parameters were measured: total length(Lt),standard length(Ls),fork length(Lf)and total weight(Pt). Measures andweightswere carried out using anichtyometregraduatedto the nearest cmandan electronic scale.

2.3 Study of the Growth

2.3.1 Structuresizes

Itis thesize frequencydistribution. Measurements ofindividualshaveto drawsize structuresto observethe evolution ofthe size of bonga. Individuals aregroupedby sizeof 1 cm.

2.3.2 Condition Factor(K)

Thecondition factor(K)is used to estimateseasonal changes ofstoutnessunder the influence ofexternal factors (environment) or internal (physiological) (Ricker1980).It is defined bythe following relationship:

$$K = \frac{P}{Lf^3} \times 100$$

Where P=totalweight of fish, Lf=fork lengthof the fish.

2.3.3 Linear Growth

Thegrowth parametersL∞, K wereestimated fromsize frequency. It is a methodthat usesone or more samplescollectedat different dates. The approximate value of$t_0$was estimated bythe following relationship:

$$\text{Log}(-t_0) = -0.3922 - 0.2752\text{Log}(L\infty) - 1.038\text{Log}(K).$$

FromL∞, K and $t_0$theVonBertalanffyequationwas established:

$$L(t) = L\infty\left[1 - \lambda^{-k\times(t-t_0)}\right]$$

Where L=∞is the asymptoticlength.Theoretically,itis the average sizereached bya fish thatcan liveand growindefinitely,L(t):the total lengthat age t, K = thegrowth coefficient. It characterizesthe speed with whichthefish growto theasymptotic length; t_0=is the theoreticalage for whichthe fishwould havezero length.The comparisons of results obtained with other growth studies weremadeusingthe performance indexgrowth(Φ ')andauximetricgrid (PaulyandMunro,1984).

$$\Phi' = \text{Log}(k) + 2\,\text{Log}(L\infty)$$

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2.4 Statistical Analysis

Statistical analysis and graphics were performed with Excel, ELEFAN and R software. The Student t test was used to verify the significance of certain results.

3. Results

3.1 Structure Sizes

In estuary, the sizes are distributed between 12 cm and 26 cm. The size frequency distribution shows that bonga whose size range from 19 cm to 21 cm are more common in the landings (Figure 2). Analysis of the structure indicates that at sea the size of catches are between 15 cm and 29 cm and fishing generally target individuals of medium size 18 cm to 22 cm with the dominance of size classes of 19 to 20 cm(Figure 2).

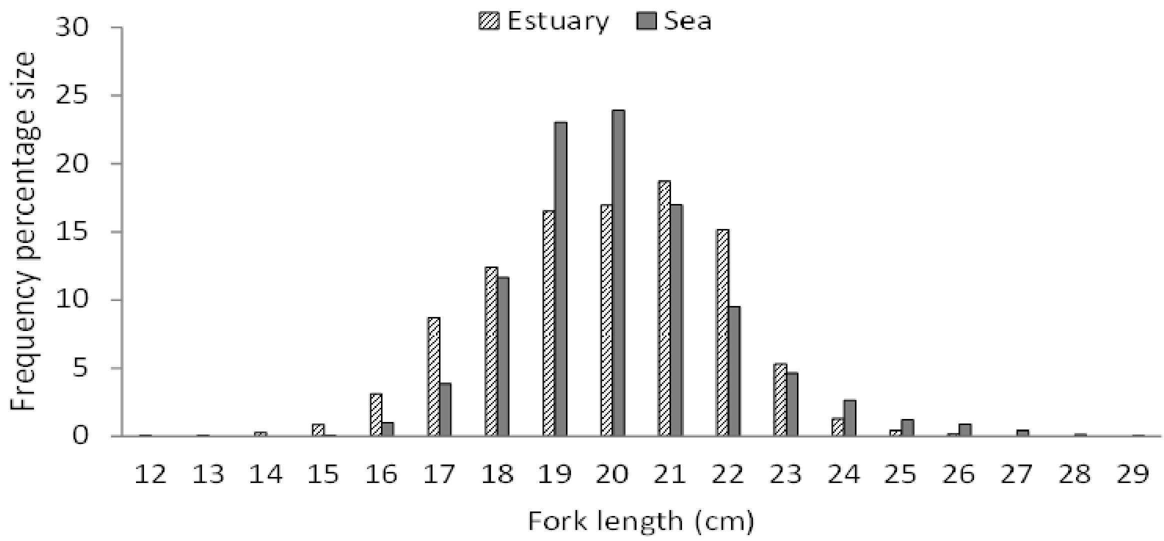

Figure 2. Frequency distribution ofsize of *Ethmalosafimbriata* in estuary and at sea

3.2 Condition factor (K)

Figure 3shows an increase in condition factor from May to December with a small decline in the month August in estuary. From January this coefficient decreases sharply until March and it does not vary almost until June.Thus, the condition factor of *Ethmalosa fimbriata* is slightly better in the hot season both at sea and in estuary.The mean valuesof condition factor found in estuaries (1.75) and at sea (1.82) are significantly different ($p < 0.05$).

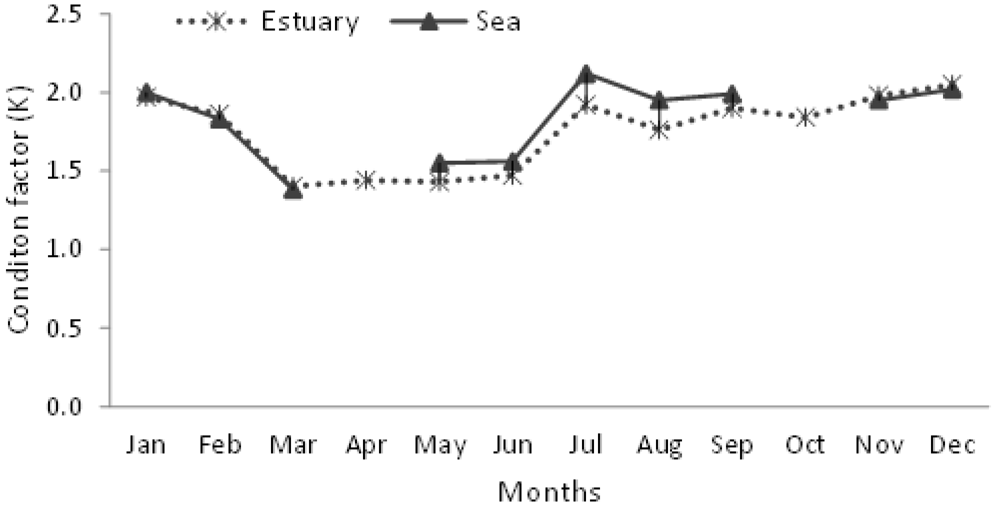

Figure 3. Condition factor(K) of *Ethmalosafimbriata*in estuaryand at sea

3.3Linear Growth

Figures 4 and 5 are established through ELEFAN program with growth parameters in the estuary and at sea respectively equal to (L ∞ = 29.10 and K = 0.36) and (L ∞ = 31.40 and K = 0.47). Analysis of Figures 4 and 5 reveals a seasonal effect of *Ethmalosa fimbriata* growth. Indeed, there is a slowdown in growth during the cold season whatever the area. In estuary the appearance of the first cohort was observed in June while at sea the first cohort appeared in September.

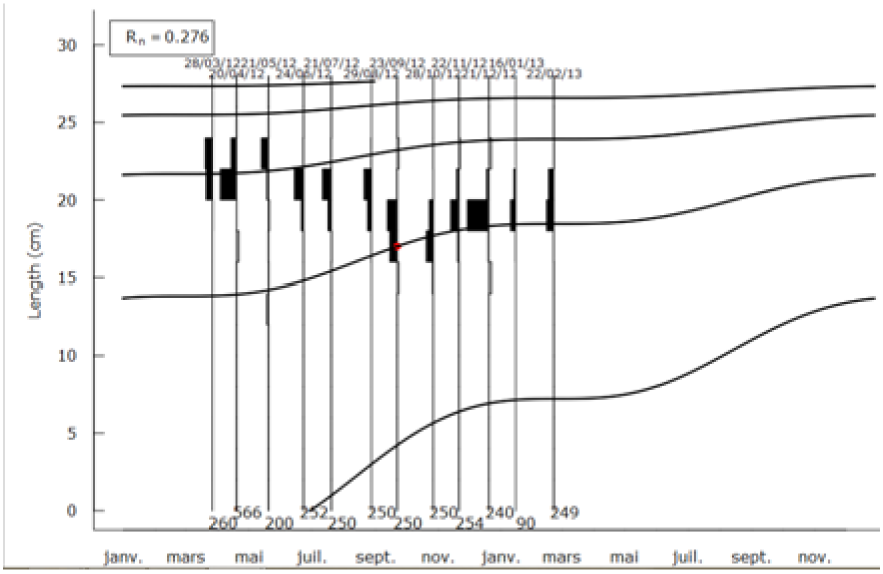

Figure 4. Seasonal Growth of *Ethmalosafimbriata*in estuary

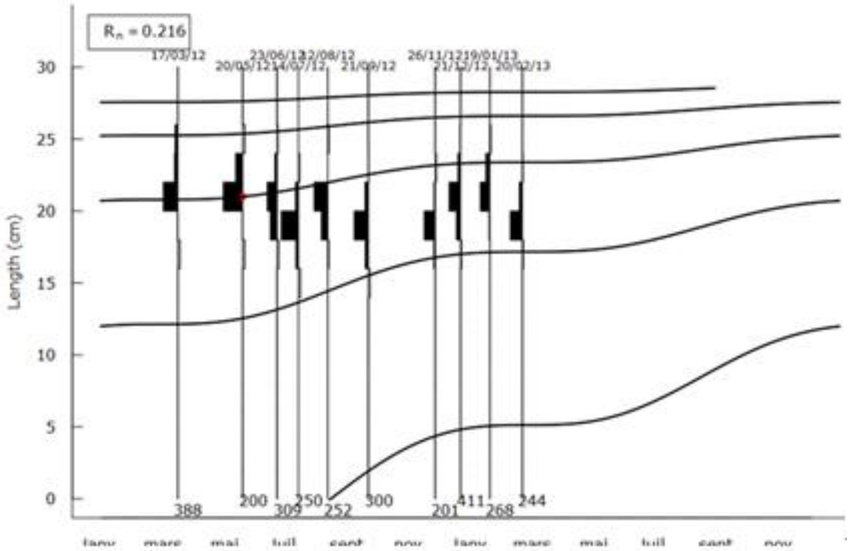

Figure 5. Seasonal Growth of *Ethmalosafimbriata*at sea

From the length L∞ and K, the parameters t_0 and (Φ)'are estimated. Thus, the equations and the growth curves of Von Bertalanffyof *Ethmalosa fimbriata*in estuary and at sea are established. The analysis of Figure 6 and growth performance indices ((Φ)'sea>(Φ)'estuary) shows that the growth of*Ethmalosa fimbriata* is slightly faster at sea. Species present rapid growth, whatever the area during his youth especially during the first two years phase.

$$L(t) = 29{,}10 \times \left[1 - \lambda^{(-0{,}36\times(t+0{,}46))}\right] \text{ : Estuary}$$

$$L(t) = 31{,}40 \times \left[1 - \lambda^{(-0{,}47\times(t+0{,}34))}\right] \text{ : Sea}$$

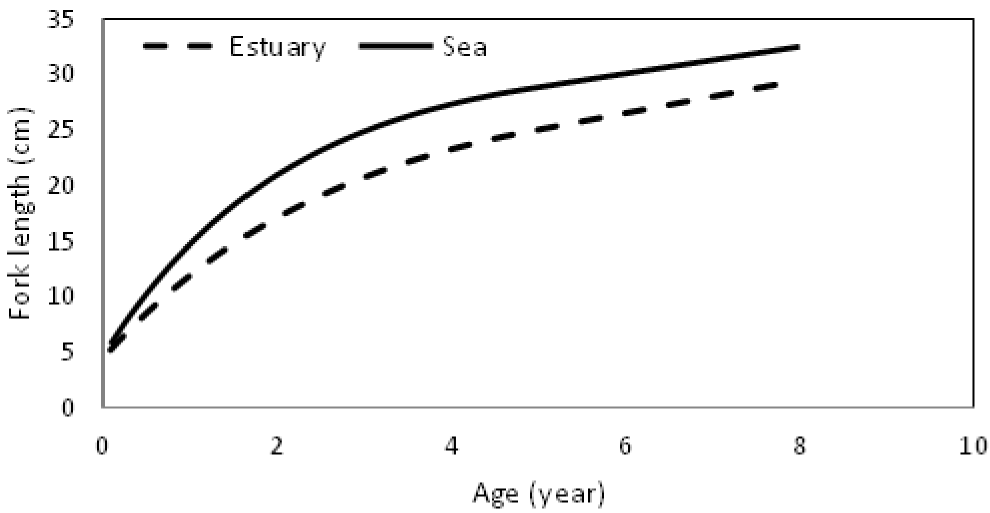

Figure 6. Growth curveofVonBertalanffy of *Ethmalosafimbriata* in estuaryand at sea

The auximétrics grids (Figure 7 and 8) show the relationship between the logarithms of L∞ and K of the various studies done on this species. This grid allows seeing the performance of *Ethmalosa fimbriata* growth studied in different localities. It is used to separate families, genera or species from the growth parameters L ∞ and K (Pauly, 1997). The pairs of values (L∞/K) representative of a taxon tend to form scatter elliptical. And studies showing no bias were represented by dots grouped. The yellow dots represent all fish species combined, the green dots correspond to the species of the same family (clupeidae) that Bonga and red dots represent the studies of the same species in other countries. The present study is represented here by the black dot.

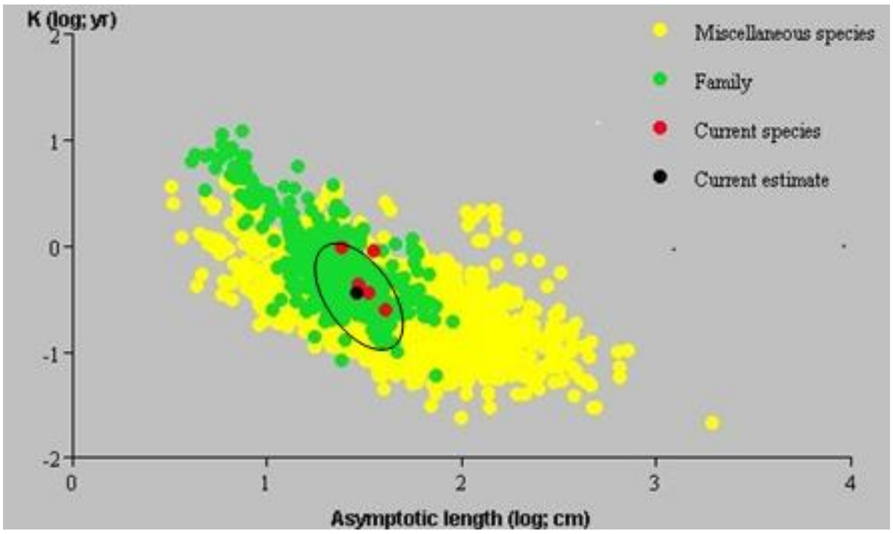

Figure 7. Auxim étric grid (estuary)

4. Discussion

4.1Growth

4.1.1 Structure Sizes

In estuary, the sizes are distributed between 12 cm and 26 cm, whereas at sea sizes ofcatches are between 15 cm and 29 cm. Size structure observed is not the same for the two environments. The smaller sizes are encountered in the estuary while the larger ones are captured at sea. This is confirmed by the works of Boely and Freon (1979).According to them, beyond a size of 25 cm, the bonga adults appear to remain in sea where they can reproduce. This result is confirmed by Boely and Elwertowski (1970) who showed that at sea there seems to have as adults, while it appears in estuary two groups ofage, young and adult individuals. Indeed before migrating to sea, juveniles live in the estuary until maturity (Albaret, 2004). Similar results were found by Gerlotto (1976) in Ivory Coast showing complementarity between the populations of the two areas.

4.1.2 Condition Factor (K)

The condition factor is higher in hot season than the cold season in the estuary and at sea.Bonga diet would be better during this period in the estuary. This result is consistent with the works of Mainguy and Doutre (1958). They showed that the era of hot water from June to October is superimposed on that of fattening *Ethmalosa fimbriata*. This period corresponds to the appearance of favorable development of phytoplankton optimum conditions. However, there is a strong correlation between changes in the rate of fat *Ethmalosa fimbriata* and those of phytoplankton abundance (Watts, 1957). The difference in condition factor between the sea (1.82) and the estuary (1.75) would be due to several factors. Indeed, the area offood is much restricted in the estuary than in the sea, so the competition with other species is strong estuary. This would be also explained by a greater richness of marine waters compared with estuarine waters (Scheffers et al. 1972).

4.1.3 Linear Growth

The slowdown of growthobserved during the cold season would be due to factors such as temperature drop during this period. Indeed, the lowest temperature values are recorded between November and February each year in the estuary (Gnigue et al. 2008). At sea, the increase in growth in the hot season would be due to the fact that the period June-July corresponds to the passage of water from the upper layers 23^0cto maximum bearing 28^0c, only period in the year during which both salinities surface and depth are the highest (Maingy and Doutre, 1958). According to these authors, this is favorable to the growth of phytoplankton whose density must reach its maximum in two months. The results of the seasonal growth confirmed those found for the condition factor which was higher in the hot season in both estuary and sea.The slight difference in linear growthin favor of individuals caught at sea would be due to the fact that in the estuary, the population density is higher than at sea. However, in environments with high density, lower growth rate may be due to aggressive interactions due to the availability of food.

The performance index of growth and auximetric relationship shows that the results of this study are similar to those of Panfili et al. (2004) in Senegal, Moses (1988) and Essen (1995) Nigeria and Gerlotto (1976) in Ivory Coast.

Table 1. Growth parametersof*Ethmalosafimbriata*in different countries

Countries	L∞ (Lf cm)	K (an^{-1})	Φ’	Authors
Sea (Senegal)	31.4	0.47	2.67	Presentstudy
Estuary (Senegal)	29.1	0.36	2.48	
Ivory Coast	24.5	0.96	2.76	Gerlotto (1976).
Nigeria	26.3	0.43	2.47	Moses (1988).
Nigeria	29.2	0.36	2.49	Essen (1995).
Nigeria	31.2	0.9	2.94	Ama-Abasi et al. (2004).
Sierra Leone	40.8	0.25	2.62	Showers (1996).
Senegal	27.0	0.48	2.54	Panfili et al. (2004)

5. Conclusion

The data acquired on the growth of bonga contributed to a better understanding of its biology in Senegalese waters, essential for the valuation models and inventory management, decision making and management to ensure profitability and the sustainability of their exploitation.

Size structure observed is not the same for both walks of life. The smaller sizes are encountered in estuaries while the larger ones are caught at sea. Condition factor shows that nutritional conditions *Ethmalosa fimbriata* are better in warm season in both estuary and offshore. Growth parameters were determined from the size frequency for the first time for *Ethmalosa fimbriata* Senegal. The study of the growth showed a slightly linear growth faster at sea than in estuary.

The parameters estimated from the study of the growth will enable the development of management models of exploited stocks and therefore the fishery management of Bonga.

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