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Comparative study of the growth parameters of *Lates niloticus* (Linnaeus, 1758) from the lake of Tiné (North, Bandama basin, Ivory Coast) and the fishing area of Guéssabo (West, Sassandra river, Ivory Coast)

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Abstract

The present study was carried out between January 2021 and February 2022 on 30 specimens of *Lates niloticus* from the lake of Tiné, located in the Bandama watershed, and from the Guéssabo fishing area, in the Sassandra watershed. This study, initiated by the Continental Fisheries and Aquaculture program of the National Center for Agronomic Research (CNRA-PAC) of Bouaké, is part of the genetic improvement of *L. niloticus*, a species of great economic and food importance in Ivory Coast. This study aims to identify a successful population of *L. niloticus*, to be promoted in our farms. It uses the comparison of the growth parameters of this species, from the two catchment areas of Bandama and Sassandra. Experimental fisheries were carried out using gillnets, traps and hawks. At each site, the individuals were grouped in plastic containers and then transported to the laboratory of the National Center for measurements and weight gain. The distributions of size frequencies show that *L. niloticus* originating from the Guéssabo region have larger sizes than those coming from lake of Tiné. On the other hand, the analysis of condition factors reveals that the living conditions of *L. niloticus* in the lake of Tine are better than those of the Guéssabo region. Moreover, this species grows more in size than in weight (allometric type growth), over both watersheds. In addition, the sex ratio indicates a preponderance of female individuals in the lake of Tiné than in the Guéssabo area, dominated by males.

Keywords: *Lates niloticus*; Growth parameters; Tiné lake; Guéssabo bridge; Bandama and Sassandra rivers

1. Introduction

Lates niloticus is one of the largest freshwater fish on the African continent. This species, native to the Nile basin in the Ethiopian region, was introduced into the Bandama watershed in Ivory Coast in 1978 via the Tiné reservoir by the Tropical Forest Technical Centre (CTFT), now part of the National Center for Agricultural Research (CNRA). From this impoundment, the interconnection between the rivers allowed it to colonize other watersheds [1]. However, his presence has not yet been reported in the Cavally, a victim of gold mining. As for the Comoé river, the CNRA research team does not have a reference.

The choice of this species is based on one hand on its economic importance related to its high market value in relation with its rapid growth and high corpulence and on the other hand on its nutritional importance revealed by the gustatory quality of its flesh. Its introduction zone follows the peculiarity of this river which is typically Ivorian. In the wild, this fish can reach nearly 200 cm long and weigh up to 250 kg. Females can lay between 3,000,000 and 15,000,000 eggs [2].

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1.1. Statement of the problem

Lates niloticus has a negative effect on the biodiversity of native species, although its ability to naturally control the density of forage fish such as tilapia is demonstrated [3]. However, the overfishing of this species coupled with increasing anthropogenic factors such as water pollution and habitat destruction, due to urbanization and industrialization, could influence population dynamics. This would affect the morphogenetic variability and zootechnical performance of *Lates niloticus* populations.

1.2. Significance of the study

Unlike other species of farmed fish available, *Lates niloticus* remains poorly documented in Côte d'Ivoire. Therefore, the Continental Fisheries and Aquaculture Program of the National Agricultural Research Centre (CNRA-PAC) in Bouaké has launched a study program aimed at identifying and genetically improving a high-performance strain of *Lates niloticus* found in two of Côte d'Ivoire's four river basins.

1.3. Objectives of the study

1.3.1. General objective

This article aims to assess the body condition of Lates niloticus harvested in the Guéssabo fishing area (Sassandra River basin) and the Tiné reservoir (Bandama River basin).

1.3.2. Specifics objectives

- Compare the growth parameters of *Lates niloticus* in the Guéssabo fishing area and the Tiné reservoir.
- Highlight the sex ratio of *Lates niloticus* in the Guéssabo fishing area and the Tiné reservoir.

2. Methodology

2.1. Presentation of the watersheds of Sassandra and Bandama

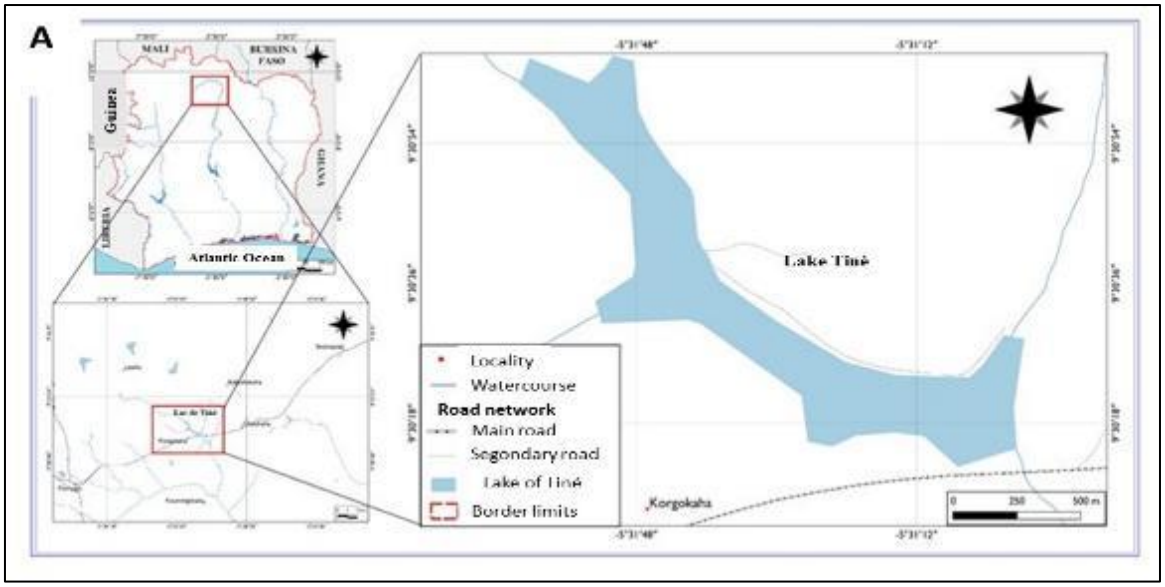
The Sassandra drainage basin, located in western Côte d'Ivoire, is 650 kilometers long and covers 75,000 km2. This river originates in Guinea, in the Beyala region, and has an average annual flow of 245 m3/s. The rivers Bafing on the right bank and N'Zo on the left bank are its main tributaries [4].

As for the Bandama river, it extends over a length of 950 kilometers and covers 97,500 km2, with an annual average flow of 390 m3/s. Located in the center of the country, it is the only river entirely Ivorian. It rises in the north of the country between the cities of Korhogo and Boundiali. Its main tributaries are the Marahoué on the right bank and the N'Zi on the left bank.

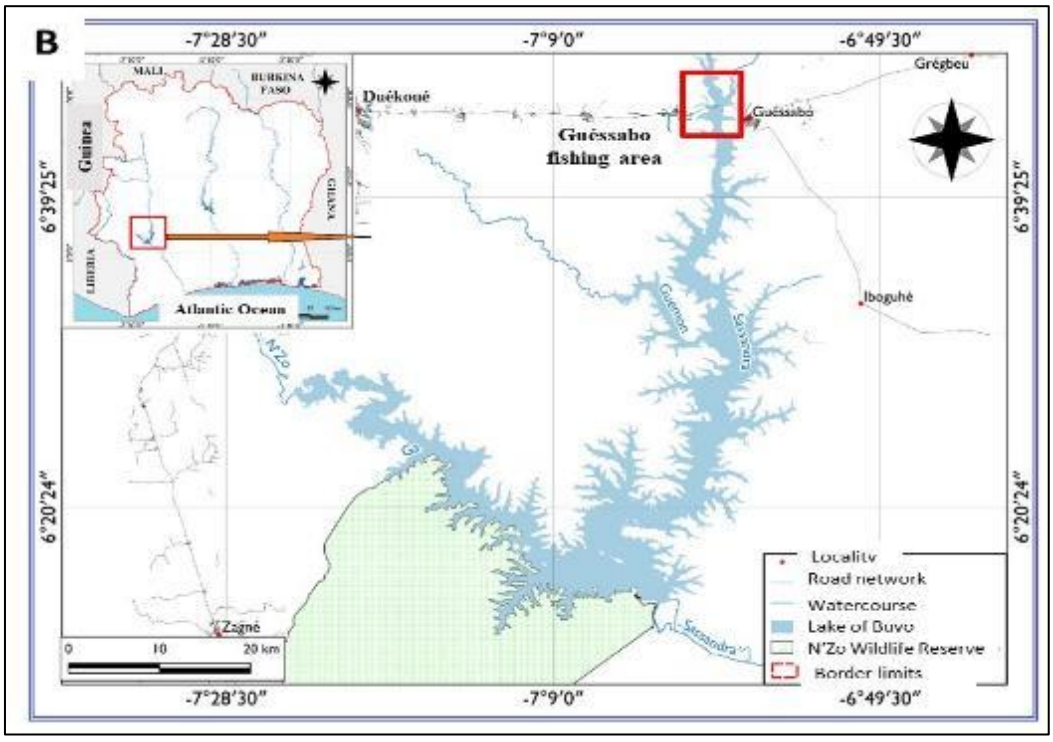
These rivers flow from the North and empty into the Atlantic Ocean further south [5].

2.2. Choice and location of fishing areas on the watersheds

The fishing areas were selected according to criteria specific to the fishing team, mainly based on the accessibility of the sites. The present study was carried out on two (2) of the four (4) watersheds that Ivory Coast has and on which a collection point was selected. In the Bandama watershed, sampling was carried out in the Tiné reservoir, located between 5°32' west longitude and 9°31' north latitude, in the northern region of Côte d'Ivoire (Figure 1a). That of the Sassandra river, located between -6°46' west longitude and 7°2' north latitude in the west of the country, was done at the level of the bridge of the city of Guéssabo (Figure 1b).



A = Lake Tiné



B = Guéssabo fishing area

Figure 1 Location of fishing areas

2.3. Fieldwork

2.3.1. Sampling of Lates niloticus

The experimental fisheries were carried out between January 2021 and February 2022 by the fishing team of the National Center for Agronomic Research (CNRA-PAC) of Bouake, in the lake of Tiné for the river Bandama and in the fishing area of Guéssabo, for the river Sassandra. At each site, gillnets of 10 to 40 millimeters in length, 100 meters in length and 2.5 to 3.5 metres in depth, and traps were set between 4 p.m. and 5 p.m. and surveyed the next day between 6 a.m. and 7 a.m., for night fishing. They were restocked between 07:00 and 08:00, then taken back up between 15:00 and 16:00, for day fishing. Furthermore, the sparrow hawk was also used to capture fish. After each fishing, the

specimens of *Lates niloticus* were kept in-situ in plastic bins labeled according to origin, without distinction of sex, then transferred to the laboratory for measurements.

2.3.2. Measurement of Lates niloticus specimens

In the laboratory, the total and standard individual lengths of the 30 specimens of Lates niloticus from each river basin were determined using an ichthyometer. An electronic scale accurate to 0.001 grams was used to weigh each individual. Only phenotypic variables were taken into account immediately after fishing.

2.4. Data analysis

2.4.1. Size frequencies

The size frequency distributions of Lates niloticus, depending on the fishing environment, were determined according to the Sturge rule [6], defined by the equation:

$$\mathbf{NC} = \mathbf{1} + (\mathbf{3,3} \times \boldsymbol{Log}\ \mathbf{10}\boldsymbol{N})$$

with NC = Number of classes and N = Total number of specimens examined.

The interval of each class is determined according to the following formula:

$$\boldsymbol{Ic} = \frac{\boldsymbol{Ls}\ \mathbf{max} - \boldsymbol{Ls\ min}}{\mathbf{NC}}$$

with IC = Class interval, Ls = Standard length, max = maximum and min = minimum

2.4.2. Weight-length relationship

The growth of the populations of Lates niloticus in the Sassandra and Bandama catchments was established by the weight-length relationship of the specimens [7], defined by the formula:

$$\mathbf{Pt} = \boldsymbol{aLt^b}$$

where Pt = Total weight, Lt = Total length of the fish, a = Characteristic factor of the environment and b = Characteristic factor of the species shape

The coefficient b varies between 2 and 4 but it is often close to 3. When b equals 3, the growth is said to be isometric. In other cases, we talk about allometric growth. Thus, when b is less than 3, the growth is called negative allometric. With b greater than 3, we speak of positive allometry which indicates the dominance of weight over the length of the species [8].

The Fulton Condition Factor (K) allows one to assess the overweight state of the species according to its origin [9]. K is established according to the following formula:

$$\mathbf{K} = \mathbf{100} \times \frac{\boldsymbol{Pt}}{\boldsymbol{Ls^b}}$$

with Pt = Body weight, Ls = Standard length of the fish and b = Allometry coefficient of the weight-length relationship.

When the condition factor K is positive, it reflects good living conditions of the species in the environment and vice versa. Furthermore, a condition factor K lower than 1 suggests that the species is in poor living conditions and vice versa [10].

2.4.3. Sex ratio of Lates niloticus

The sex ratio (Sr) or masculinity ratio of a watershed is the quotient of the number of female individuals by that of male individuals. When the sex ratio is greater than 1, it means that there are more females than males and vice versa.

3. Results

3.1. Growth parameters of Lates niloticus

3.1.1. Size structures of Lates niloticus

The size frequency distributions of Lates niloticus according to the watersheds are shown in the following figure 2. At the level of the Tiné river, standard lengths of individuals vary between 22 and 32 cm approximately. The distribution is progressive and relatively balanced, with a slight increase in the number of individuals towards the upper size classes. The intermediate classes ([25.4 - 27.1], [27.1 - 28.8] and [28.8 - 30.5]) each group 5 individuals. The most represented class is the largest ([30.5 - 32.2 cm]) with 9 individuals (about 30%). The distribution suggests a preponderance of medium to large individuals, reflecting a relatively homogeneous growing population. At the level of the Guéssabo area (Sassandra), sizes vary between 29 and 38 cm, therefore higher than those of the lake of Tine. The distribution is more contrasted; the small number is in class [32.06 - 33.59] which has 1 individual. The high concentration in the upper classes, notably [35.12 - 36.65 cm] with 9 individuals, followed by intermediate classes [36.65 - 38.18 cm] with 8 individuals.

The majority of individuals therefore belong to the large size classes, indicating an older population or benefiting from more favorable growth conditions. The specimens of Sassandra (Guéssabo) are significantly larger than those of Bandama (Tiné). Overall, Lates niloticus has a bimodal distribution over the two watersheds.

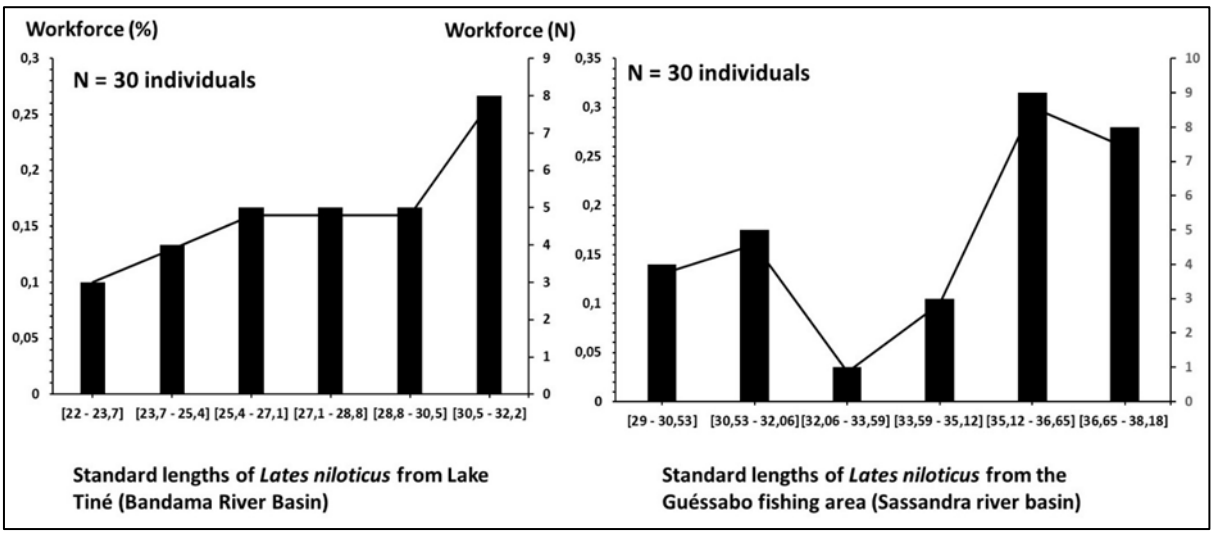
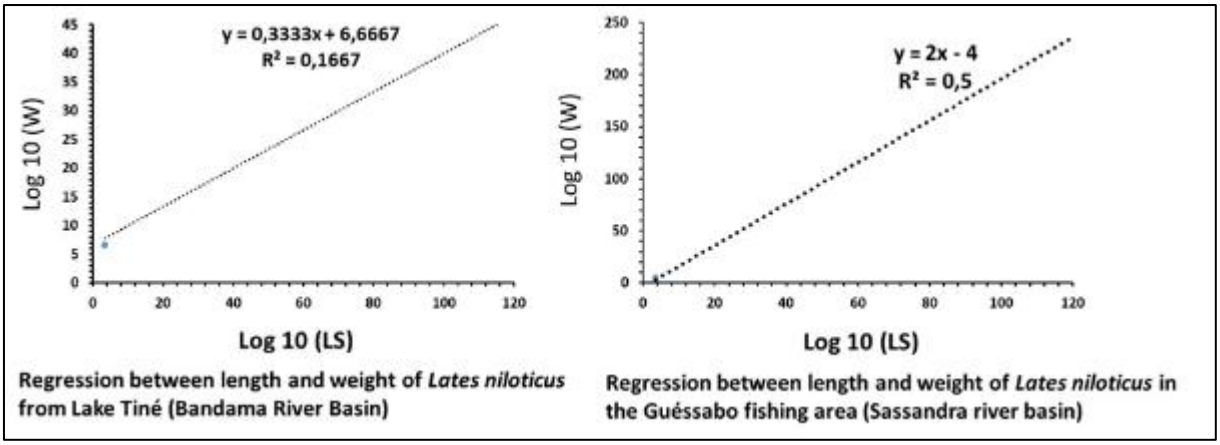


Figure 2 Distributions of size frequencies (Ls) of *Lates niloticus* by watershed

3.1.2. Length-weight relations of Lates niloticus

The regressions of Lates niloticus are highly significant in Lake Tiné, belonging to the Bandama watershed compared to those obtained in the Sassandra river at the level of the Guéssabo bridge, with correlation coefficients (r) of 1.41 and 0.71 respectively (Figure 3). The values of the allometry coefficient (b) of L. niloticus of 1.89 in Lake Tiné and 2 for the Sassandra watershed are below the threshold value of 3 (Student t-test; p 0.05) (Table 1). These values indicate negative allometric growth. This means that *L. niloticus* grows more in size than in weight across the two studied watersheds.

Lates niloticus records a higher condition factor (K = 1.64) in the Tiné than at the Guéssabo bridge (K = 0.67). These positive values indicate good living conditions for this species in these watersheds. However, the living conditions of L. niloticus are much better in the catchment area of Bandama (K>1) than in that of Sassandra (K<1).



Log10 = Logarithm to base 10, LS = Standard length and W = Weight

Figure 3 Regressions between the length and weight of *Lates niloticus* by watershed

Table 1 Parameters of the length-weight relationships of *Lates niloticus* by watershed

Watersheds	Nbr	Standard length LS (cm)			Weight (g)			a	b	ES (b)	r	K	Cr
		Min	Moy	Max	Min	Moy	Max						
Tiné (Bandama River)	30	22	31,18	32	26,5	310,35	692	-1,08	1,89	0,0012	0,41	1,64	A
Guéssabo (Sassandra River)	30	29	34,48	38	67,2	238,81	828	-1,28	2	0,0023	0,71	0,67	A

Nbr = Number of specimens, Min = Minimum, Max = Maximum, Avg = Mean, a = Consistency of proportionality, b = Coefficient of allometry, ES = standard error, K = Condition factor, r = Coefficient of correlation, Cr = type of growth, A = Allometric

3.1.3. Sex ratio of Lates niloticus

The masculinity ratio indicates that individuals captured in lake Tiné, Bandama watershed, are dominated by females (Sr = 2.75). On the other hand, those collected in the Sassandra watershed, on the side of Guéssabo, are mostly male (Sr = 0.11). The chi-square test indicates that the sex distribution is strongly related to the watershed (p-value is much less than 0.05), indicating a highly significant difference.

Table 2 Sex ratio of *Lates niloticus* by watershed

Watersheds	**Number of individuals**	**Sexes**		**Sex ratio**
		Female	Male	
Tiné (Bandama river)	30	22a	8a	2,75a
Guéssabo (Sassandra river)	30	3b	27b	0,11b

The letters a and b indicate a significant difference between the distribution of genders in the two catchment areas.

4. Discussion

The size frequency distributions of *Lates niloticus* highlight a heterogeneity in the growth of individuals according to the studied watersheds. Lake Tiné is characterized by younger individuals or those in intermediate growth stages, dominated by the intermediate classes (22-32 cm Ls). The Guéssabo fishing area has a mature population dominated by large individuals in the upper size classes (35-38 cm Ls). This situation reflects a more favorable genetic or environmental potential. The difference may reflect distinct trophic or ecological conditions (habitat quality, food availability, population density). It can also indicate differentiated growth dynamics between the two basins, suggesting that the Guéssabo fishing area could offer a more favorable environment for the development of *Lates niloticus*. The extent of this area represents an ideal environment for the development of the species. Indeed, a larger habitat provides fish with better feeding, reproductive and protective conditions that ensure good growth and perfect maturation [11].

Yet, it is the lake of Tiné that seems to present living conditions favorable to the improvement of the market value of this species, L. niloticus, which experiences overfishing in this environment. Also, the Bandama river experiences strong exploitation because of its regularity, due to its low slope. Overall, these standard-length values are lower than those recorded [12] (standard lengths of 10 to 79.9 cm Ls on 603 specimens of this species) in the region of Lafia in Chad.

The condition factor values show that *Lates niloticus* lives in better conditions in Lake Tiné, Bandama watershed (K>1) than in the Guéssabo area, Sassandra watershed (K<1). This result would first be attributable to the high fishing pressure exerted in the Guéssabo region. It is believed that fishermen operating in this environment do not follow the fishing instructions [13]. Indeed, the latter use nets of 10, 15 and 20 mm instead of 35 mm and can be 25 fishermen per km2 instead of the maximum of 3 fishermen, as stipulated in the different fishing recommendations. In addition, the residues of agricultural pesticides used for the maintenance of market gardeners are found, by gravitation, in the riverbed. These agents destroy plankton (phyto and zoo) and thus create an imbalance of the ecosystem by impoverishing the marine environment, nutrients and other minerals. This phenomenon has already been observed during studies on the exposure of tilapia *Oreochromis niloticus* to agricultural pesticides in the water reservoirs of northern Benin [14,15]. Furthermore, the assessment of exposure from ingestion of heavy metals and pesticide residues (Mercury (Hg), Cadmium (Cd), Lead (Pb), Copper (Cu) and Iron (Fe)) related to fish consumption in the vicinity of Guéssabo, showed that the concentrations of these chemical elements in fish were higher than the standard of 0.1 µg/L, required by the European Union [16].

The masculinity ratio indicates that the lake of Tiné abounds with more females of *Lates niloticus* (Sr = 2.75) and vice versa in the fishing area of Guéssabo (Sr = 0.11). The dominance of female individuals on lake Tiné would be related to the high temperature values, of the order of 33°C, recorded in the Northern zone of the country, against 25.6° C in the Western zone (Guéssabo). Indeed, some fish species are temperature-sensitive and a rise in water temperature would promote their feminization, and females are generally larger than males. But in all fish species, temperature is a key factor for reproduction. Moreover, in *Lates niloticus*, males mature to a smaller size than females and after the first maturity, individuals grow larger and feminize. Adult female *L. niloticus* are larger than age-matched males in the population, due to sexual growth dimorphism in this species [17]. These values confirm the cause of overfishing in lake Tine and the presence of many males at Guéssabo.

5. Conclusion

The present study was based on the comparison of growth factors of Lates niloticus captured in the lake of Tiné for the watershed of Bandama and at the level of the bridge of the city of Guéssabo, fishing area, erected in the watershed of Sassandra. The size frequency distributions show that *L. niloticus* specimens have smaller sizes in the lake of Tiné, which paradoxically presents the best living conditions (K>1) and a dominance of female individuals.

The specimens of *Lates niloticus* on these different watersheds grow more in size than in weight, for values of allometry coefficient lower than 3.

Recommendations

Given the concentrations of heavy metals and pesticides in fish from Guéssabo that exceed the thresholds set by the European Union, preserving this aquatic environment and its biodiversity would be a guarantee of food security for the population.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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