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Adaptive growth of the species *Ethmalosa fimbriata* (Bowdich) in a polluted environment: Case of Bietry Bay, Abidjan, Côte d'Ivoire

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Abstract

Ethmalosa fimbriata (Bowdich) is a species exploited by the riverside populations of the Ebrié lagoon. Morphometric measurements of all specimens of *Ethmalosa fimbriata* caught in the highly anthropized Bietry Bay were used to study their growth. The samples were collected from fishermen's catches from April 2020 to September 2021. In *Ethmalosa fimbriata*, the total length (Lt) varied from 76.18 to 119.39 mm and from 5 to 14 g for weight (W). The allometry coefficient b was significantly different from 3 for the seize-weight relationship and from 1 for seize-seize relationships. Therefore, the growth was of negative allometry type for this species living on the coast and off the bay. Environmental factors related to the pollution in the Bay of Bietry influenced the growth of both species of fish.

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Introduction

Ethmalosa fimbriata (Bowdich) is coastal species that play an important role in West African artisanal fisheries. They are exploited in Côte d'Ivoire in its two biotopes: at sea and in the lagoon. Ethmalose lagoon fishing is done with several gears (cast nets, gillnets, beach seines, etc.) and accounts for 80% of landings (Briet *et al.*, 1975). In Côte d'Ivoire, ethmalose production is still fragmented, as in Senegal, where catches are monitored on landing (Scheffers, 1973). The size of this fishery resource is less than 200 cm in breeding females in Senegal and Côte d'Ivoire (Scheffers, 1973; Gerlotto, 1976; Guyonnet *et al.*, 2003; Side *et al.*, 2021). The development of a living being in its environment will depend on the availability of nutrients and its adaptation to its environment (Yapi *et al.*, 2017). However, anthropogenic activities impact our environment. This is the case of lagoons and rivers which are receptacles for industrial waste, urban pressure and illegal gold panning. This environmental pollution could be the cause of the disappearance of certain animal and plant species in certain ecosystems (Gold, 2002). Thus, fish species living in these environments develop ecophysiological adaptations for their growth and reproduction in response to environmental disturbances. This present work will focus on the growth of *Ethmalosa fimbriata* (Bowdich, 1825) in the Bay of Bietry, known for its variability in pollution (Guyonnet *et al.*, 2003).

Material and methods

Study site

Bietry Bay is located in the heart of the Abidjan metropolitan area, between 5°15 and 5°18 north latitude and 3°58 and 4°00 west longitudes (Fig. 1). It is a confined environment that communicates with the rest of the lagoon system only through a narrow channel to the west and buzzards with the bay of Koumassi to the east. Its depth is approximately 3 to 4 m and covers an area of 545 ha. It is known for its very polluted environment (Arfi *et al.*, 1981; (Durand *et al.*, 1994).

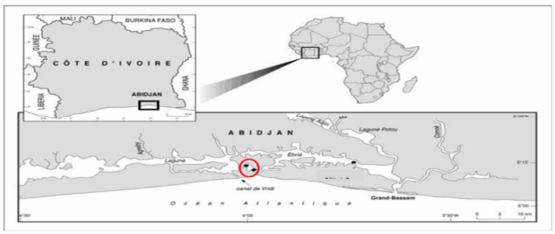

Fig. 1. Location of sampling sites in Ebrié Lagoon (Side *et al.*, 2021)

Allometric data processing

For the biometric study of *Ethmalosa fimbriata*, the following morphometric relationships were established: W = f (Lc), W = f (Lt) and Lc = f (Lt). The relations were expressed by a power function of the form $Y = aX^b$, which is transformed into a logarithmic function of the form Log Y = Log a + b Log X (Lawal-Are, 2012). This transformation is the simplest method to linearize the relationship, stabilize the variances and normalize the variables. The term (b) is the allometry coefficient reflecting the proportionality of the growth of a given character in relation to the reference character. For a size-size relationship, b is theoretically equal to 1, for a size-weight relationship, b is theoretically equal to 3.

Three cases can occur: If b calculated = theoretical b, there is isometry between the two characters, if b calculated < theoretical b, there is a minor allometry and if b calculated > theoretical b, the allometry is increasing.

Statistical analysis of the biometric data

The allometric coefficient b of each equation was compared with the standard coefficient (1 for the size-size relationship and 3 for the weight-size relationship). Then, Student's t-test allowed a comparison of these coefficients. The STATISTICA version 7.1 software was used to perform these tests. The significance level of these different tests is $\alpha = 0.05$.

Results

The Table 1 shows the evolution of morphometric parameters in *E. fimbriata* off the coast of the Bietry Bay. Negative allometry was recorded in the relationships linking total weight to total length, weight to dorsal fin length, total length to standard length, and total length to caudal fin length.

Table 1. Morphometric relationship of *Ethmalosa fimbriata* off the coast of the Bietry lagoon

Morphometric relationship	Equation of regression	r	Allometric Coefficient (b)	Type of allometry	P>F
W/Lt	$W= -14.97Lt^{1.85}$	0.82	1.85	Negative	< 0,05
W/NaD	$W= -1.02NaD^{0.82}$	0.67	0.82	Negative	< 0,05
Lt/Ls	$Lt= - 46.59Ls^{0.88}$	0.13	0.88	Negative	> 0.05
Lt/NaC	$Lt= 3.12NaC^{0.63}$	0.83	0.63	Negative	< 0.05
Lt/NaD	$Lt= 4.35NaD^{0.43}$	0.78	0.43	Negative	< 0,05

W: Total mass, Ls: Standard length, a: Regression constant, b: Regression coefficient, r: Coefficient of correlation, t: Student's t-test, Lt: Total length, NaD: Dorsal fin length, NaC: Caudal fin length,

Table 2. Morphometric relationship of *Ethmalosa fimbriata* on the coast of the Bietry lagoon

Morphometric relationship	Equation of regression	r	Allometric Coefficient (b)	Type of allometry	P>F
W/Lt	$Pt= -0.42Lt^{1.79}$	0.69	1.79	Negative	< 0,05
W/NaD	$Pt= 1.44NaD^{0.39}$	0.31	0.39	Negative	< 0,05
Lt/Ls	Lt= 1.88Ls0.72	0.75	0.72	Negative	< 0,05
Lt/NaC	Lt= 6.31NaC0.07	0.19	0.07	Negative	< 0,05
Lt/NaD	Lt= 6.94NaD0.13	0.27	0.13	Negative	< 0,05

Table 3. Characterization of the morphometric ratios of *E. fimbriata* from the Bietry lagoon

Morphometric relationship	Site	N	Average morphometric ratio	Variance	t	F	P>t
W/Lt	Off the coast	600	10.50^{a}	7.10^{-5}			
	On the coast	600	12.68^{b}	5.10^{-5}	-4.05	1.10	< 0,05
W/NaD	Off the coast	600	1.64^{a}	$0.3.10^{-2}$			
	On the coast	600	2.20^{b}	$0.3.10^{-2}$	-8.64	1.05	< 0,05
Lt/Ls	Off the coast	600	0.92^{a}	$0.18.10^{-2}$			
	On the coast	600	0.22^{b}	$0.2.10^{-2}$	2.57	1.11	< 0,05
Lt/NaC	Off the coast	600	0.22	0.04			
	On the coast	600	0.22	0.39	0.98	11.02	0.33
Lt/NaD	Off the coast	600	1.11^{a}	0.18			
	On the coast	600	0.17^{b}	0.31	-2.76	1.73	< 0,05

The Table 2 shows the evolution of biometric parameters in *E. fimbriata* on the coast of Bietry bay. Morphometric analysis of the fish population revealed negative allometry in the relationships linking total weight to total length, total weight to dorsal fin length, total length to standard length, total length to caudal fin length.

The Table 3 shows the mean morphometric ratios at the two studies sites (P<0.05). The intra-site comparison of these means shows that they are statistically different from each other except the relationship linking the total length to the caudal fin length (Lt/NaC) with the highest mean values of morphometric ratios (Lt/NaD and Lt/Ls) offshore and (W/NaD and W/Lt) on the Bietry Bay coast. Indeed, the values of Lt/NaD and Lt/Ls are respectively 6.53 times and 4.18 times greater on the coast than off the Bietry lagoon. On the other hand, those of W/NaD and W/Lt offshore are higher respectively by 1.34 and 1.21 compared to the bay coast.

Discussion

The weight-size relationship is an important and widely used tool in biology, in physiology, in stock assessment for the management and conservation of fish populations in natural environments (Tah *et al.*, 2012; Tenda *et al.*, 2020). The study of the relative growth of ethmalose required a biometric characterization. Thus, a negative allometry was obtained in the ethmalose population fished on the coast and off Bietry Bay for W/Lt, W/NaD, Lt/Ls, Lt/NaC and Lt/NAD relationships. This is a lower allometry as a whole. In other words, the growth rate in weight and total length grows faster than the growth rate in total length, dorsal fin length, standard length and caudal fin length, respectively.

Animals collected from the various sites are stunted growth. This delay could be related to the physico-chemical disturbances of the lagoon. Indeed, previous studies have shown the state of pollution of the Ebrié lagoon including that of Bietry (Guyonnet *et al.*, 2003; Side *et al.*, 2021).

Physico-chemical disturbances of water cause stress and negatively impact immune responses in some fisheries resources. This is the case of the bivalve *Mya arenaria* whose gametogenesis and progesterone levels are delayed in relation to in situ contamination by organotin compounds and heavy metals in the St. Lawrence River (Canada) (Siah *et al.*, 2003). However, a positive allometry was recorded in this species in Benin in Lake Ahémé and its channels (Viaho, 2021). Positive allometry was also observed for *E. fimbriata* in the Mvassa lagoon of Lower Guinea (Tenda *et al.*, 2020). Abowei (2009) obtained isometric growth for the same species in the Nkoro River of the Niger Delta (Nigeria). Thus, the high level of pollution of the Ebrié lagoon could generate pathogens and/or toxic phytoplankton blooms and stress linked to physico-chemical disturbances (temperature, salinity, dissolved oxygen etc.), would be the most important factors impacting physiological responses (Lee, 2000; Guyonnet *et al.*, 2003; OIE, 2006). Other authors have also reported isometric growth for *E. fimbriata* in brackish (lagoons) and freshwater (lakes and rivers) in Nigeria. Variations in length-weight relationships are not unusual in fishes from tropical waters (Niyonkuru and Lalèyè, 2012; Lederoun *et al.*, 2016 and Minoungou *et al.*, 2020). Moreover, *E. fimbriata* mobilizes their energy to reproduction and metabolism, to the detriment of body growth in the face of pollution. Their adaptability to environmental stresses suggests that they possess different ecophysiological responses to various environmental conditions.

Conclusion

This study revealed that the species *Ethmalosa fimbriata* had negative allometry. Given the rusticity of this species in this polluted environment, it appears as potential bio-indicators of the pollution of the Ebrié lagoon of Bietry.

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