Length-Weight Relationship And Condition Factor Of Mangrove Fish Species In Azagny National Park (Grand-Lahou Department, Ivory Coast)

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Abstract
        The length-weight relationship and condition factor of mangrove fish species in Azagny National Park (ANP) were studied, to provide baseline data of the impact of mangrove disturbances on ichthyofauna. Specimens were captured from March 2019 to February 2020 using gillnets and mesh traps. After identification, each specimen was weighed to the nearest gram and measured to the nearest millimeter. Twenty-eight species belonging to 17 families and 24 genera were selected based on their numbers (only species with at least 10 specimens were considered). Most of these species have a negative allometry (22 species, 78.57%). 14.28% species showed positive allometry and 7.14% species showed isometry. The length-weight regressions

are significant with a coefficient of determination (r²) varying between 0.115 for *Chrysichthys maurus* and 0.936 for *Labeo coubie*. The coefficient of allometry b varies from 0.413 for *Chrysichthys maurus* to 4.272 for *Labeo coubie* with a mean value of 2.384 ± 0.810. The condition factor ranged on average from 0.935 ± 0.966 for *Schilbe mandibularis* 113.3 ± 10.644 for *Chrysichthys maurus*. This study provides information on the effects of mangrove disturbance on the growth of species of the said ecosystem and contributes to the management of the ichthyofauna of the ANP.

Introduction

Mangroves are one of the most productive ecosystems in the world and provide highly diverse ecosystem services (Barbier et *al.*, 2011; UNEP, 2014). Duarte et *al*. (2020) estimate that these ecosystem services are all highly dependent on the ecological condition of the forest massifs. Indeed, mangroves offer a multitude of environments conducive to the feeding and development of fish, crustaceans and mollusks for which it is a breeding ground. It is the basis for the productivity of marine waters, and the back mangrove has good potential for aquaculture in brackish waters (Youmbi et *al*., 1991). On the other hand, mangroves are not immune to stresses related to global change, including first and foremost the risk of sea level rise, which may constitute a major threat locally (Gilman et *al*., 2008; Giri et al., 2011). In Ivory Coast, mangroves are increasingly degraded by their conversion into agricultural land, inhabited areas and infrastructure on the one hand and on the other hand by the various pressures and pollution they are subjected to (Égnankou, 2009 source). For example, Égnankou (2009) announced the considerable decrease of the surface area of the mangrove, between 1980 and 2005, from 30,200 ha to 9,900 ha in Ivory Coast. The mangroves of the ANP are not spared by this situation, whereas they contain a strong biological diversity. This plague impacts aquatic communities in general and the fish fauna in particular. The protection of these environments today is needed and it goes through good systematic, biological and ecological knowledge of the beings that live there (Lalèyé, 2006).

However, there are almost no studies that effectively and specifically address the ichthyofauna of the mangroves of the ANP. The aim of this study is to propose a rational management plan for fish stocks. It is based on the length-weight relationship and the condition factor. According to Hossain et *al*. (2012) and Bolognini et *al*. (2013), the length-weight relationship is an important tool in biology, physiology, ecology and stock assessment for the management and conservation of natural fish populations. Indeed, it is a

critically important key used in fisheries assessment and in fish biology (Da Costa and Araàjo, 2003). The condition factor provides information on the overweight status of a fish (Lévêque et *al*., 1990). It is an instrument often used to compare the overall physiological status of populations over a seasonal cycle or between ponds with similar or different ecological conditions (Le Cren, 1951).

For Baby (2011), the condition factor can be used as an index to assess the level of disturbance in an aquatic ecosystem that is strongly influenced by environmental parameters. The present study aims to determine some biological knowledge base of the ichthyological fauna of the ANP mangroves and the effect of mangrove disturbance on the growth and condition of 28 fish species for appropriate management of the said ecosystem. It was done based on length-weight relationships and condition factor of fish.

Materials And Methods
Study Area

The study was conducted in the Azagny National Park (ANP) to Grand-Lahou in southwestern Ivory Coast, between 5°14' and 5°31' North and 4°76' and 5°01' West (Figure 1). ANP has an area of 19,400 ha with grassy savanna and dense forest vegetation (Avenard et *al*., 1971; Bouichou, 1978). Three quarters of the park's area is made up of the Bandama River-Ebrié Lagoon complex. According to Roth (1979), 45% of its area is flooded throughout the year and 62% during the rainy seasons. This water regime gives the park an ecological specificity. Sampling was conducted at three stations along the study area. The stations were selected based on easy accessibility and the possibility of conducting a year-round sampling program.

Fish Sampling

Fish sampling campaigns were conducted monthly over a 12-month period from March 2019 to February 2020 using monofilament gillnets with mesh sizes between 10 and 35 mm and mesh pots with mesh sizes between 15 and 25 mm. The duration of each campaign is 10 days. The gillnets were set at 5:00 p.m. and visited the next day at 7:00 a.m. for night fishing, and then lifted at 12:00 p.m. for day fishing. As far as the grid traps are concerned, they were set up in the evening around 5 pm and collected the next day starting at 7 am. The specimens collected were identified using the identification keys of Paugy et al (2003a and b). Each individual captured was weighed using a TERRAILLON type electronic scale with a precision of 0.01 g and measured (SL) to the nearest cm using an ichthyometer.
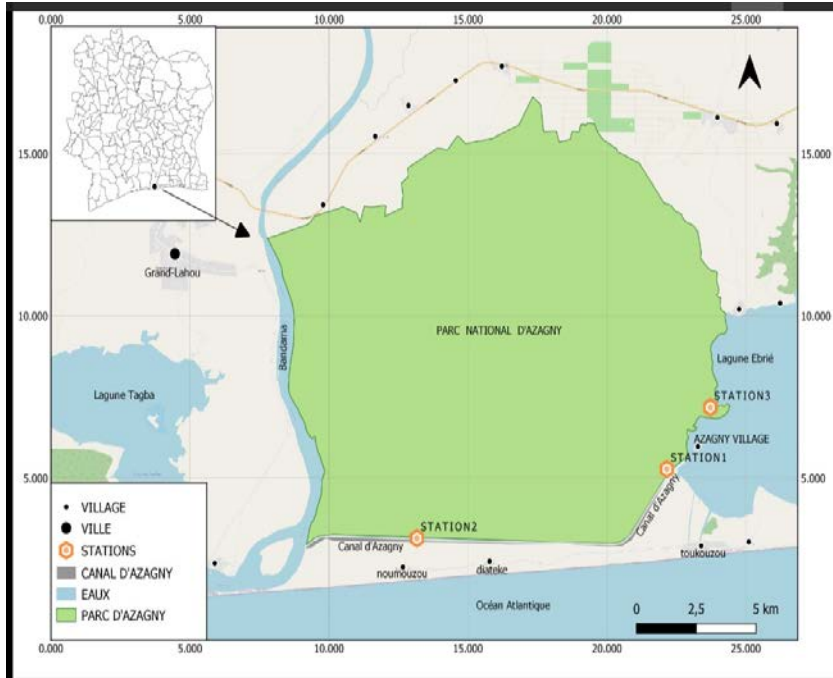
Figure 1: Location of sampling sites in Azagny National Park

Data processing and statistical analysis

To characterize the community structure of fishes in the study area, length-weight relationships were established for fish species according to the formula of Le Cren (1951):

$$Pt = aSL\,b$$

With Pt = total mass of the fish in (g), SL = standard length of the fish in centimeter (cm),

a = constant and b = allometry coefficient.

The parameters a and b were estimated after transforming the previous linear function into a logarithmic function of the formula:

$$\log Pt = \log a + b \log SL$$

In order to check whether the value of b is significantly different from 3, the Student's t-test was used ($p = 0.05$). The allometry coefficient b varies between 2 and 4 but is most often close to 3. When b = 3, there is growth isometry (the growth in weight of the animal is equal to its growth in length). A coefficient b greater than 3 indicates a better growth of the species in weight than in length (positive allometry) and, conversely, a better growth in length than in weight when b is lower than 3 (negative allometry). The coefficient of determination (r^2) was used as an indicator of the degree of correlation between length and mass.

For the present study, the Fulton condition factor (Bagenal, 1978) was calculated for each fish using the formula:

$$K = 100 \, Pt \, / \, SL^{\,3}$$

With Pt = total fresh weight of the fish in g.
SL = standard length of fish in centimeter.
3 = exponent of the weight-length relationship or allometry coefficient (b).
In the present study, only species represented by at least 10 specimens
(Batiabo et *al.*, 2019; Ibala Zamba et *al.*, 2020), from which presence was
noted at all stations during the entire collection period were used.

Results

The length-weight relationship of 28 fish species studied are presented
in Table I. A total of 2294 specimens belonging to 17 families were analyzed.
The number of specimens vary from 10 (*Pellonula vorax*) to 658
(*Sarotherodon melanotheron*). The standard lengths (SL) of the specimens
vary from 2.5 cm in *Pellonula vorax* to 50 m in *Sarotherodon melanotheron*
with weights that vary between 1g in *Pellonula leonensis* and *Pellonula vorax*
and 1000 g in *Neochelon falcipinnis*. The coefficients of determination (r^2) of
the linear regressions are ranged between 0.115 for *Chrysichthys maurus* and
0.936 for *Labeo coubie* and all regressions indicate a significant relationship
($p < 0.05$) between length and weight of the fish studied. Furthermore, the
values of (r^2) are greater than 0.90 for 4 species (14.28%), 0.80 for 5 species
(17.85%) and less than 0.80 for 19 species (67.85%).

The allometry coefficients (b) range from 0.413 for *Chrysichthys maurus* to
4.272 for *Labeo coubie*. The distribution of the allometry coefficient (b) for
the 28 species studied has a mean value of 2.384 ± 0.810 (Figure 2).

In terms of growth, the allometry coefficient (b) of two species, *Distichodus
rostratus* and *Hepsetus odoe* is equal to 3 (Student's t-test: p = 0.5), attests that
the growth is isometric (Table 1). In contrast, 26 species (93%) have an
allometry coefficient (b) significantly different from 3 (Student's t-test: p <
0.05). Among these species, 22 species show negative allometric growth (b <
3). These are *Elops lacerta, Pellonula leonensis, Pellonula vorax, Ethmalosa
fimbriata, Chrysichthys maurus, Chrysichthys nigrodigitatus, Schilbe
mandibularis Hemichromis fasciatus, Sarotherodon melanotheron, Coptodon
guineensis, Coptodon hybride, Coptodon zillii, Pelmatolapia mariae,
Tylochromis jentinki, Pomadasys jubelini, Monodactylus sebae, Trachinotus
teraia, Awaous lateristriga, Gobioides sagitta, Porogobius schlegelii,
Citharichthys stampflii* et *Cynoglossus senegalensis*. On the other hand, 4
species such as Labeo coubie, Neochelon falcipinnis, *Parachanna obscura*
and *Polydactylus quadrifilis* have a positive allometric growth (b > 3).

As for the condition factors K, the results in Table 1, indicate that 27 fish
species (96.42%) out of the 28 have a good body weight. Only *Schilbe
mandibularis* has a bad weight. The average condition factors vary from 0.935
± 0.966 for *Schilbe mandibularis* to 113.3 ± 10.644 for *Chrysichthys maurus*.

Family	Species	N	Standard length		Weight		Length - Weight Relationship						
			Min	Max	Min	Max	a	b	SE (b)	r²	Growth	t	K
Elopidae	*Elops lacerta*	56	7,6	22	15	103	1,28	1,306	0,093	0,483	A-	-1,499	1,685
Clupeidae	*Pellonula leonensis*	21	3,8	10,2	1	30	0,255	1,87	0,121	0,543	A-	-1,149	6,874
	Pellonula vorax	10	2,5	8	1	19	1,307	1,117	0,107	0,307	A-	-1,302	15,86
	Ethmalosa fimbriata	18	4,7	17,5	11	101	0,107	2,275	0,136	0,645	A-	-1,028	4,063
Hepsetidae	*Hepsetus odoe*	33	12,3	22,5	30	356	0,012	3,036	0,142	0,883	I	-0,989	1,624
Distichodontidae	*Distichodus rostratus*	52	9	20,5	13	198	0,018	3,023	0,114	0,891	I	-1,222	1,98
Cyprinidae	*Labeo coubie*	11	12,7	22	49	295	0,001	4,272	0,152	0,936	A+	-0,917	2,502
Claroteidae	*Chrysichthys maurus*	69	14	33,5	44	312	36,103	0,413	0,147	0,115	A-	0,947	113,299
	Chrysichthys nigrodigitatus	147	8,5	24	11	293	0,082	2,541	0,148	0,646	A-	-0,942	2,309
Schilbeidae	*Schilbe mandibularis*	45	11,5	18,5	13	78	0,127	2,077	0,098	0,475	A-	-1,416	0,935
Cichlidae	*Hemichromis fasciatus*	76	5,6	16,2	8	148	0,06	2,746	0,133	0,789	A-	-1,048	3,262
	Sarotherodon melanotheron	658	6,5	50	3	999	0,23	2,315	0,207	0,923	A-	-0,673	3,773
	Coptodon guineensis	23	9	16,1	35	152	0,09	2,391	0,143	0,553	A-	-0,979	4,084
	Coptodon hybride	63	6,8	16,3	19	155	0,114	2,528	0,127	0,92	A-	-1,098	3,472
	Coptodon zillii	427	7,3	23,1	15	471	0,064	2,781	0,162	0,929	A-	-0,864	3,663
	Pelmatolapia mariae	20	9	15	35	148	0,046	2,663	0,148	0,577	A-	-0,943	4,502

	Tylochromis jentinki	126	7,5	19,5	8	199	0,059	2,696	0,148	0,85	A-	-0,941	2,78
Haemulidae	*Pomadasys jubelini*	40	10,1	21	30	298	0,029	2,943	0,182	0,643	A-	-0,767	3,172
Monodactylidae	*Monodactylus sebae*	56	5,5	13	12	147	0,476	1,991	0,097	0,637	A-	-1,434	5,453
Polynemidae	*Polydactylus quadrifilis*	21	7,5	21	7	211	0,011	3,142	0,149	0,829	A+	-0,936	2,447
Carangidae	*Trachinotus teraia*	48	4,3	15	13	198	0,365	1,837	0,093	0,615	A-	-1,502	3,351
Channidae	*Parachanna obscura*	32	13,7	32,5	61	807	0,005	3,381	0,217	0,878	A+	-0,645	2,187
Gobiidae	*Awaous lateristriga*	79	7,3	24	15	409	0,185	2,345	0,204	0,745	A-	-0,685	3,014
	Gobioides sagitta	38	5,6	31,2	13	90	0,873	1,473	0,086	0,502	A-	-1,625	2,248
	Porogobius schlegelii	13	6,5	10,1	9	26	0,046	2,575	0,133	0,782	A-	-1,045	2,772
Mugilidae	*Neochelon falcipinnis*	17	10,7	27,5	36	1000	0,011	3,138	0,247	0,759	A+	-0,565	3,246
Paralichthyidae	*Citharichthys stampflii*	80	3,6	14,3	10	53	2,486	1,041	0,117	0,456	A-	-1,192	3,557
Cynoglossidae	*Cynoglossus senegalensis*	15	8,7	22,5	25	157	0,022	2,845	0,136	0,766	A-	-1,023	2,136

Table I: Length-weight relationship, allometry coefficient, growth type and condition factor of 28 fish species caught in the mangroves of Azagny National Park between March 2019 and February 2020.

N: number; Min: minimum; Max: maximum; a and b: growth parameters; SE (b): standard error of b; r²: coefficient of determination; A: allometry; I: Isometry
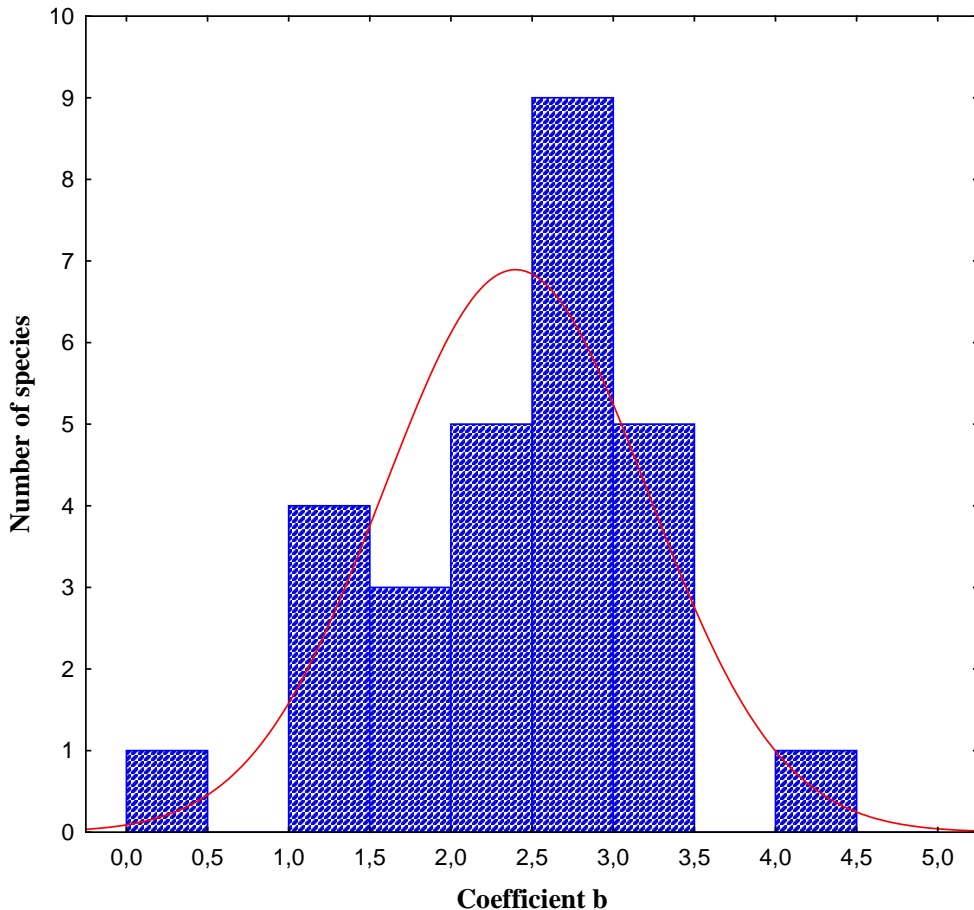
Figure 2: Distribution of b value for length-weight relationships in 28 fish species caught in ANP mangroves between March 2019 and February 2020.

Discussion

Allometry coefficients (b) ranged from 0.413 for *Chrysichthys maurus* to 4.272 for Labeo coubie with a mean of 2.384 ± 0.810. This mean value is significantly different from 3 (Student's t-test: $p < 0.05$). This is in contrast to the results obtained by Mikembi et *al*. (2019) for 13 species and Dembe et *al*. (2020) for 16 fish species in Congo but does not differ from observations made in Ivory Coast for 15 fish species exploited in the Ebrié Lagoon (Nobah et *al*., 2019). In addition, the allometry coefficient is significantly less than 3 for most species (Table 1). The values of this coefficient for *Distichodus rostratus* (3.02) and for *Hepsetus odoe* (3.03) are not significantly different from 3

(Student's t-test: p = 0.05), indicating isometric growth. In contrast, *Labeo coubie*, *Neochelon falcipinnis*, *Parachanna obscura* and *Polydactylus quadrifilis* have positive allometric growth resulting in a b coefficient greater than 3 (Student's t-test: p < 0.05). This indicates better growth in weight than in length of these species (Da et *al*., 2018). Indeed; fish with positive allometric growth, are heavier reflecting optimal growth conditions. However, this result is contrary to that of Koffi et *al*. (2014) who worked in the Aby Lagoon in Ivory Coast and Dembe et *al*. (2020) in the Mvassa Lagoon in Congo, who reported negative allometry for these fish. These changes in growth patterns can be justified by environmental parameters related to the changing hydrological regime. For twenty-two (22) species (*Elops lacerta, Pellonula leonensis, Pellonula vorax, Ethmalosa fimbriata, Chrysichthys maurus, Chrysichthys nigrodigitatus, Schilbe mandibularis, Hemichromis fasciatus, Sarotherodon melanotheron, Coptodon guineensis, Coptodon hybride, Coptodon zillii, Pelmatolapia mariae, Tylochromis jentinki, Pomadasys jubelini, Monodactylus sebae, Trachinotus teraia, Awaous lateristriga, Gobioides sagitta, Porogobius schlegelii, Citharichthys stampflii* and *Cynoglossus senegalensis*.), the value of b is less than 3 (Student's t-test: p < 0.05) and shows that the growth of these fishes is of negative allometric type characterized by a growth in length more important than the growth in weight. Similar results were observed by Kamelan et *al*. (2014) and N'Dri et *al*. (2020), in Taï National Park and Lake Buyo, respectively. On the other hand, this result is different from the work of Hazoume et *al*. (2017) in the Sô River in Benin where the value of the coefficient b indicates a positive allometry for most of the species in the said river.

The generally accepted norms for the allometry coefficient are between 2 and 4 (Bagenal and Tesch, 1978). Thus, except for a few samples, the various values observed in the present study are in accordance with those usually reported and accepted in the literature. The low values of the allometry coefficient (b < 2.5) observed in the ANP mangroves could be related to a narrow sample size range. According to Yakubu et al. (2016), the allometry coefficient is related to the quality of the aquatic environment. Indeed, mangroves undergo a galloping demographic pressure through domestic discharges and canalization with direct discharges into the environment impacting the growth of species. These mangroves are like nursery and spawning areas, sheltering an important proportion of fish resources and juvenile fish. Therefore, the low values of allometry coefficient can be associated with a food competition by the availability of resources in the environment. Thus, it can be inferred that the low values of allometry coefficient of fish in ANP could be due to the advanced state of degradation an anthropogenic activities, such as overfishing by local fishermen, removal of sand for construction and cutting of firewood and timber. Indeed, the study

area is being an island, the riparian populations have only fished as their main activity, which could also justify the variation of the fish b coefficient. According to Biswas (1993), the variation of b in different regions would be due to the physiological conditions of the fish, the time of collection, the sex, the development of the gonads and the nutritive conditions in the fish environment. This variation in allometry coefficient could also be justified by the destruction of food sources leading to their scarcity, thus constraining the ideal growth of fish.

The condition factor (K) gives a good idea of the overweight of the fish, i.e. the relative importance of its body mass compared to its length. It is a parameter that allows us to compare species to each other or to the same species in different environments and to characterize the quality of the trophic relationship between the fish and its environment (Kumolu-Johnson and Ndimele, 2010). The condition factor (K) in the present study is generally greater than 1, which would mean that fish are doing well in this ecosystem. According to Alhassan et *al*. (2015),

K ≥ 1 expresses that the fish are in good conditions and K < 1 means that the fish are not overweight in their biotope. On the other hand, the lowest condition factor was observed in *Schilbe mandibularis* (0.935) and the highest in Chrysichthys maurus (113.3). Twenty-seven (27) species of mangrove fish namely *Elops lacerta, Pellonula leonensis, Pellonula vorax, Ethmalosa fimbriata, Hepsetus odoe, Distichodus rostratus, Labeo coubie, Chrysichthys maurus, Chrysichthys nigrodigitatus, , Hemichromis fasciatus, Sarotherodon melanotheron, Coptodon guineensis, Coptodon hybride, Coptodon zillii, Pelmatolapia mariae, Tylochromis jentinki, Pomadasys jubelini, Monodactylus sebae, Polydactylus quadrifilis, Trachinotus teraia, Parachanna obscura, Awaous lateristriga, Gobioides sagitta, Porogobius schlegelii, Neochelon falcipinnis, Citharichthys stampflii* as well as *Cynoglossus senegalensis* had their K-values outside the range (2.4 - 4.8) recommended as appropriate for mature freshwater fish by Bagenal and Tesch (1978). The condition factor values obtained in the present study show that the species studied were in good conditions in the PNA mangroves. This was not the case in *Schilbe mandibularis*. These results are similar to those found in the twenty-four fish species where K values are greater than 1, except in Mormyrus rume (0.79) in Lake Buyo (N'Dri et *al.*, 2020). This difference would be related to species, sex and diet. On the other hand, Konan et *al*. (2014) showed that the high values of condition factor K could be explained by the presence of a diverse and abundant diet in the environment.

Conclusion

The present study, which provides information on the length-weight relationships and condition factors of 28 fish species, provides information on

the biology of the fish fauna of the mangroves of the ANP. It mainly provides an important database for researchers and nature managers in the development of management and conservation measures for mangrove fish populations. Indeed, the knowledge of the length-weight relationship and the condition factor of the species targeted by this study, because it allows to put at the disposal of the decision-makers, data likely to help in the elaboration of measures of optimal and sustainable management of the mangrove ecosystems of the ANP. In the Azagny mangroves, the present study noted 2 species of fish showing isometric growth, 4 species showing positive allometry and 22 species showing negative allometry. Most of the species studied have et good weight. The mangroves, because of their richness in biodiversity are widely exploited by man. However, in the face of the galloping demographic growth of the populations of the Azagny area, these ecosystems are increasingly threatened and / or overexploited. It is therefore necessary to draw the attention of the populations to the importance of these areas and the aquatic organisms that live there for the sustainability of aquatic biodiversity.

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