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RESEARCH ARTICLE

CONDITION FACTOR AND LENGTH-MASS RELATIONSHIP OF THE MAIN FISH SPECIES IN THE BANDAMA RIVER DOWNSTREAM OF THE TAABO DAM (COTE D'IVOIRE)

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Abstract

Length-mass relationship and condition factor are important tools used in biology, ecology and stock assessment for the management and conservation of fish populations and also to assess the level of disturbance of an aquatic ecosystem. The present study aims at providing baseline data on the length-mass relationship and condition factor of sixteen (16) fish species landed at N'Dènou, downstream of the Taabo dam, prior to the impoundment of the dam under construction on this part of the Bandama River. The fish were collected monthly from november 2019 to october 2020.They were measured (standard length in cm) and weighed (mass in g). The data were processed in Excel and Statistica 7.1 software. A total of 16047 fish were examined. The standard lengths of these fish varied from 3.50 to 40 cm with masses ranging from 2.87 to 1400 g. The values of the allometry coefficient ranged from 1.64 for *Hemichromis bimaculatus* to 2.99 for *Labeo coubie*. Fourteen (14) fish species studied have negative allometric growth ($b < 3$; $p < 0.05$). *Distichodus rostratus* and *Labeo coubie* species have isometric growth. The condition factor has values between 0.83 ± 0.39 (*Mormyrops anguilloides*) and 3.65 ± 0.74 (*Coptodon hybrid*).

Introduction:-

Fish in tropical aquatic systems experience fluctuations in growth due to factors such as environmental conditions, prey availability, population density. The length-mass relationship is an important tool used in biology, ecology and stock assessment for the management and conservation of fish populations (Bolognini *et al.*, 2013; Mikembi *et al.*, 2019). According to Paugy and Lévêque (2017), the condition factor provides information on the overweight status of a fish. It is an instrument often used to compare the overall physiological status of fish populations over a seasonal cycle or between ponds with similar or different ecological conditions (Lizama and Ambrósia, 2002; Mikembi *et al.*, 2019). The condition factor is used as an index to assess the level of disturbance in an aquatic ecosystem (Baby *et al.*, 2011). In West Africa, mainly in Côte d'Ivoire, governments rely on the large river system to carry out multiple development programs. After independence, the human impact on the Bandama River increased significantly, with the construction of two large dams for hydroelectric use (Kossou in 1972 and Taabo in 1979) and many other small dams for hydro-agricultural use in the upstream part. Currently, the new Singrobo-Ahouaty hydroelectric dam is

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being constructed on the main riverbed of the Bandama River downstream of the Taabo dam. The present study aims at providing baseline data on the length-mass relationship and condition factor of the main fish species landed at N'Dènou, downstream of the Taabo dam, before the impoundment of the new dam. Specifically, the aim is to determine the type of allometry of these fish through the length-mass relationship and to estimate their overweight status by calculating the condition factor.

Material and Methods:-

Study area

The study area is located downstream of the Taabo hydroelectric dam and upstream of the Singrobo-Ahouaty dam under construction on the Bandama River (Figure). This area is heavily exploited by artisanal fishers who land their catch in N'Dènou, a locality located about 85 km from the political capital (Yamoussoukro) and 160 km from Abidjan, the economic capital of Côte d'Ivoire. The study area is under the influence of the Attean climate. This climate is characterized by a long rainy season between april and july and a short dry season between august and september. A short rainy season covers the months of october and november and a long dry season extends from december to march-april (Savané and Konaré, 2010). This site was chosen for its accessibility, the commercial fishing landings that take place there and the impact that the dam under construction could have on the fish populations in this area.

Data collection

The biological material used in this study consists of individuals of sixteen (16) fish species. These fish came from artisanal fishing landings in N'Dènou. The fishing gears used on the Bandama River in this locality are mainly traps, gillnets and hawks. The traps consist of a frame made of liana and are covered with a multi-filament net with a mesh size of between 20 and 45 mm. The gillnets used are made of monofilament with a mesh size of 20 to 70 mm. The hawk net generally consists of a circular flat sheet 6-8 m in diameter with sinkers around the periphery. Data collection was conducted monthly from november 2019 to october 2020. Collected fish were identified according to the key of Paugy *et al.* (2003 a and b). They were then measured (Standard length in cm) and weighed (mass in g).

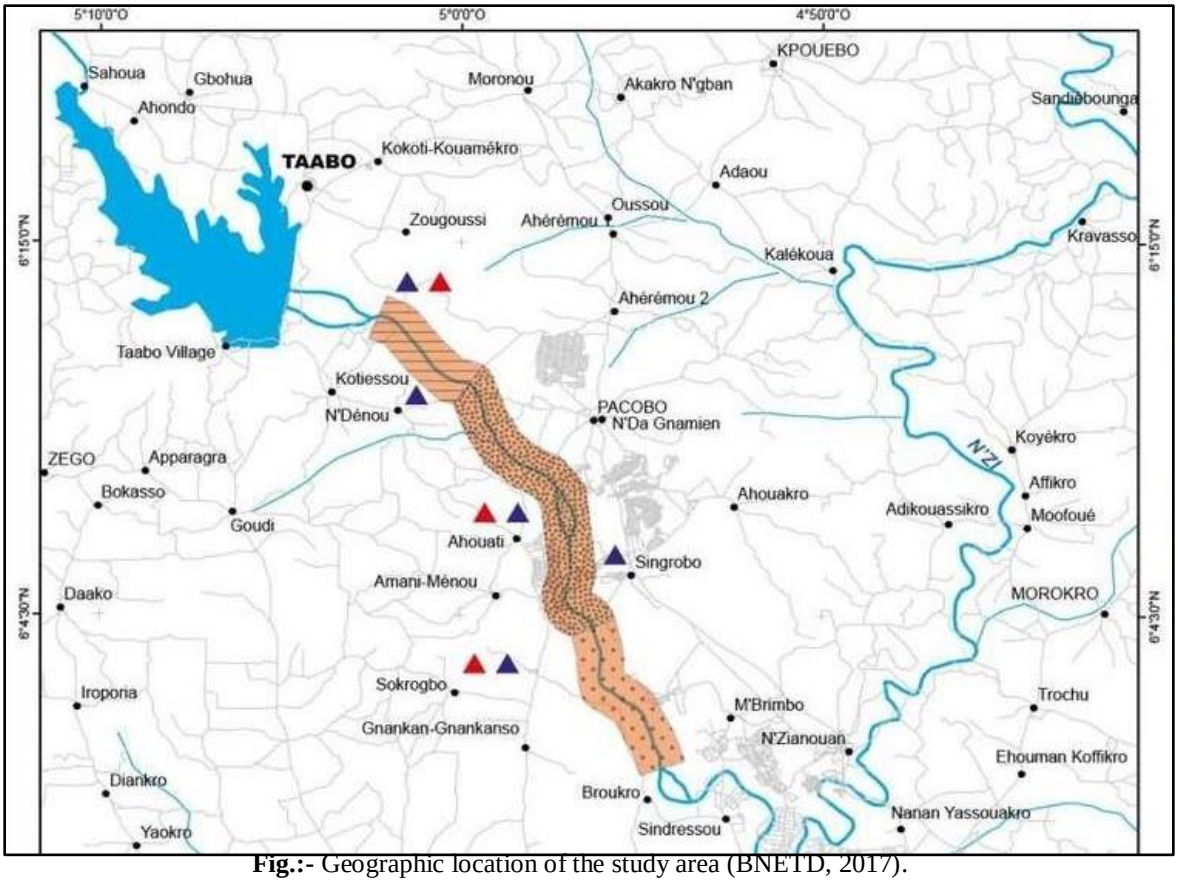

Fig.:- Geographic location of the study area (BNETD, 2017).

Data processing and statistical analysis

Estimation of the length-mass relationship

The length-mass relationship was evaluated in order to specify the type of allometry of the species studied. The length-mass correlation is established according to the formula of Ricker (1975):

$M = aSL^b$

With M = mass of the fish in g; SL = standard length of the fish in cm; a = constant and b = allometry coefficient.

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

$Log_{10}M = log_{10}\ a + b\ log_{10}SL$

The value of b gives information about the type of growth of the fish. Student's t-test was used to test whether the obtained b-value differs significantly from 3. The null hypothesis of isometric growth (H0: b = 3) was tested using the ts = (b-3)/SE statistic of Sokal and Rohlf (1987) where ts is the calculated t-value of the test; SE, the standard deviation of the b-slope at p-value = 0.05. When b = 3, growth is isometric and when $b \neq 3$, growth is allometric. If $b < 3$, the allometry is negative or minorizing, the fish grows faster than it gets bigger. If $b > 3$, the allometry is positive or majoring, the fish is growing faster than it is growing (Lévêque, 1999). The correlation coefficient r^2 was used as an indicator of the quality of linear regressions. An r^2 value close to 1 means a good correlation between length and mass. Statistical treatments were performed using Statistica 7.1 software.

Determination of the condition factor

In order to determine the overweight status of the fish, the condition factor for each species was calculated using the formula of Tesch (1971):

$K = 100 \times M/SL^3$

Where M represents the mass of the individual (g) and SL the standard length (cm).

The condition factor K can be classified into five categories namely: Very Poor (0.8-1.0), Poor (1.0-1.2), Balanced (1.2-1.4), Good (1.4-1.6) and Very Good (>1.6) according to Morton and Routledge (2006).

Results:-

A total of 16047 fish were examined. The standard lengths of these fishes vary from 3.50 cm for *Coptodon zillii* to 40 cm for *Mormyrops anguilloides* with masses ranging from 2.87 g for *Coptodon zillii* to 1400 g for *Distichodus rostratus* (Table 1). The values of the allometry coefficient oscillate between 1.64 for*Hemichromis bimaculatus* and 2.99 for *Labeo coubie* (Table 2). Student's t tests show that only the values of the allometry coefficient of *Distichodus rostratus* (2.96) and *Labeo coubie* (2.99) are not statistically different from the reference value 3 ($p > 0.05$). These two species therefore have an isometric growth. All other fish species (14 species) have an allometric coefficient value less than 3 (Student's t-test $p < 0.05$). Therefore, these fish have negative allometric growth. The values of the coefficient of determination (r^2) vary between 0.56 for *Hemichromis bimaculatus* and 0.99 for *Oreochromis niloticus*.

The condition factor has values between 0.83 ± 0.39 (*Mormyrops anguilloides*) and 3.65 ± 0.74 (*Coptodon hybrid*). The condition factors of the species *Mormyrops anguilloides* (0.83 ± 0.39) and *Mormyrus rume* (0.85 ± 0.13) of the Family Mormyridae are classified as "Very poor". That of *Schilbe mandibularis* (1.003 ± 0.18) is considered "poor" and the remaining thirteen (13) species all have a condition factor greater than 1.60. It is therefore considered "very good".

Table 1:- Statistical description of length and mass obtained for sixteen fish species sampled in Bandama river downstream of the Taabo dam (Côte d'Ivoire). N = Number; Min = Minimum; Max = Maximun

			Standard length(cm)			Mass (g)		
Family	Species	N	Min	Max	Mean	Min	Max	Mean
Mockokidae	*Synodontis bastiani* Daget, 1948	1422	5.10	25.0	12.95 ± 2.81	9.00	298.71	45.97 ± 34.85
	Synodontis punctifer Daget, 1965	975	7.40	18.0	10.21 ± 1.59	7.63	77.43	23.28 ± 12.10
	Synodontis schall (Bloch Schneider, 1801)	801	6.50	16.2	12.50 ± 1.71	6.40	85.17	22.52 ± 10.84

Schilbeidae	*Schilbe mandibularis* (Günther, 1871)	1436	6.00	22.0	13.26 ± 1.88	6.64	86.60	24.40 ± 10.51
Claroteidae	*Chrysichthys nigrodigitatus* (Lacepède, 1803)	7635	7.20	37.0	12.06 ± 2.83	6.32	630.65	33.57 ± 31.93
Cichlidae	*Hemichromis fasciatus* Peters, 1852	619	5.50	17.0	10.06 ± 1.54	6.45	159.20	32.01 ± 15.98
	Hemichromis bimaculatus Gill, 1862	155	5.50	11.0	7.24 ± 0.93	5.56	23.12	12.74 ± 3.55
	Oreochromis niloticus (Linnaeus, 1758)	98	5.50	31.0	13.11 ± 6.05	6.12	1000.0	133.34 ± 189.65
	Chromidotilapia Guntheri (Sauvage, 1882)	1038	5.00	18.0	7.88 ± 1.16	3.60	76.20	16.53 ± 7.20
	Coptodon zillii (Gervais 1848)	439	3.50	28.5	14.5 ± 5.2	2.87	650.00	145.53 ± 128.85
	Coptodon hybrid (Coptodon zillii X Coptodon guineensis)	107	6.00	35.0	15.67 ± 5.86	7.80	527.49	190.33 ± 157.97
Mormyridae	*Mormyrops anguilloides* (Linnaeus, 1758)	104	13.0	40.0	21.98 ± 5.07	30.0	194.04	84.05 ± 39.67
	Mormyrus rume Valenciennes, 1847	109	12.5	39.0	19.53 ± 3.79	15.92	296.52	67.83 ± 38.40
Distichodontidae	*Distichodus rostratus* Günther, 1864	141	11.3	36.0	20.08 ± 4.42	20.07	1400.0	172.57 ± 166.59
Cyprinidae	*Labeo coubie* Rüppell,1832	835	8.00	34.0	17.64 ± 4.86	9.78	1200.0	147.59 ± 126.03
Alestidae	*Brycinus macrolepidotus* Valenciennes, 1850	133	7.00	35.5	14.73 ± 5.21	8.43	359.36	90.69 ± 86.81

Table 2:- Length-mass relationship, allometry coefficient, growth type and condition factor of 16 fish species caught in Bandama river A^- = Negative allometry; I = Isometry

		Length-mass relationship				Condition factor (K)		
Family	Species	a	b	r^2	Growth type	Min	Max	Mean
Mockokidae	*Synodontis bastiani*	0.0246	2.88	0.93	A^-	0.28	7.53	1.86 ± 0.32
	Synodontis punctifer	0.0283	2.85	0.86	A^-	0.71	4.83	2.05 ± 0.35
	Synodontis schall	0.0920	2.32	0.76	A^-	0.77	3.65	1.96 ± 0.38
Schilbeidae	*Schilbe mandibularis*	0.0490	2.65	0.83	A^-	0.24	4.50	1.003 ± 0.18
Claroteidae	*Chrysichthys nigrodigitatus*	0.0280	2.77	0.89	A^-	0.14	10.73	1.66 ± 0.35
Cichlidae	*Hemichromis fasciatus*	0.0385	2.87	0.86	A^-	0.66	7.93	2.85 ± 0.53
	Hemichromis bimaculatus	0.4748	1.64	0.56	A^-	0.91	6.35	3.39 ± 0.74
	Oreochromis niloticus	0.0460	2.90	0.99	A^-	2.49	6.02	3.63 ± 0.48
	Chromidotilatia guntheri	0.0720	2.59	0.78	A^-	0.17	7.06	3.24 ± 0.55
	Coptodon zillii	0.0540	2.83	0.94	A^-	0.45	8.57	3.63 ± 0.80
	Coptodon hybrid	0.0440	2.91	0.93	A^-	0.41	4.74	3.65 ± 0.74
Mormyridae	*Mormyrops anguilloides*	0.3720	1.73	0.76	A^-	0.22	3.72	0.83 ± 0.39
	Mormyrus rume	0.0270	2.59	0.92	A^-	0.49	1.57	0.85 ± 0.13
Distichodontidae	*Distichodus rostratus*	0.0190	2.96	0.79	I	0.29	4.65	1.82 ± 0.45
Cyprinidae	*Labeo coubie*	0.0210	2.99	0.95	I	0.50	4.22	2.17 ± 0.32
Alestidae	*Brycinusmacrolepidotus*	0.0400	2.76	0.97	A^-	0.80	4.67	2.22 ± 0.41

Discussion:-

The study of length-mass relationships in sixteen (16) species of fish landed at N'Dènou showed that the values of the allometric coefficient b are between 1.64 and 2.99. The values obtained are within the range of 2 - 4 indicated by Bagenal and Tesch (1978), except for those of *Hemichromis bimaculatus* (1.64) and *Mormyrops anguilloides* (1.73). The b values for *Distichodus rostratus* (2.96), and *Labeo coubie* (2.99) are not significantly different from 3. These fish have an isometric growth. They grow and fatten at the same rate. Similar results were observed by N'Dri *et al*. (2020) in Lake Buyo and by Kouadio *et al*. (2022) in Azagny National Park for *D. rostratus*. Concerning the species *L. coubie*, Kien *et al*. (2022) and Kouadio *et al*. (2022) gave a value of b greater than 3, reflecting a positive allometric growth for this species. The remaining fourteen (14) species with a b value statistically different from 3 have allometric growth. This means that the growth in mass of these species does not occur at the same time, in the same proportions as the growth in length. The allometry observed here is negative or minorizing because b is less than 3. The fish studied therefore grow faster than they get bigger. Our results corroborate those of Kien *et al*. (2022) for the species *Chrysichthys nigrodigitatus*, *Synodontis bastiani* and *S. schall* in the Bandama River. Kamelan *et al*. (2021) however, noted isometric growth in Lake Ayame 1 for *Schilbemandibularis*. For this same species, N'Dri *et al*. (2020) reported positive allometric growth in Lake Buyo. The same is true for the species *Synodontis punctifer* according to the latter authors. For this fish, our results are similar to those of Tah *et al*. (2012). Indeed, these authors observed negative allometric growth in *S. punctifer* in Buyo Lake. All observed differences are thought to be due to the physiological conditions of the fish at the time of collection, sex, stage of gonad development, and nutritional conditions of the fish environment (Biswas, 1993).They could also be explained by the fact that the allometry coefficient b can be influenced by growth stage, stomach contents, water quality and hydrological conditions (Mikembi *et al*., 2019; N'Dri *et al*., 2020; Kamelan *et al*., 2021).

The values of the coefficient of determination (r^2) obtained in the present study for the species studied, are relatively high (0.56 - 0.99). Thus, there is a strong correlation between length and mass of these different species. These high values of coefficient of determination suggest that growth in size causes an increase in mass in these fish species (Mikembi *et al*., 2019; Kamelan *et al*., 2021).

According to Kouadio *et al*. (2022), the condition factor (K) gives a good idea of the overweight of the fish, that is, the relative importance of its body mass to its length. Fish condition factor is a biological parameter that provides information on the condition of fish species and is of great importance for the management and conservation of fish populations (Muchlisin *et al*., 2010; Bédia *et al*., 2022). In the present study, out of sixteen (16) fish species studied, thirteen (13) have a condition factor higher than 1.6. These values would indicate that these fish have favourable environmental and nutritional conditions for their growth. This is not the case for the species, *Mormyrops anguilloides* (0.83 ± 0.39), *Mormyrus rume* (0.85 ± 0.13) and *Schilbe mandibularis* (1.003 ± 0.18) which have a condition factor included in the interval 0.8 - 1.0 estimated as "Very poor" in the classification of Morton and Routledge (2006). Similar results were reported for the species *S. mandibularis* by Bédia *et al*. (2022) in the Ebrié Lagoon (K = 0.59 ± 0.2) and by Kouadio *et al*. (2022) in Azagny National Park (K = 0.93 ± 0.966). According to Kartas and Quignard (1984) and Koné (2000), the condition factor is not constant for a given specimen, species or population. Variation in this parameter may be associated with fish feeding mechanisms (Ahmed *et al*., 2018). According to Soedarto and Tembalang (2019), the condition factor can also be associated with the quantity and/or quality of food available in different fish environments.

Conclusion:-

The study of the length-mass relationship of sixteen species of fish landed at N'Dènou, before the impoundment of the Singrobo-Ahouaty dam, showed that the species *Distichodus rostratus* and *Labeo coubie* have an isometric growth and that the fourteen other species have a negative allometric growth. Except for the species *Mormyrops anguilloides*, *Mormyrus rume* and *Schilbe mandibularis*, the section of the Bandama River located downstream of the Taabo dam provides a favorable environment and a suitable habitat for the growth of the fish species studied.

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