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RESEARCH ARTICLE

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR FOR THREE EXPLOITED SYMPATRIC CICHLIDS INHABITED MARGINAL LAGOONS OF THE SOUTH-EAST OF CÔTE D'IVOIRE, WEST AFRICA

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Abstract

This study investigated the length-weight relationships (LWRs) and condition factors (K) of three Cichlids viz., *Sarotherodonmelanotheron*, *Coptodonguineensis* and the hybrid *Coptodonguineensis* x *Coptodonzillii* in three small lagoons invaded by macrophytes from the South-east of Côte d'Ivoire. Fishes were caught monthly from September 2017 to August 2019 using traps, gill nets, harpoons and hawks. Standard length and weight of individuals were taken to the nearest 1 mm and 0.1 g respectively. A total of 721, 932and 755 specimens were collected respectively in Ono, Kodjoboue and Hebe lagoons. For all species, two size classes namely sizes of 7-12 cm and 14-29 cm were encountered. About 65-70% of individuals have sizes varying from 14 cm to 20 cm vs. 20-25% of individuals with size ranging between 7 and 10 cm. The growth patterns were significant with a coefficient of determination (r^2) varying from 0.89 to 0.98. The slope values were 2.88-2.97 for *S. melanotheron*, 2.84-2.85 for *C. guineensis* and 2.90-2.98 for hybrids, with a significant variation according to sexes and localities. The condition factor showed the range of 3.96 ± 0.61 to 4.25 ± 1.97, indicating that despite being invaded by several macrophytes, the environment of these lagoons is well suitable for Cichlids.

Introduction:-

The Cichlid family is the richest family in inland waters worldwide with at least 1300 species. Their geographical distribution includes fresh and brackish waters of tropical and sub-tropical areas. However, the advancing of agricultural exploitation, the pollution, the impact of climate change and the accelerated demographic growth constitute a real threat for natural resources. According to AlbaretandLaë (2003), the fishing pressure induced significant changes in fish communities, including the decrease of fish diversity, fish biomass, average catch length and trophic level of catches, hence the use of models for fish stock management.

Length-weight relationship (LWR) is of great importance in fishery assessments (Goncalves et al., 1996) and in fish biology (Haimoviciand Velasco, 2000). Indeed, length and weight measurements can give information on the stock composition, life span, mortality, growth and production (Bolger and Connolly, 1989; Stergiou andMoutopoulos,

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2000). For production, this key is used to predict the biomass of fish from the length measure (EcoutinandAlbaret, 2003).

On the other hand, the condition factor is used to compare the "condition", "fatness" or wellbeing of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal, 1978). Condition factor is also a useful index for monitoring of feeding intensity, age, and growth rates in fish (Oni et al., 1983). It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene, 2005).

The study was therefore aimed for studying the LWR and condition factor of three Cichlids species useful to provide information for fisheries management of Ono, Kodjoboue and Hebe lagoons in the South-east of Côte d'Ivoire.

Materials and methods:-

Study area:

Ono lagoon (5°22'22"N and 3°33'53"W), Kodjoboue lagoon (5°14'11 "N and 3°35'9" W) and Hebe lagoon (5°12'14" N and 3°33'15" W) are three small lagoons of the Southeast of Ivory Coast (Fig 1). Their surfaces are respectively 400 ha, 423 ha and 244 ha. Because Ono lagoon is invaded by several floating macrophytes, the exploitable surface is 296 ha. In the other lagoons, only the banks are occupied by the floating macrophytes, with a pronounced degree of invasion in Kodjoboue lagoon. These lagoons, permanently connected to the Comoe river have an equatorial climate, including two rainy seasons (April-July and October-November) and two dry seasons (December-March and August-September). The permanent linkage with the Comoé river produces typical freshwater characteristics of these lagoons.

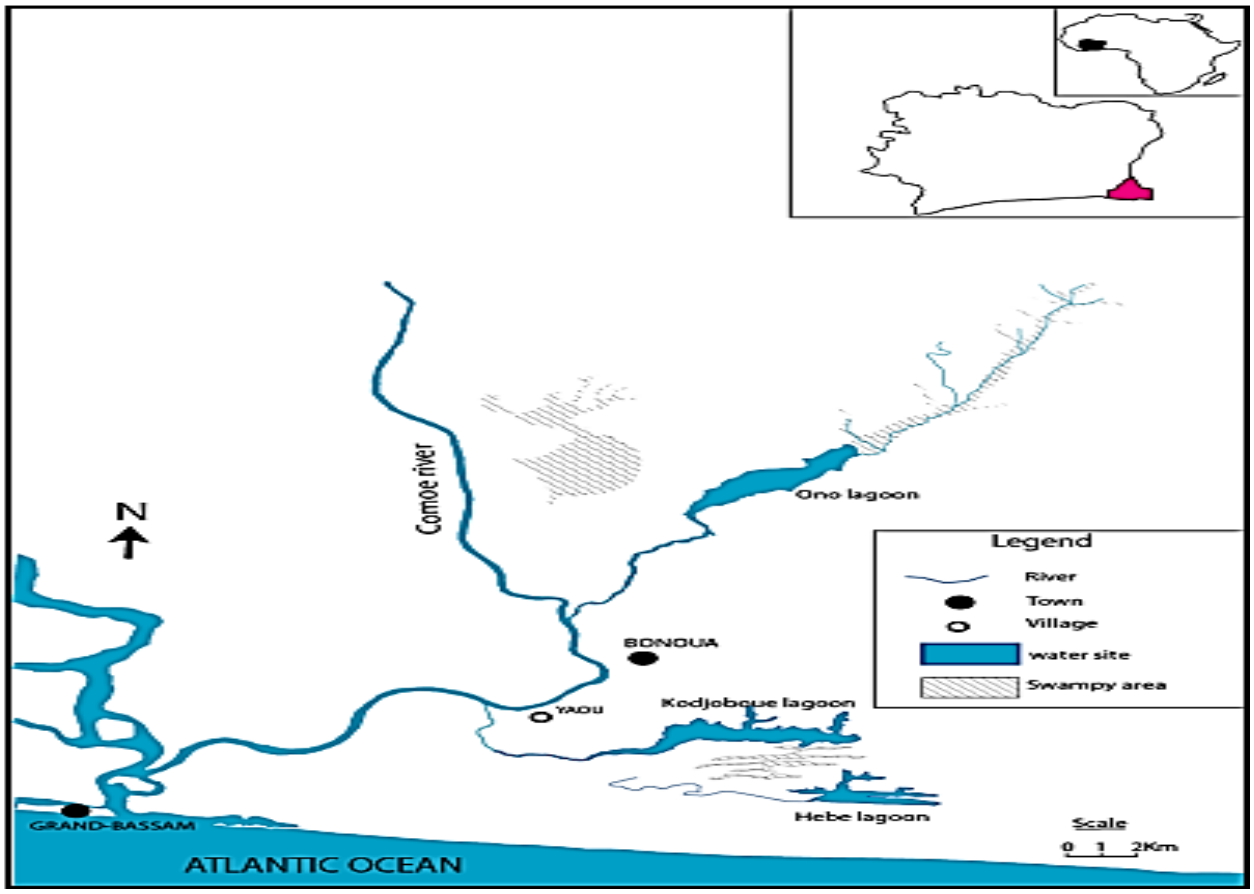


Fig 1:- Geographic situation of the Ono, Kodjoboue and Hebe lagoon.

Data collection:
Fish were monthly sampled from September 2017 to August 2019 using traps, gill nets, harpoons and hawks. All specimens were systematically identified using the identification key of Teugels et al. (1988) and Paugy et al. (2003). Immediately after identification, individual fish were measured to the nearest 1 mm (standard length [SL]), weighed in terms of total body weight to the nearest 0.01 g using a Sartorius A200 S-F1 electronic balance.

Statistical processing and analysis of data:
To characterize fish size community in the study area, the size frequency distribution of all individuals was established using standard lengths. This allowed to determine the dominant sizes in catches. The LWRs was established for the three species using the following formula:
$W = aSL^b$

With W = body weight of fish (g), SL = standard length of fish (mm), a = scaling constant and b = allometric coefficient.

A logarithmic transformation was then used to make the relationship linear using the following expression:
Log W = log a + blog SL
For each species, a regression was used to estimate the intercept (Log a) and the regression coefficient or slope (b), using Microsoft Excel. The coefficient of determination (r^2) was used as an indicator of the quality of the linear regression (Quinn andDeriso, 1999). In order to check if the b value was significantly different from 3, the t-Student test was used at p = 0.05. The coefficient b is between 2 to 4, but it is more often close to 3. When b = 3, there is isometric growth whereas there is negative or positive allometric growths when b < 3 or b > 3 respectively (Ricker, 1973; King, 1996).
The mean condition factor (K) for each species were calculated using Fulton condition factor (Nielsen and Johnson, 1983):

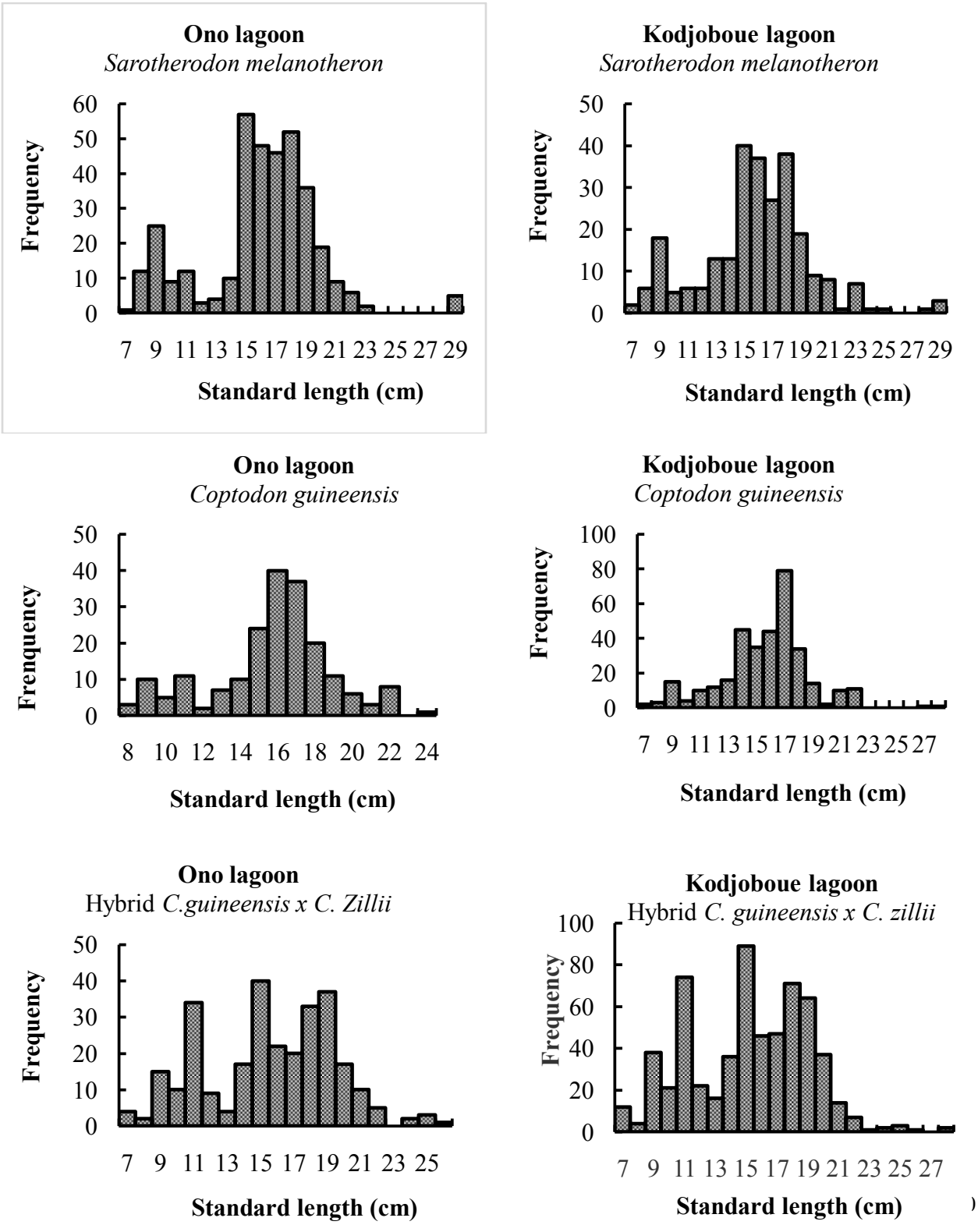
$$K = \frac{W}{SL^3} \times 10^5$$

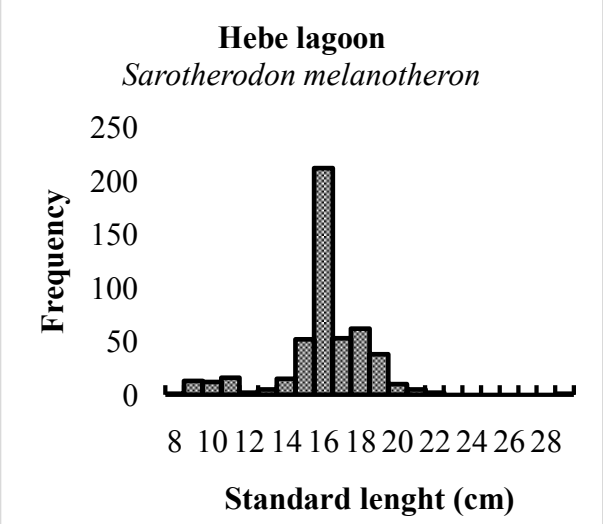
where W = body weight (g); SL = standard length (mm).

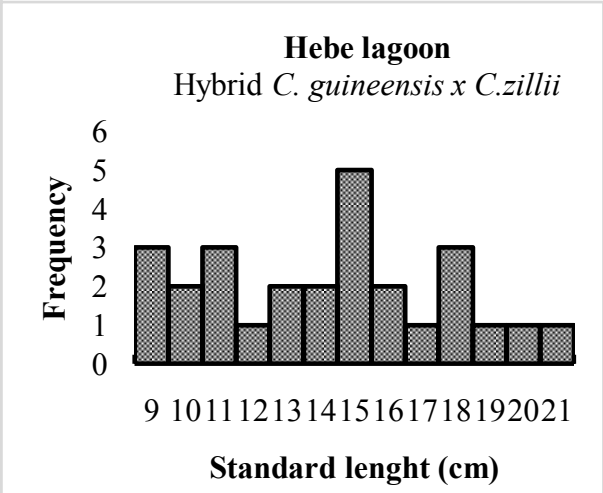
Results:-

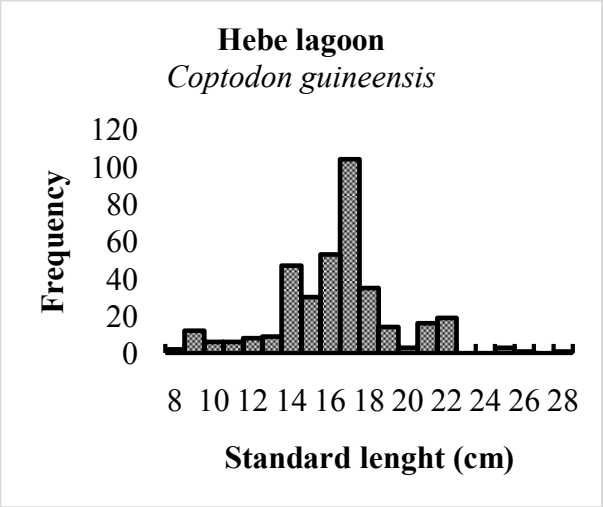
Size frequency distribution:
The standard lengths ranged from 7 cm to 29 cm for *S. melanotheron*, from 8 cm to 24 cm for *C. guineensis* and 7 to 30 cm for hybrids 7 cm to 29 cm for *S. melanotheron* in Ono lagoon (Fig 2). In Kodjoboue lagoon, fish sizes were about of 7-29 cm for *S. melanotheron*, 7-22 cm for *C. guineensis* and 7-28 cm for hybrids vs. 8-29 cm (*S. melanotheron*), 8-28 cm (*C. guineensis*) and 9-21 cm (hybrids) in Hebe lagoon. For all species, two size classes namely 7-12 cm and 14-29 cm were encountered. Several fish with size classes of 14-29 cm were caught in Ono and Kodjoboue lagoon than in Hebe lagoon. About 65-70% of individuals have sizes varying from 14 cm to 20 cm vs. 20-25% of individuals with size ranging between 7 cm and 10 cm.

Fig 2: Length frequency histogram for Hybrid *Coptodonguineensis* x *Coptodonzillii*, *Coptodonguineensis* and *Sarotherodonmelanotheron* in the samples collected in Ono, Kodjoboue and Hebe lagoons, southeast of Côte d'Ivoire from September 2017 to August 2019









Length-weight relationships:
The number of specimens, length ranges (minimum and maximum), parameters of LWR (a and b), the coefficient of determination (r^2) and the condition factor (K) are given in Table 1. A total of 721, 932 and 755 specimens were collected respectively in Ono, Kodjoboue and Hebe lagoons. The growth patterns were significant with a coefficient of determination (r^2) varying from 0.89 to 0.98. The slope (b) values for the three cichlids were 2.88-2.97 for *S. melanotheron*, 2.83-2.85 for *C. guineensis* and 2.90-2.98 for *Coptodon* hybrids. All species exhibited negative allometric growth for pooled sexes except *S. melanotheron* and hybrids which had isometric growth in Ono and Kodjoboue lagoons. The analysis of variance indicated that there was no significant difference in the LWR between sexes except *S. melanotheron* in Ono and Kodjoboue lagoons and hybrids in Ono lagoon.

Condition factor:
The result for the K factor showed the range of 4.02 ± 0.62 (Ono lagoon) to 4.25 ± 1.97 (Hebe lagoon) for *S. melanotheron*, of 4.04 ± 0.46 (Ono lagoon) to 3.85 ± 0.43 (Hebe lagoon) for *C. guineensis* and of 3.91 ± 0.71 (Ono lagoon) to 4.04 ± 0.42 (Hebe lagoon) for hybrids (Table 1). The three Cichlid species showed a high condition factor ($K > 3$) in all lagoons. Similarly, the analysis of variance showed that this parameter varied greatly according to sexes and localities.

Table 1:-Descriptive statistics and estimated length-weight relationship parameters of three species of Cichlids sampled in Ono,Kodjoboue and Hebelagoons, southeast of Côte d'Ivoire from September 2017-August 2019. I = isometric growth, A- = negative allometric growth, A+ = positive allometric growth.

	Ono lagoon							
Species	**Number**	**$L_{min-max}$ (mm)**	**a**	**b**	**r^2**	**Se(b)**	**Growth**	**K**
	Combine sexes							
Sarotherodonmelanotheron	356	79-295	0.013	2.97	0.96	0.001	I	4.02 ± 0.62
Coptodonguineensis	198	84-249	0.017	2.85	0.96	0.001	A-	4.04 ± 0.46
Hybrid Coptodon	167	72-301	0.014	2.93	0.97	0.003	A-	3.91 ± 0.71
	Females							
Sarotherodonmelanotheron	186	84-232	0.012	3.00	0.94	0.002	I	4.06 ± 0.65
Coptodonguineensis	108	84-223	0.016	2.88	0.95	0.001	A-	4.11 ± 0.55
Hybrid Coptodon	47	88-208	0.018	2.83	0.97	0.010	A-	3.92 ± 0.74
	Males							
Sarotherodonmelanotheron	170	79-295	0.014	2.93	0.98	0.002	A-	3.97 ± 0.59
Coptodonguineensis	90	89-249	0.017	2.94	0.97	0.002	A-	3.97 ± 0.38
Hybrid Coptodon	120	72-301	0.013	2.96	0.97	0.005	I	3.90 ± 0.68
	Kodjoboue lagoon							
	Number	**$L_{min-max}$ (mm)**	**a**	**b**	**r^2**	**Se(b)**	**Growth**	**K**
	Combine sexes							
Sarotherodonmelanotheron	261	72-295	0.014	2.95	0.96	0.001	A-	3.96 ± 0.61
Coptodonguineensis	350	76-220	0.017	2.83	0.97	0.001	A-	3.99 ± 0.40
Hybrid Coptodon	321	71-282	0.013	2.98	0.95	0.001	I	3.96 ± 0.76
	Females							
Sarotherodonmelanotheron	152	84-250	0.013	2.96	0.94	0.002	I	4.05 ± 0.65
Coptodonguineensis	190	77-206	0.020	2.77	0.97	0.001	A-	3.92 ± 0.44
Hybrid Coptodon	209	86-220	0.012	2.99	0.92	0.001	I	4.05 ± 0.67
	Males							
Sarotherodonmelanotheron	109	72-295	0.014	2.93	0.98	0.003	A-	3.86 ± 0.56
Coptodonguineensis	160	76-220	0.016	2.88	0.98	0.001	A-	3.85 ± 0.35
Hybrid Coptodon	112	71-282	0.013	2.98	0.98	0.003	I	3.89 ± 0.85
	Hebe lagoon							
	Number	**$L_{min-max}$ (mm)**	**a**	**b**	**r^2**	**Se(b)**	**Growth**	**K**
	Combine sexes							
Sarotherodonmelanotheron	359	80-295	0.016	2.88	0.91	0.001	A-	4.25 ± 1.97
Coptodonguineensis	368	84-220	0.017	2.84	0.97	0.001	A-	3.85 ± 0.43
Hybrid Coptodon	28	90-217	0.015	2.90	0.97	0.010	A-	4.04 ± 0.42
	Females							
Sarotherodonmelanotheron	203	80-208	0.015	2.90	0.89	0.001	A-	4.21 ± 1.61
Coptodonguineensis	195	84-201	0.020	2.79	0.95	0.001	A-	3.91 ± 0.49
Hybrid Coptodon	20	90-201	0.015	2.91	0.97	0.012	A-	4.19 ± 0.43
	Males							
Sarotherodonmelanotheron	156	94-295	0.016	2.88	0.93	0.001	A-	4.30 ± 2.34
Coptodonguineensis	173	94-220	0.016	2.87	0.98	0.001	A-	3.80 ± 0.50
Hybrid Coptodon	08	94-217	0.015	2.89	0.97	0.060	A-	3.90 ± 0.41

Discussion:-

The length- frequency distribution of the three Cichlid species within lagoons revealed a wide size range that represented a number of cohorts. Fish sizes between 14 cm and 20 cm SL (65-70%) dominated the population in all months although small sizes (7-10 cm SL) representing 20-25% were encountered in the catches. This distribution trend was found in *S. melanotheron* and *C. guineensis* by NiyonkuruandLalaye (2012) in Noukoué and Ahémé Lakes.

Growth is considered isometric when allometric coefficient "b" value is equal to 3 or allometric if otherwise (positive allometric if b>3 and negative allometric if b<3). The isometric growth implies that small specimens in the samples under consideration have the same form and condition as large specimens (Nandikeswari et al., 2014). In the present study, the values of b for the LWR varied significantly according to sexes and localities. The values showed negative allometric growth for each of the three Cichlid species, except *S. melanotheron* and *Coptodon* hybrids which exhibited isometric growth in Ono and Kodjoboue lagoons. This type of growth pattern has been observed for most of 52 species of lagoons and estuaries in West Africa (EcoutinandAlbaret, 2003), 57 species of small coastal rivers in south-eastern of Côte d'Ivoire (Konan et al., 2007) and 36 species of two tropical reservoirs of Côte d'Ivoire (Tah et al., 2012). This is due to the fact that the LWR is greatly affected by many factors related to population variability and to sampling and estimation methods. Sampling related factors include sample size, length distribution in the sample and type of length measure, while nutritional conditions account for intrinsic biological variability (Ricker, 1975). Arame et al. (2020) reported that negative growth trends could be attributed to multiple degradation factors such as the proliferation of invasive floating plants, dumping of domestic wastes, overfishing, introduction of invasive exotic fishes, uses of chemical fertilizers and pesticides in agriculture occurring in lagoons. However, all b values were within the expected range from 2.5 to 3.5 for tropical fish stocks (Froese, 2006).

The mean condition factors for the three Cichlid species in these marginal lagoons showed greatly variations according to sexes and localities. A closer examination revealed that all species had their K values within the range (2.9-4.8) recommended as suitable for matured fresh water fish by BagenalandTesch (1978). The result of this study is consistent with those reported by Anene (2005) for four Cichlid species from an artificial lake in Nigeria that observed K values other than 3. Oni et al. (1983) noted that condition factor was not constant for a species or population over a time interval and might be influenced by both biotic and abiotic factors such as feeding regime and state of gonadal development. Despite the presence of several floating macrophytes, especially in Ono and Kodjoboue lagoons, the environment of these lagoons is well suited to cichlids. These macrophyte communities provide habitat complexity and breeding areas, as well as being substrata for periphyton and sites of abundant food production for many aquatic animals (Zimmer et al., 2000; Rennie and Jackson, 2005). Therefore, there would be need for more studies on the physicochemical properties and macroinvertebrates in these lagoons to be able to establish the suitability of the lagoon for fish survival.

This study has provided baseline information on the LWR and condition factor of three Cichlid species from Ono, Kodjoboue and Hebe lagoons. All species showed negative allometric growth, except S. melanotheron and Coptodon hybrids which exhibited isometric growth in Ono and Kodjoboue lagoons. The condition factor of 2.9-4.8 was within the range recommended as suitable for matured fresh water fish.

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