RESEARCH PAPER   **OPEN ACCESS**

Length-weight relationships and condition factor of fish species from Taï National Park Basins, Côte d'Ivoire

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Abstract

This study describes the length-weight relationships (LWR) and condition factors of twenty-four fish species from eleven families found in rivers of Taï National Park. A total of 1545 specimens were caught by using various mesh size of gill nets between January 2012 and September 2013. The growth coefficient (b) values obtained for the twenty-four fish species ranged between 1.890 for *Barbus ablabes* and 4.437 for *Chromidotilapia guntheri*. The value of *b* for four species indicated isometric growth at Tai National Park. For the other twenty species, *b* differed significantly (p<0.05) from 3. The length-weight relationships for three species (*Micralestes eburneensis*, *Malapterurus punctatus* and *Polypterus palmas*) in Ivoirian waters are hereby published for the first time. The condition factors (K) of the fish species ranged from (0.589) in *Papyrocranus afer* to (3.809) in *Tilapia zillii*. Twenty fish species had their K values outside the range (2.9-4.8) recommended as suitable for matured fresh water fish.

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Introduction

Tropical zone contains the most threatened forest areas of the globe. Particularly, the West Africa is currently one of the priority areas for conservation of biodiversity at global level, because of the importance of its richness, its high rate of endemic species and threats facing its biological diversity. Indeed, the Guinean forest is one of eight "hot spots" identified in Africa on 43 currently existing worldwide. However, this important sanctuary of biodiversity West African is one of the most degraded areas of the world. To date, only 15% of original forest cover of this hotspot exists and much of these relics forest continues to be exploited for production of wood and farming. The accelerating rate of extinction of plants and animals because of anthropogenic impacts in ecosystems is a world-wide crisis (Myers *et al.,* 2000). The problem is particularly severe in freshwater habitats, which are among the world's most threatened ecosystems (Sala *et al.,* 2000), with a projected extinction rate of about five times greater than the average species extinction rate for terrestrial fauna (Ibanez *et al.,* 2007). In Côte d'Ivoire, deforestation associated with farming and timber exploitation became a serious concern. With an annual deforestation which varies between 1.1 and 2.9%, Côte d'Ivoire ranks the second African countries affected by deforestation after Madagascar (Archard *et al.,* 2002). The southwestern of Côte d'Ivoire contains last forests of this country. Unfortunately, these forests are threatened by farming. Today, forests untapped were estimated to a few thousand hectares confined in classified forests and the Tai National Park, on which Côte d'Ivoire based the conservation of flora and fauna of this region. Taï National Park is a one of the protected areas in Côte d'Ivoire and one of the largest remaining tropical rain forests in West Africa (Kouakou *et al.,* 2009). Initially designated as a Forest Reserve in 1926 and promoted to National Park status in 1972, Taï was recognized as a UNESCO Biosphere Reserve in 1978 and added to the list of Natural World Heritage Sites in 1982 (Surhone *et al.,* 2011).This park represents more than 50% of the total surface of forest areas placed under the West African

high protection status. Tai National Park is nearly three-quarters of the area of rainforest ombrophilous that still exists in Côte d'Ivoire (Koffi, 2000).

The length-weight relationship is very important for proper exploitation and management of the population of fish species (Anene, 2005). Oni (1983) stated that LWR provides valuable information on the habitat where the fish lives while Kulbilki *et al.* (2005) stressed the importance of length-weight relationship in modeling aquatic ecosystems. At the same time, the relationship of length-weight estimates condition factor of the fish species and fish biomass through the length frequency. In fisheries science, the condition factor is used in order 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 et Tesch, 1978). Condition factor is also a useful index for monitoring of feeding intensity, age, and growth rates in fish (Ndimele *et al.,* 2010). It is strongly influenced by both biotic and a biotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene, 2005). The aim of the present study was twofold: (i) to estimate its population parameters via length frequency methods (ii) to determine the length-weight relationship of the population of this species in Tai National Park. The results of this study will contribute to management of the ichtyofauna of Taï National Park and will serve as references for future studies.

Material and methods

Area sampling

The Taï National Park is located in south-western Côte d'Ivoire (5°08'-6°24'N, 6°47'-7°25'W). Several tributary rivers flow through the park. These include Hana, Moumo, Méno and N'Zè rivers which run into the Cavally River; Zakoué River which is a tributary of the Sassandra River; and the Palabod River which flows into the San-Pedro River (Riezebos *et al.,* 1994; OIPR, 2006). Samplings were performed in fourteen stations distributed along the study area (Fig. 1). Three stations were located on the Hana River (Ha1,

Ha2 and Ha3); two on the Moumo River (Mo1, Mo2); two on the Méno River (Me1, Me2), two on the N'Zé River (Ze1, Ze2), two on the Zakoué River (Za1, Za2) and three on the San Pedro River (SP1, SP2, SP3).
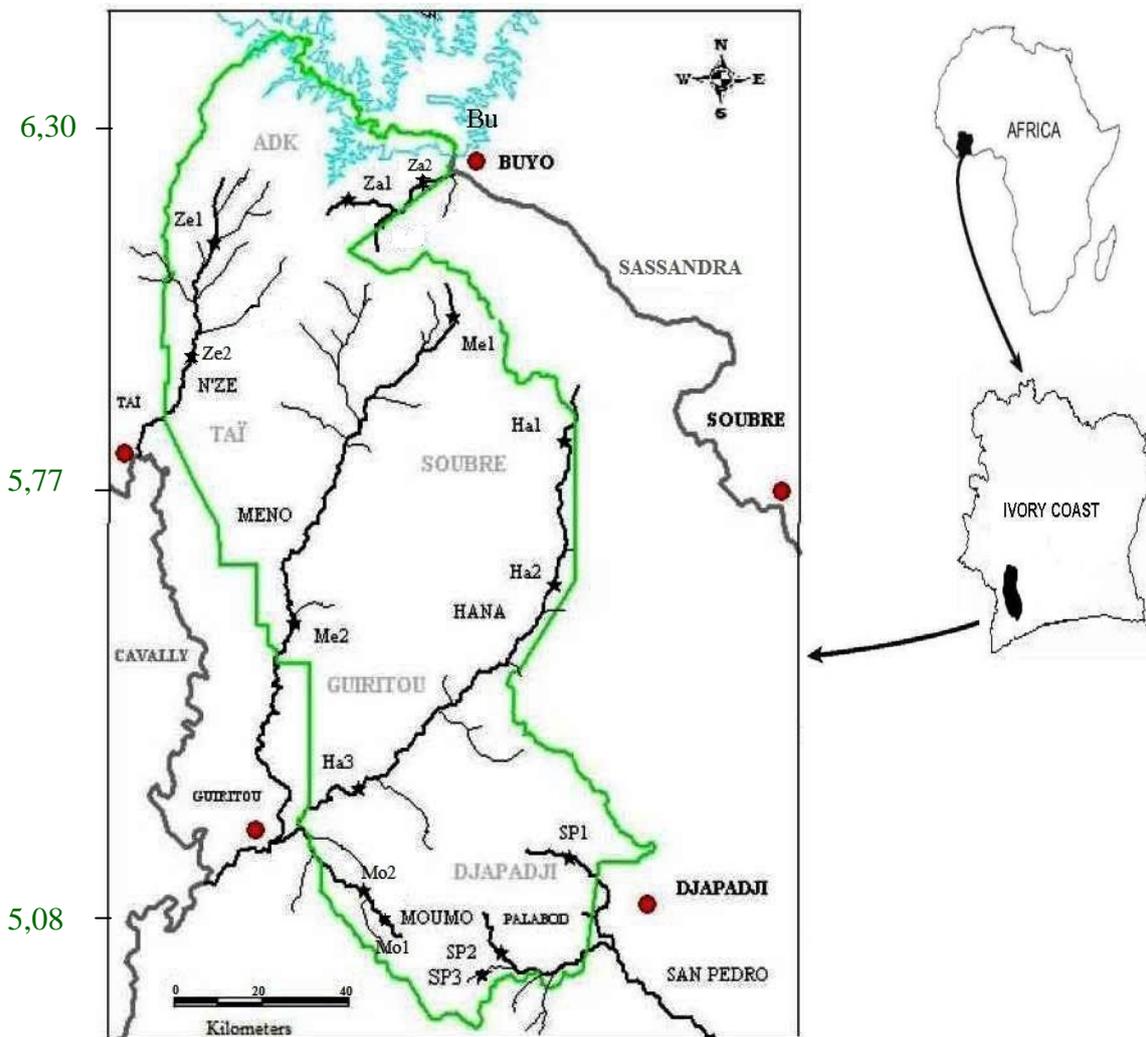
Fig. 1. Distribution of rivers basins and sampling sites (★) within Taï National Park.

The fourteen stations were sampled for instream environmental variables and fishes from January 2012 to September 2013.

Fish sampling

Sampling took place between January 2012 and September 2013. Fishing was done with multi-meshed nylon gillnets (10-40 mm mesh sizes). Each gill net measures 30 m long by 1.5 m deep. Gill nets are usually set during the afternoon at 5 p.m and fish were removed the following morning at 7 a.m and again at 12 a.m. Fishes captured were identified following Paugy *et al.* (2003a, b) keys. The standard length (SL) of each specimen was measured to the nearest 1 mm on a measuring board. The individual body weight was measured to the nearest 0.1 g with an electronic balance.

Data analysis

For length-weight relationship, the standard length was measured to the nearest millimeter from the tip of the snout to the outset of the caudal fin ray and then weighed to the nearest gram. The allometric relationship between standard length (SL) and weight (W) was calculated by the formula: $W = a \times SL^b$

where **W** = weight of an individual fish in gram ; **SL** = standard length of an individual fish in millimeter ; **a** and **b** are constants.

After log–log transformation of the data, the parameters of the linear relationships were analyzed by the least square method using the equation of Le Cren (1951) given as:

$$\text{Log } W = \text{Log } a + b \text{ Log } SL$$

where **a** and **b** are constants estimated by linear regression of the log transformed variables. Each species were chosen in this study which had the graph corresponding to length–weight model (Ecoutin and Albaret, 2003; Konan *et al.,* 2007). In this work, and as a function of the defined aims, the coefficient of determination (r²) was used as an indicator of the degree of association between the length and weight (Scherrer, 1984). The Student's t-test was used to confirm whether *b* values obtained in the linear regressions were significantly different from the isometric value (b=3) (p<0.05) (Sokal and Rohlf, 1987).

The mean condition factor (*K*) for each fish species were calculated using Fulton condition factor (Nielsen and Johnson, 1983):

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

where **W** = the weight of the fish in grams; **SL** = the standard length of the fish in millimeters.

Results

Overall 1545 specimens of 24 fish species belonging to 11 families were sampled. The families with the highest genres number were Mormyridae (n=4), Cichlidae (n=3), Alestidae and Clariidae (n=2). The number of individuals varied from 7 in the case of *Chrysichthys nigrodigitatus, Hepsetus odoe and Malapterurus punctatus* to 393 for *Schilbe mandibularis*. The standard length of the fish species ranged from 21 mm to 410 mm, and the body weights were between 0.5 g and 611 g with the smallest fish represented by *Micralestes eburneensis* and the biggest fish, by *Mormyrops anguilloïdes* and *Hepsetus odoe* respectively. The detailed description of the fish fauna of the Tai National park is presently being prepared by the authors. The estimated parameters of the LWRs of the twenty-four species of freshwater fishes are given in Table 1. The estimated values of *b* ranged between 1.890 (*Barbus ablabes)* and 4.437 (*Chromidotilapia guntheri*). The *b* values of *Petrocephalus bovei* (2.979), *Schilbe mandibularis* (2.981), *Chrysichthys maurus* (3.052) and *Heterobranchus isopterus* (3.0594) exhibited isometric growth, with no significant difference from the theoretical value of 3 (t-test: t= 0.022; df = 3; *p-value* > 0.05). The Student's t-test showed that *b* values of *Hemichromis fasciatus, Hepsetus odoe, Brycinus longipinnis, Tilapia zillii and Chromidotilapia guntheri* were significantly higher than 3 (b=3.122 - 4.437; t-test: t= 2.881; df = 4; *p-value* < 0.05) indicating positive allometric growth. For 62.5 % of the species (15 species), *b* values were significantly different from 3 indicating negative allometric growth (b=1.890 – 2.890; t-test: t= -6.174; df = 14; *p-value* < 0.05). The mean value of *b* for all the species was 2.887 (SD 0.308), with a median value of 2.691.

Table 1. Number of specimens (n), standard length (minimum and maximum), total weight (minimum and maximum) and parameters of the length-weight relationship of fish species caught in Tai National Park (Côte d'Ivoire).

Family	Species	n	Length (cm)		Weight (g)		a	b	SE (b)	r²	K	Growth
			Min	Max	Min	Max						
Polypteridae	*Polypterus palmas*	94	155	342	40	228	0,04	3,25	0,52	0,86	3,25	A+
Notopteridae	*Papyrocranus afer*	19	128	315	26	160	0,04	2,14	0,61	0,88	0,59	A-
Mormyridae	*Marcusenius senegalensis*	62	75	241	6	183	0,01	2,72	0,20	0,91	1,43	A-
	Marcusenius ussheri	240	63	205	3	126	0,01	3,79	0,15	0,92	1,56	A+
	Mormyrops anguilloïdes	23	185	410	45	267	0,02	2,53	0,34	0,97	1,63	A-
	Mormyrus rume	27	154	230	28	80	0,01	2,82	0,13	0,88	1,84	A-
	Petrocephalus bovei	41	60	100	4	22	0,01	2,98	0,02	0,83	1,93	I
Hepsetidae	*Hepsetus odoe*	7	180	330	91	611	0,01	3,15	0,11	0,963	1,44	A+
Alestidae	*Brycinus imberi*	119	59	165	6	101	0,02	2,69	0,22	0,917	2,66	A-
	Brycinus longipinnis	84	34	96	0,5	25	0,00	4,03	0,73	0,858	2,29	A+
	Brycinus macrolepidotus	159	70	260	7	562	0,02	3,70	0,21	0,864	2,63	A+
	Brycinus nurse	58	86	155	18	94	0,01	2,89	0,08	0,92	2,69	A-
	Micralestes eburneensis	19	21	70	0,5	10	0,03	2,44	0,40	0,929	2,82	A-
Cyprinidae	*Barbus ablabes*	23	28	78	1,5	10	0,07	1,89	0,79	0,946	3,10	A-
Claroteidae	*Chrysichthys maurus*	13	52	187	3	127	0,01	3,05	0,04	0,953	2,18	I
	Chrysichthys nigrodigitatus	7	125	200	51	180	0,01	2,71	0,20	0,96	2,29	A-
Schilbeidae	*Schilbe mandibularis*	393	65	263	3	277	0,01	2,98	0,01	0,925	1,30	I
Clariidae	*Clarias buettikoferi*	89	110	265	18	120	0,02	2,47	0,38	0,875	1,96	A-
	Heterobranchus isopterus	23	75	335	7	555	0,01	3,06	0,04	0,894	1,22	I
Malapteridae	*Malapterurus punctatus*	7	115	290	28	404	0,01	2,81	0,13	0,984	1,69	A-
Cichlidae	*Chromidotilapia guntheri*	11	63	140	3	105	0,00	4,44	1,02	0,741	2,78	A+
	Hemichromis bimaculatus	15	58	92	7	23	0,02	2,62	0,27	0,885	3,64	A-
	Hemichromis fasciatus	15	88	155	25	147	0,01	3,12	0,09	0,958	3,46	A+
	Tilapia zillii	18	97	170	12	207	0,00	4,15	0,81	0,812	3,81	A+

In the present study, overall growth parameter, r² values were positive and highly correlated with r² > 0.7 between fish total length and body weight measurements. The values of coefficient of determination (r²) varied from 0.74 in *Chromidotilapia guntheri* to 0.984 in *Malapterurus punctatus*. All relationships were highly significant ($p<0.05$) with r²>0.9 in thirteen (13) different species, r² = 0.9 – 0.8 in ten (10) and r² < 0.7 in one.

The mean condition factors ranged from 0.589 (SD 0.303) for *Papyrocranus afer* to 3.809 (SD 0.315) for *Tilapia zillii*. The values obtained from this study showed that 83.33% (20 out of 24 fish species) of the fish had their K values lower than 2.9 and only *Tilapia zillii*, *Hemichromis bimaculatus*, *Hemichromis fasciatus* and *Barbus ablabes* had K values between 2.9–4.8.

Discussion

The present study showed there were variations in length and weight data of fish from Tai National Park. The length-weight distributions of fishes from Tai National Park showed considerably large variations in fish sizes (21 mm in *Micralestes eburneensis* to 410 mm *Mormyrops anguilloïdes*) hence the weight which ranged from 0.5 g (*Micralestes eburneensis* and *Brycinus longipinnis*) to 611 g (*Hepsetus odoe*). The size of the fish captured ranged from the smallest to the biggest and from young to adult stages with differences in their growth rates.

The slopes (*b*) of the fish length- weight regression lines from the Tai National Park fell within 1.890 and 4.437 this within the value recorded by Lawson *et al.* (2013), which studied the length-weight relationships and morphometry for 11 fish species from Ogudu Creek, Lagos. The growth parameter values of *Barbus ablabes* (1.891), *Brycinus longipinnis* (4.028), *Tilapia zillii* (4.148) and *Chromidotilapia guntheri* (4.437) were outside the limits (2 and 4) reported by Bagenal and Tesch (1978) for most fishes. Despite the many variations in fish forms between species, the allometric coefficient *b* is close to 3, indicating that fish grow isometrically; values significantly different from 3.0 indicate allometric growth (Bagenal and Tesch, 1978). The value of *b* for *Petrocephalus bovei*, *Schilbe mandibularis*, *Chrysichthys maurus* and *Heterobranchus isopterus* indicated isometric growth at Tai National Park. For the other twenty species, *b* revealed allometric growth.

The present results were comparable with the earlier available studies on freshwater fish species in Cote d'Ivoire. Nevertheless, the length-weight relationships for three species (*Micralestes eburneensis*, *Malapterurus punctatus* and *Polypterus palmas*) in some Ivoirian waters are hereby published for the first time.

Several authors have reported both isometric and allometric growth for different fish species from various water bodies. *Barbus ablabes, Brycinus imberi, Clarias buettikoferi* and *Mormyrops anguilloïdes* were found to exhibit allometric growth pattern according to Konan *et al.* (2007), Tah *et al.* (2012) and Koffi *et al.* (2014). *Chrysichthys maurus*, *Heterobranchus isopterus*, *Petrocephalus bovei* and *Schilbe mandibularis* presented isometric growth in present study while they showed negative allometric growth in Ayame and Buyo reservoirs and the five coastal rivers of the south-eastern of Côte d'Ivoire except for *Petrocephalus bovei* and *Schilbe mandibularis* indicated positive allometry respectively for Buyo reservoir and the coastal rivers of the south-eastern. *Brycinus longipinnis*,

Chromidotilapia guntheri, *Hepsetus odoe*, *Hemichromis fasciatus* and *Tilapia zillii* have positive allometric growth characteristics in present study. Konan *et al.* (2007) also reported a positive allometric growth pattern for *Hepsetus odoe* and *Hemichromis fasciatus*. Whereas they obtained respectively an isometric growth patterns for *Brycinus longipinnis, Chromidotilapia guntheri* and negative allometric for *Tilapia zillii*. Tah *et al.* (2012) also reported in Ayame lake the positive allometric growth pattern for *Hepsetus odoe* and *Tilapia zillii* while *Chromidotilapia guntheri* and *Hemichromis fasciatus* exhibited a negative allometric growth. *Brycinus macrolepidotus*, *Brycinus nurse*, *Chrysichthys nigrodigitatus*, *Hemichromis bimaculatus*, *Marcusenius ussheri* and *Mormyrus rume* presented negative allometric growth in present study as already noted by Tah *et al.* (2012) in the man-made Lake from Ayame. In contrast, Konan *et al.* (2007) observed a positive allometric growth for *Brycinus macrolepidotus*, *Brycinus nurse* and isometric growth for *Chrysichthys nigrodigitatus*, *Marcusenius ussheri*, *Mormyrus rume* and *Papyrocranus afer* in small coastal rivers in south-eastern Côte d'Ivoire. Teixeira-de Mello *et al.* (2009) explained that negative allometric growth may be attributed to the allocation of more energy to axial growth rather than to biomass.

The coefficient of determination (r^2) for length weight relationships is high for all fish species which indicates that the length increases with increase in weight of the fish. This is in agreement with previous studies on different fish species from various water bodies: (Konan *et al.,* 2007; Tah *et al.,* 2012; Koffi *et al.,* 2014)

The condition factor reflects the well-being of the fish (Kumolu and Ndimele, 2010; Abowei, 2010). It gives information on the physiological state of the fish in relation to its welfare.

Ighwela *et al.* (2011) reported that the condition factor gives information when comparing two

populations living in certain feeding, density, climate and other conditions when determining the period of gonad maturation, and when following up the degree of feeding activity of species to verify if it is making good use of its source. It is influenced by both environmental conditions and can be affected by factors like sex, season, age and maturity stages of fish. Condition factor can also be used as an index to access the status of the aquatic ecosystem (Edah *et al.,* 2010). It is usually decreases as the fish increases in size. It was observed in the present study, that condition factor for all species were of values of 2.031 above which indicate that fish are doing well in the Taï National Park. The condition factor was lowest in *Papyrocranus afer* (0.589) and highest in *Tilapia zillii* (3.809). Twenty fish species had their K values outside the range (2.9-4.8) recommended as suitable for matured fresh water fish by Bagenal and Tesch (1978). The value obtained from the study showed that all species studied were in good condition. This could have been caused by adverse environmental factors (Anene, 2005). This suggests that the condition of the Tai National Park in comparison to fresh water bodies may be different to fishes in the park. Sarkar *et al.* (2013) noted also that condition factor is not constant for a species or population.

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