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Weight-Length Models and Relative Condition Factors of Nine (9) freshwater fish species from the Yapei Stretch of the White Volta, Ghana

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ABSTRACT

Weight-Length relationships (WLRs) and Relative condition factors (Kn) were estimated for 9 freshwater fish species namely *Brycinus leuciscus* **(Günther, 1867)**, *Hydrocynus forskali* (**Cuvier, 1819**), *Odaxothrissa mento* **(Regan, 1917),** *Labeo coubie* (**Rüppell, 1832**), *Labeo parvus* (**Boulenger, 1902**), *Labeo senegalensis* (**Valenciennes, 1842)**, *Distichodus engycephalus* (**Günther, 1864**), *Parailia pellucida* **(Boulenger, 1901)**and *Schilbe mystus***(Linnaeus, 1758)**from the lower reaches of the White Volta. Samples were collected from the catches of the artisanal fishermen from October 2011 to March 2012. Using $W=aTL^b$, the weight-length relationships of the species were calculated. Relative condition factors of the species were obtained using the formula: Wo/Wc. The WLRs of all the 9 fish species were highly significant (P<0.001). The determination coefficients (r^2) ranged between 0.5764 for *Parailia pellucida* to 0.9784 for *Hydrocynus forskali*. The slopes (*b*values*)* of the WLR regression models of the nine (9) species ranged from 2.0045 to 3.1614 with 95% confidence interval of *b* for all the nine fish species within 1.386 to 3.352. In terms of growth pattern, 4 out of the 9 species exhibited isometric growth (*b*=3). Three (3) were observed to have negative allometric growth (*b*<3) and 2 fish species had positive allometric growth (*b*>3) patterns. Mean relative condition factors of the species ranged from 1. 00 to 1.09. A T-test of the observed weight (Wo) versus the calculated (Wc) on all the nine (9) species produced no significant difference (P>0.05) between the observed weight and the calculated weight. The models are thus good proxies for approximating the weights of the species.Even though, not all the species exhibited isometric growth, the general wellbeing of the fish specieswas suitable during the study period as inferred from relative condition factors (Kn). This is a contribution of information to support researchers in future and fishery managers for reliable growth estimation and health status of freshwater fishes.

Introduction

Weight-length relationships (WLRs) and condition factor areof great importance to the fishery industry as they help to predict the best length and time suited to harvest a particular species of fish. The estimation of population size of a fish stock for the purpose of its rational exploitation often requires knowledge of individual body WLRs in the population (Dulčić and Kraljević, 1996).WLRs have several applications, namely on fish biology, physiology, ecology and fisheries assessment. In biological studies, WLR enables seasonal variation in fish growth to be followed and the calculation of condition indices. WLR gives us life history and morphological comparisons between different fish species or between different fish populations from different habitats (Gonçalves et al., 1997; Petrakis and Stergiou, 1995,Santosetal., 2002). This study was conducted to determine WLRs of9fishspeciesfromthe lower reaches of the White Volta at Yapei, Northern Region of Ghana.

According to Abobi and Ekau (2013), the importance of the Yapei fishery cannot be underestimated. Yapei is 52 km from the Northern regional capital Tamale. Tamale is the third largest city in Ghana with a population of 537,986 (Wikipedia, 2012). Yapei is easily accessible as it is on the Accra-Kumasi-Tamale trunk road. Yapei is one of the 9 main sources of smoked fish to the Tamale Central Market. The Tamale Central Market is the largest market center in the metropolis. It thus makes Yapei an important supplier of fish especially smoked fish. Fishermen at the Yapei stretch of the White Volta River practice unregulated and unselective harvesting of fish with fishermen harvesting all sizes of fish without regard to the sustenance of the fishery. These practices targeted at more catches for more income. Fish can only be harvested at the maximum sustainable yield (MSY) when all the biological parameters are known (Abobi and Ekau 2013).

Yapei is thus the terminal point for the lake Volta and the lower reaches of the White Volta River (WVR) starts from there. According to Braimah (2003) some 300 000 fisher folk depend on the Volta reservoir for their livelihood. The Volta reservoir is endowed with fisheries resources. Dankwa *et al.* (1999) identified 121 species in the Volta reservoir.

The Lake Volta and its tributaries in the last four decades have undergone great changes in its ecology, limno-chemistry and socio-economy. Increased pressure on land along the banks has led to high rates of deforestation. This has resulted in increased soil erosion leading to the transportation of high loads of silt and nutrients through rivers into the lake, there by

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contributing to its eutrophication. Furthermore, wetlands bordering the lake are being converted into agricultural land or land for grazing cattle, and therefore may not be able to act as natural filters for nutrients and silt, and now do not provide breeding grounds for many fish species (Ofori-Danson *et al.*, 2001). As a result of these problems, the Lake Volta Research and Development Project (VLR&DP) was undertaken under the Food and Agricultural Organization and United Nations Development Programme during the first decade of the lake's existence (FAO and UNDP 1971, 1979). These studies came to an end in 1978. Since then, systematic data collection from the Lake Volta and Volta Rivers natural resources has been lacking. There have been calls for renewed studies to facilitate their management due to declining catches.

Understanding the weight-length relationship is of paramount importance in fishery resource management and useful in comparing life history and morphological aspects of populations inhabiting in different regions (Karna *et al.,* 2012). Furthermore, this relationship is used to ascertain the condition of fish and to determine whether the growth pattern is isometric or allometric. Besides, the weight-length measurement also provides information on the stock composition, life span, mortality, growth and production of fish (Bolgar and Connoly, 1989; King, 1996; Moutopoulos and Stergiou, 2000).The relative condition factor is used to know the variation between observed and expected weight of fishes (Kund *et al*., 2011). Therefore, in the present study, an attempt has been made to estimate the weight-length relationships and relative condition factors of *Brycinus leuciscus, Hydrocynus forskali, Odaxothrissa mento, Labeo coubie, Labeo parvus, Labeo senegalensis, Distichodus engycephalus, Parailia pellucida and Schilbe mystus* harvested from the lower reaches of the White Volta, Ghana. Such information is useful in understanding the key biological attributes of these species and their sustainable management.

Materials and Methods

Study area

The samples were conducted at the Yapei stretch of the White Volta River (Figure 1), which is a major landing site in the Northern Region of Ghana. Yapei is located within the Central Gonja District of the Northern Region of Ghana. It lies within latitudes 9° 10′ 0″ N, 1° 10′ 0″ W.

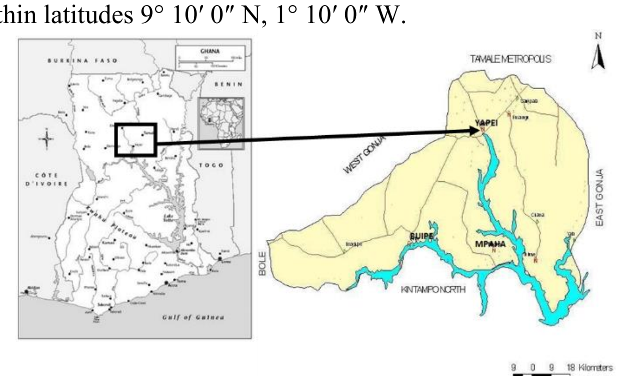

Figure 1. Map of Ghana with an insert showing Central Gonja District and study area Yapei

Fish sampling, measurement and analysis

The samples of the selected fish species were taken at random from landings and their total length recorded to the nearest 0.1 cm using a fish measuring board while the body weight was recorded to the nearest 0.01 g using a balance after using tissue to mop off water from the surface of the specimens.

The length-weight equation; $W = aTL^b$ as described by Ricker (1975) was used to establish the length-weight relationship of the species measured, where W is the weight (g), TL is the total length (cm), *a* is a constant determined empirically and *b* is the slope of the equation. The degree of relationship between the variables was computed by the determination coefficient (r^2). The slope *b* has a numerical value which is mostly between 2.5 and 3.5 and is often close to 3 (Bagenal and Tesch, 1978; Carlander, 1969; Gayanilo and Pauly, 1997; Froese, 2006; Weatherley and Gill, 1987). Under isometric growth *b* equals to 3 but isometric growth in fish is rare (Bolger and Connolly, 1989; McGurk, 1985). The 95% confidence limits for *b* (CL 95%) were calculated using the equation: CL= b ± (1.96 x SE) where SE is the standard error of *b*. The values of the exponent *b* provide biological information on kind/pattern of growth of fish. The growth is isometric if *b*=3 and the growth is allometric if *b*≠3 (negative allometric if b<3 and positive allometric if *b*>3).In order to check if the value of b was significantly different from 3, the Student's t-test was conducted as expressed by the equation according to Sokal & Rohlf (1987): *ts*=(*b*-3)/SE, where *ts* is the t-test value, *b* the slope and SE the standard error of the slope *b*. The test statistics (*ts*) values were compared with critical values from the T-Table. All the statistical analyses were considered at significance level of 5% ($p<0.05$).

The equation relating weight-length gives some indication of the state of wellbeing of a fish in a population which is known as the condition factor. Fish in good condition have higher condition factor value than those in poor condition. The relative condition factor (Kn) which is a ratio of observed weight (Wo) and calculated weight (Wc) that is Wo/Wc was estimated as suggested by Le Cren (1951). The relative condition factor being one or closer to one indicates, the good condition of fish.

All calculations were performed using descriptive statistics of the Software STATISICA 8.1 and Microsoft Excel 2013. They were used to analyse weight-length data for means, deviations, frequencies, percentages, weight-length power regression functions, relative condition factors and T-test of significant difference between observed weight and calculated weight.

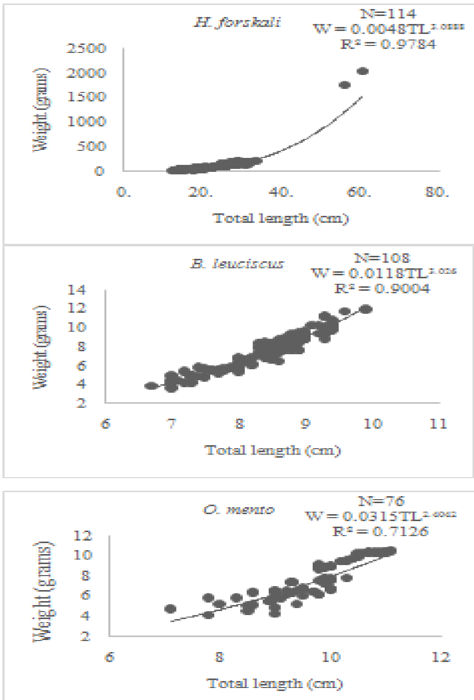

Figure 2. Length-weight relationships *Hydrocynus forskali, Brycinus leuciscus and Odaxothrissa mento* from the Yapei stretch of the White Volta River. N, Number of fish; W, Weight (grams) and TL, Total Length (cm)

Results and Discussion

A total of 741 individuals belonging to 9 species from 5 families were sampled for this study. Cyprinidae had 3 species, Alestidae and Schilbedae were represented by two species each while Clupeidae and Distichodontidae had one species each. The parameters of the weight-length relationships of *Brycinus leuciscus, Hydrocynus forskali, Odaxothrissa mento, Labeo coubie, Labeo parvus, Labeo senegalensis, Distichodus engycephalus, Parailia pellucida and Schilbe mystus*are presented in Table 1 with their scatterplots in Figures 2-4.The weight-length relationships (WLRs) were highly significant (P<0.001) for all the 9 fish species. The determination coefficients (r^2) ranged between 0.5764 for *Parailia pellucida* to 0.9784 for *Hydrocynus forskali.* The estimates of *b* ranged from 2.0045 in *Parailia pellucida to* 3.1614 in *Labeo coubie* with 95% confidence interval of *b* for all the nine fish species ranging from1.386 to 3.352. The finding on the *b* estimates of this study is similar to the observations of Enstua-Mensah *et al.* (1995) who reported that estimates of b ranged from 2.32 to 3.27 for 45 fish species (which included species from all the families of this study) sampled in the Oti, Pru and Black Volta rivers of Ghana.However, confidence interval of *b* for all the nine fish species of this present studyis different from confidence interval of *b* of 2.5 to 3.2 observed on freshwater fishes from Ologe Lagoon, Lagos, Nigeria reported by Kumolu-Johnson nd Ndimele (2011).

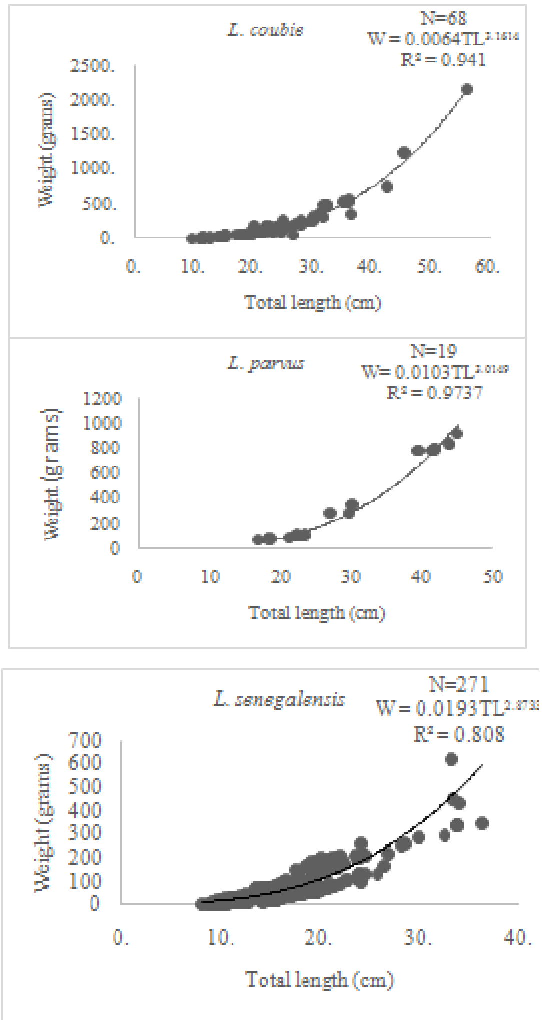

Figure 3. Length-weight relationships of *Labeo coubie, Labeo parvus* and *Labeo senegalensis* from the Yapei stretch of the White Volta River. N, Number of fish; W, Weight (grams) and TL, Total Length (cm)

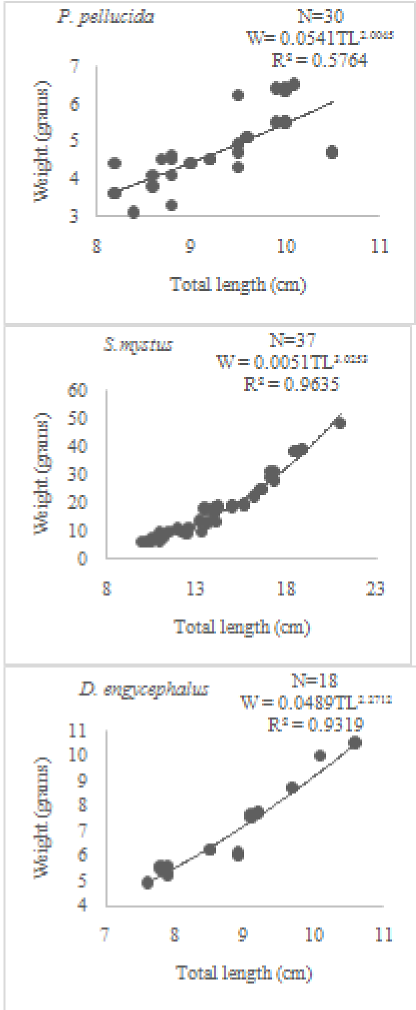

Figure 4. Length-weight relationships of, *Parailia pellucida*, *Schilbe mystus* and *Distichodus engycephalus* from the Yapei stretch of the White Volta River. N, Number of fish; W, Weight (grams) and TL, Total Length (cm)

The numerical values of *b* of the weight-length relationships of *Brycinus leuciscus, Hydrocynus forskali, Labeo coubie, Labeo parvus, Labeo senegalensis* and *Schilbe mystus* were within the acceptable and expected range of 2.5 and 3.5 which is typical for tropical fish stocks (Carlander, 1969; Froese, 2006). However, the remaining 3 species: *Odaxothrissa mento, Distichodus engycephalus* and *Parailia pellucida* had *b* values below 2.5 (*b*<2.5) and thus indicating negative allometric growth pattern. Additionally on growth pattern, 4 fish species namely *Brycinus leuciscus, Labeo senegalensis, Labeo parvus and Schilbe mystus* were observed to be growing isometrically in weight while 2 species: *Hydrocynus forskali* and *Labeo coubie* had positive allometric growth. Patra *et al.* (2000) stated that the departure of “b” values from 3.0 would be due to the seasonal changes while, Le Cren (1951) opined that the deviation of “b” value from isometric growth either due to environmental condition or condition of fish. The departure of 5 species from isometric growth in this present study agrees with the findings of the previous authors.

The results on the relative condition factors (Kn) of the 9 species are shown in Table 2.The relative condition factor ranged between 1.00 and 1.09. Subsequently the highest deviation from the expected weight was 0.09 (9%). A t-test of the observed weight (Wo) versus the calculated weight (Wc) showed no significant differences (P>0.05) between the two weights in all the 9 species.

Table 1. Descriptive statistics and W-TL relationship parameters for 9 selected fish species of the Yapei Stretch of the White Volta, Ghana (N: sample size; W: weight (g); min: minimum; max: maximum; TL: Total length (cm); S.D.: standard deviation; S.E.: standard error; C.I.: confidence interval; *b*: slope)

Family/ Species	N	Mean W ±SD (W_{min} - W_{max}) grams	Mean TL ±SD (TL_{min} - TL_{max}) cm	W-L Model	Determination Coefficient (r^2)	b	S.E. of *b* (95% C.I. of *b*)	Growth Type
ALESTIDAE *Brycinus leuciscus*	108	7.51 ±1.88 (3.6-11.9)	8.39 ±0.69 (6.7-9.9)	$W = 0.0118TL^{3.026}$	0.9004	3.026	0.0978 (2.834-3.218)	Isometric
Hydrocynus forskali	114	100.28±248.57 (10.80-2040.00)	21.07 ±7.9607 (12.50-60.30)	$W = 0.0048TL^{3.0888}$	0.9784	3.0888	0.0434 (3.004-3.174)	Allometric (+)
CLUPEIDAE *Odaxothrissa mento*	76	7.43±1.7993 (4.1-10.5)	9.61±0.8096 (7.1-11.1)	$W= 0.0315TL^{2.4042}$	0.7126	2.4042	0.1775 (2.056-2.752)	Allometric (-)
CYPRINIDAE *Labeo coubie*	68	226.52 ±317.44 (7.50-2160.00)	24.11 ±8.50 (9.60-56.20)	$W = 0.0064TL^{3.1614}$	0.941	3.1614	0.0974 (2.970-3.352)	Allometric (+)
Labeo parvus	19	427.10±340.57 (73.20-910.20)	31.12±9.98 (17.00-45.00)	$W = 0.0103TL^{3.0149}$	0.9737	3.0149	0.1203 (2.779-3.251)	Isometric
Labeo senegalensis	271	84.32 ±80.89 (5.20-620.00)	16.78 ±5.29 (8.00-36.40)	$W = 0.0193TL^{2.8733}$	0.808	2.8733	0.0854 (2.706-3.041)	Isometric
DISTICHODONTIDAE *Distichodus engycephalus*	18	6.94±1.69 (4.90-10.50)	8.80 ±0.88 (7.60-10.6)	$W= 0.0489TL^{2.2712}$	0.9319	2.2712	0.1535 (1.970-2.572)	Allometric (-)
SCHILBEDAE *Parailia pellucida*	30	4.77 ±0.93 (3.10-6.50)	9.23 ±0.68 (8.20-10.50)	$W= 0.0541TL^{2.0045}$	0.5764	2.0045	0.3248 (1.368-2.641)	Allometric (-)
Schilbe mystus	37	18.52 ±11.34 (5.70-47.90)	14.39 ±2.90 (10.00-21.00)	$W= 0.0051TL^{3.0253}$	0.9635	3.0253	0.0995 (2.830-3.220)	Isometric

Table 2. Mean relative condition factors of the nine (9) selected fish species from the Yapei Stretch of the White Volta, Ghana (N: sample size; Wo: observed weight (g); Wc: calculated weight (g))

	N	Mean Wo	Mean Wc	Relative Condition Factor Wo/Wc	Mean Deviation (Wo-Wc)/Wc	T-test of Wo Vs. Wc P-values
B. leuciscus	108	7.51	7.50	1.00	0.00	0.99 (P>0.05)
H. forskali	114	100.28	92.63	1.01	0.01	0.79 (P>0.05)
O. mento	76	7.43	7.35	1.01	0.01	0.79 (P>0.05)
L. coubie	68	226.52	221.91	1.03	0.03	0.93 (P>0.05)
L. parvus	19	427.10	424.47	1.01	0.01	0.98 (P>0.05)
L. senegalensis	271	84.32	82.29	1.09	0.09	0.78 (P>0.05)
D. engycephalus	18	6.94	6.92	1.00	0.00	0.97 (P>0.05)
P. pellucida	30	4.77	4.73	1.01	0.01	0.83 (P>0.05)
S. mystus	37	18.52	18.28	1.01	0.01	0.93 (P>0.05)

P>0.05: No significant difference between observed weight (Wo) and calculated weight (Wc)

The relative condition factor being exactly1.00 for 2 species and very close (1.01) to 1 for 5 species suggested the overall suitability and good state of wellbeing for the fish species.

Conclusion

The fitted weight-length power regression models ($W=aTL^b$) generated from this study for the 9 fish species have proven to deliver good relative condition indices are thus suitable for future approximation weights and assessment of the state of wellbeing of the studied fish species.

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