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Spatial and Temporal Variation of Length-Weight Parameters and Condition Factors of Commercial Fish Species in Lake Nasser, Egypt

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ABSTRACT

Length and weight data of fish populations are necessary in stock assessment models and ecosystem modelling. Also, they could be used to spatially compare between different fish populations under different environmental conditions. This study provides an updated information on the length weight relationships and condition factors of six fish species in Lake Nasser, Egypt. It also investigates how these parameters are affected by variation in environmental characteristics of the Lake, therefore it presents the first reference on the spatial and temporal variation of these data in Lake Nasser. More than 13,000 fish were collected on monthly basis to cover different geographical zones and seasons of the lake. The values of the growth coefficient *b* obtained in this study were very close to the values recorded by previous studies with slight inconsistency while the average condition factors, *K,* were generally lower than that reported for 1984 - 2000. Moreover, results indicate overall statistically significant differences in seasons and locations for total length, total weight and condition factor means. The results obtained from this study are contributing to the knowledge of fish populations in Lake Nasser and highlighting the spatial and temporal variation of fisheries biological parameters in such large lake system. This variation should be considered by fisheries scientists and managers for future studies.

1. INTRODUCTION

Length and weight data of fish populations are useful for estimation of growth rates, length and age structures, and other components of fish population dynamics. This information is necessary in stock assessment models and ecosystem modelling approaches [1]. Moreover, length and weight data could be used to spatially compare between different fish populations under different environmental conditions [2] and temporally to track seasonal variations in fish growth [3]. The condition factor is used in order to compare the "condition", "fatness" or wellbeing of fish. 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 [4].

Lake Nasser is a huge water body with a surface area of 5,237 km^2 at its highest water level (180 m above sea level) that now provides an important source of fish for Aswan governorate and the rest of Egypt [5]. Despite the importance of investigating the spatial and temporal variation of different biological parameters of fish populations in such a huge water body, which extends for 291.8 km from South to North, information about the spatial and temporal variation of length-weight parameters and condition factors of fish species in Lake Nasser is absent. All available information on these parameters are of the lake as whole without considering any variation in environmental conditions through different regions of the lake and over different seasons.

This study contributes to available length- weight and condition factor data for the most economically and ecologically important fish species inhabiting Lake Nasser. Also, this study investigates how these biological parameters are affected by variation in environmental characteristics of the Lake, therefore it presents the first reference on the spatial and temporal variation of these data in the Lake.

2. METHOD

Sampling Area:

The Aswan High Dam was constructed in the 1960s creating a huge water body, Lake Nasser, which contains three regions: the riverine southern part; the lacustrine northern part; and a region in between that has riverine conditions during the flood season and lacustrine characteristics in the remainder of the year [6] (Figure 1).

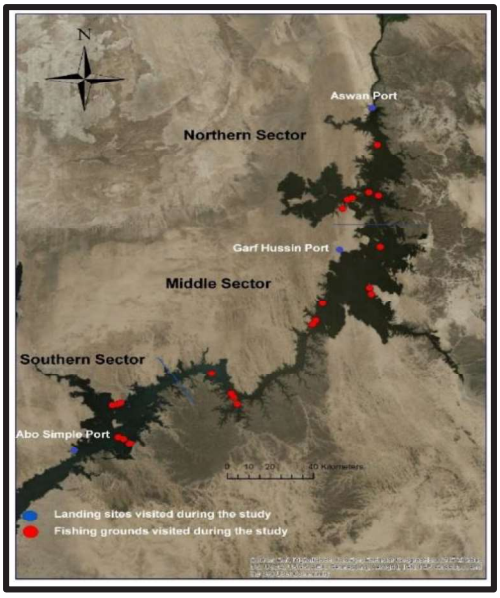

Fig. 1 Map of Lake Nasser showing sampling sites and different sectors of the lake.

Sampling of Fish:

Sampling was carried out during the period between October 2016 and September 2017. Monthly landing surveys of fishing ports (Aswan in the North, Garf Hussin in middle, and Abo Simbel in the South) have been conducted, in addition to bimonthly spatial surveys to cover the entire lake. A total of 13,091 fish belonging to six fish species (three families) were collected. Total length of each fish was taken to the nearest millimetre from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board. Body weight was measured to the nearest 0.1 gram using a top loading balance.

Data Analysis:

Parameters of the length-weight relationship (LWR) of identified fish species were estimated using the equation:

$W = a L^b$ [7]; where, W = Weight of fish (g), L = Length of fish (cm), *a* = y-intercept or the initial growth coefficient, *b* = Slope or the growth coefficient.

The values of constants *a* and *b* were estimated after total weight (TWt) was plotted against total length (TL) and a power trend line (curve) of the form $y = a x^b$ fitted to the data using Microsoft Excel. Only extreme outliers attributed to data error were omitted from analyses. Condition factor (K) was calculated by the formula: $K = 100W/ L^3$ [8]. Variations in TL, TWt, LWR (represented by '*b*') and K of the individual fish living in the lake's three regions during different seasons were analysed with one-way analyses of variance (ANOVA) with subsequent Tukey's honestly significant difference (HSD) tests using Xlstat software. All the statistical analyses were considered at significance level of 5% ($p<0.05$). Due to statistical constraints, only those species represented by at least 20 individuals in each season and sector of the lake and with a relatively wide size range were considered for ANOVA and Tukey's (HSD) tests. Therefore, *Alestidae* species were excluded from these analyses.

3. RESULTS

The species, number of specimens, LWR parameters *a* and *b*, correlation coefficient (r^2), condition factor, mean length of fish species, mean weight of fish species and growth type (allometric or isometric) are presented in (Table 1).

The family with the highest number of species was *Cichlidae*, which had three species (*Oreochromis niloticus*, *Sarotherodon galilaeus* and *Tilapia zillii*) and two species were recorded for *Alestidae* (*Alestes baremoze* and *Hydrocynus vittatus*), while, the last family *Latidae* had one species *Lates niloticus*. The sample size for the fish species varied from 375 in *A. baremoze* to 4562 in *S. galilaeus* while the value of *b* ranged from 2.92 in *S. galilaeus* to 3.29 in *A. baremoze*. The lowest condition factor (K) (0.57) was recorded in *H. vittatus* while the highest value (2.06) was observed in *O. niloticus*. The values of correlation coefficient (r^2) varied from 0.9396 in *T. zillii* to 0.9885 in *O. niloticus*. All *Alestidae* species had positive allometric growth while all *Cichlidae* species had negative allometric growth except *O. niloticus*, which had isometric growth similar to *L. niloticus*. An ANOVA revealed significant differences ($P<0.0001$) in all tested biological parameters among various seasons and locations for the four investigated species except for *b*. As ANOVA has shown an overall statistically significant difference in seasons and locations TL, TWt and K means, Tukey's (HSD) test was done to confirm where the differences occurred by pairwise comparisons for seasons and locations. The results of both statistical analyses are shown in Table 2.

4. DISCUSSION

This study provides an updated information on LWR of six fish species in Lake Nasser, Egypt. Unfortunately, the available literature on LWR parameters in Lake Nasser is outdated and limited to Nile tilapia (*O. niloticus*) as it was the main commercial fish species, besides few studies on mango tilapia (*S. galilaeus*) [9-11]. Nevertheless, the values of *b* obtained in current study for these two species (3.04 and 2.92 respectively) are very close to the values recorded by those studies where it ranged between 2.6 and 3.02 for Nile tilapia and 2.5 and 3.12 for mango tilapia. It is likely that this slight inconsistency is due to seasonal variability of the environment, food availability [12], sampling size and

the length interval within different areas or habitat suitability [13].

K of the six fish species ranged between 0.57 and 2.06 which is generally lower than that reported by Adam, 2004 [14] for the years between 1984 and 2000. This suggests that the current condition of Lake Nasser, in comparison to its former status, may be becoming unfavourable to fishes. Therefore, there would be need for more studies on the physico-chemical properties and the condition factors of other fish species to be able to establish the sustainability of the lake for fish.

Table 1. Estimated parameters of the length-weight relationships (LWR), growth type, condition factors (K) and growth performance (total length & total weight) for six fish species in Lake Nasser.

Family	Species	N	Length (cm)			Weight (g)			K	Parameters of the LWR			Growth type
			Min	Max	Mean	Min	Max	Mean		a	b	r^2	
Alestidae	*Alestes baremoze*	375	21	47	29.3982	48.8	758.4	175.206	0.59255	0.0022	3.2915	0.9617	P
	Hydrocynus vittatus	606	21.4	78	37.7711	45.9	3042	362.89	0.56516	0.0021	3.2751	0.9788	P
Latidae	*Lates niloticus*	2278	13.5	160	30.2517	26.8	43000	458.421	1.15231	0.0116	2.9968	0.9763	I
Cichlidae	*Oreochromis niloticus*	2874	14	54.7	28.7166	54.8	3384.3	600.033	2.0594	0.0177	3.0447	0.9885	I
	Sarotherodon galilaeus	4562	10.6	38	21.6902	24.5	1011.3	225.045	2.05335	0.0257	2.9249	0.9562	N
	Tilapia zillii	2302	11.5	30.5	20.3957	39	632	181.779	2.0453	0.0244	2.9404	0.9396	N

N= number of samples, K= condition factor, a= intercept of regression line, b= slope of regression line, r^2 = regression coefficient, P= positive allometric , N= negative allometric ,I= isometric

Table 2. Results of ANOVA and Tukey's (HSD) tests of studied biological parameters among various seasons and locations in Lake Nasser.

	Oreochromis niloticus			*Sarotherodon galilaeus*			*Tilapia zillii*			*Lates niloticus*		
(ANOVA)												
	T.L.	T.Wt.	K	T.L.	T.Wt.	K	T.L.	T.Wt.	K	T.L.	T.Wt.	K
R^2	0.057	0.057	0.074	0.162	0.164	0.113	0.040	0.050	0.061	0.022	0.006	0.047
F	34.791	34.544	45.578	175.767	179.248	115.833	18.938	24.207	30.019	10.271	2.682	22.597
Pr > F	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.020	< 0.0001
Tukey's HSD (LS means) - Seasons and Sites												
Autum	28.957 a	599.413 b	2.061 b	22.117 b	235.046 b	2.027 b	20.751 a	189.682 ab	2.023 b	32.083 a	623.566 a	1.128 b
Winter	29.901 a	687.274 a	2.130 a	22.313 b	250.415 a	2.137 a	20.771 a	195.584 a	2.101 a	30.737 ab	525.006 ab	1.194 a
Spring	29.667 a	653.363 ab	2.010 c	22.690 a	256.143 a	2.035 b	20.198 b	182.886 b	2.076 a	29.102 c	359.691 b	1.179 a
Summer	27.372 b	522.441 c	2.014 c	19.939 c	168.336 c	2.016 b	19.920 b	162.460 c	1.992 c	29.725 bc	383.852 b	1.125 b
Pr > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000
North	27.858 b	530.394 b	2.061 a	20.537 c	182.487 b	2.002 c	20.460 b	180.906 b	2.026 b	29.718 b	443.114 a	1.137 b
Middle	31.278 a	758.423 a	2.033 b	22.576 a	253.408 a	2.038 b	20.825 a	195.369 a	2.047 b	29.698 b	439.360 a	1.154 b
South	27.787 b	558.052 b	2.067 a	22.181 b	246.558 a	2.122 a	19.946 c	171.684 c	2.071 a	31.820 a	536.611 a	1.178 a
Pr > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000

T.L.= total length, T.Wt.= total weight, K= condition factor

This study reveals, for the first time, the geographical and seasonal variations of the studied parameters in Lake Nasser. All investigated species showed different mean TL, mean TWt and mean K in different geographical areas of the lake and through different seasons. These differences could be related to spatially different environmental and biological conditions. This variation is related to many factors such as temperature, salinity, food (quantity, quality and size), habitat and gonad development, spawning period season, sex. Fishing time, fishing gear and area may be additional causes of such variation [3, 7].

5. CONCLUSION

The results obtained from this study are contributing to the knowledge of fish populations in Lake Nasser, as a large lake system, and highlighting the spatial and temporal variation of fisheries biological parameters in such large lake system. This variation should be considered by fisheries scientists and managers in informing future studies, and preparation of fisheries management plans. This is especially necessary for the heavily exploited populations, as well as those under stock recovery plans or other management and conservation programmes.

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