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RESEARCH ARTICLE

Effect of Diplostomum Species on Length–Weight Relationship of Farmed Nile Tilapia in Kibos Area, Kisumu City, Kenya

Effect of *Diplostomum* Species on Length–Weight Relationship of Farmed Nile Tilapia in Kibos Area, Kisumu City, Kenya

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Abstract
Diplostomum species metacercariae are parasitic trematodes that pose significant economic threat to fish farming world–wide. Nile tilapia ranks the most commercialized fish in Kenya besides being a cheap source of highly nutritive protein. However, low production of pond reared Nile tilapia in western Kenya poses threats to initiatives by the Kenyan government to revamp the economy of residents in this region. Diplostomiasis infection has been scantly reported in the region, however, comprehensive studies on the effect of *Diplostomum* spp. on the health status of farmed fish is lacking. This study examined the influence of *Diplostomum* parasites on the length-weight relationships and condition factor of farmed tilapia in Kibos area near Kisumu City. 326 fish samples were collected from three fish farms between December, 2011 and February, 2012. The values of the regression co-efficient obtained for the length-body weight relationship in all the farms was around the hypothetical value '3' whereas the correlation co-efficient was greater than 0.9. This suggests an isometric growth form in all the sampled specimens. The condition factor computed exhibited values significantly greater than K_n = 1.0. There was no significant statistical difference (p>0.05) between parasitized and non-parasitized fish. Thus, it is clear the specimens were healthy and fingerlings (< 5cm) from the farms could be used for commercial production.

Keywords: Condition factor; length; weight; *Oreochromis niloticus*; pond.

1. Introduction

Metacercariae of the digenean trematode *Diplostomum* are common parasites of wild and cultured fish in temperate and tropical climates [1]. Fish heavily infected with these digenetic trematodes may experience loss of vision, reduced growth, emaciation [2] or deformation of the vertebral column, brain tumour, cellular necrosis and death [3]. It has been further shown that these parasites can reduce fish crypsis and escape response and thus increase fish susceptibility to bird predation [4]. According to reports [5], farming of *Oreochromis niloticus* in western Kenya has gradually increased from 4% in the year 2003 to 92% by 2010. This was as a result of the initiative by the Kenyan government to revamp the economy of communities in western Kenya through the Economic Stimulus Program (ESP) targeting fish farming. Kibos area near Kisumu City is located within western Kenya and is largely endowed with black soil, which is suiTable for aquaculture [6]. However, evidence of decline in fish production [7] as well as the average size of fish (100gm-180gm) caught in fish farms in the area over the last 3-5 years has been reported [8]. There are many possible reasons for the low production of tilapia, such as too early maturation, high stocking density, high mortality due to predation, biotic and abiotic environmental changes such as socio-economic and ecological condition of the place [9; 10], lack of food, and parasitism by both ecto and endoparasites [11]. Information on nutritional requirements [12], environmental changes such as pH and temperature [13; 14] and aspects of tilapiine biology [15] have well been documented in previous studies, however, there is scanty of information on the effect of parasitism on the growth of fish with particular relevance to the well-being of fishes in privately managed fish farms. According to Machado *et al.* [3], *Diplostomum* parasites pose adverse threats to growth and health status of fish. Recent studies [16; 17] demonstrated over 40% prevalence rate of diplostomiasis among farmed *O. niloticus* in western Kenya, however, comprehensive studies on the effect of *Diplostomum* spp. on the health status of farmed fish in the region is lacking. A clear understanding of the growth of farmed fish is necessary for accurate prediction of production levels in fish farms. This is because weight-length relationships provide information on the condition and growth patterns of fish. In addition, the condition of tilapia brood-stock determines the amount of seed to be produced for stocking of ponds whereas the condition of juveniles is important as they are used in stocking of fish farms. Hence, this study investigated the influence of *Diplostomum* parasites on the length-weight relationships of farmed tilapia in Kibos area near Kisumu City.

2. Methods

2.1 Study design & study area A three months cross-sectional survey (December 2011 - February 2012) was conducted in Kibos area near Kisumu City, Kenya. Kibos is located between latitudes $0^0$06′ N/ 0° 4'0.0012"S and longitudes $34^{0}81'E$ / 34° 49' 0.0012"E. Three farms were selected for the study. These sites were selected based on their location near a fry production centre which serves as the main supplier of fingerlings in western Kenya.

2.2 Fish sampling procedure and transportation

Fish sample size for Nile tilapia *O. niloticus* L.1758 used in this study was estimated according to the formula [18]. Sampling was done after every three weeks for a period of three months (December 2011 – February 2012). Sixty four (64) Nile tilapia fish were randomly sampled from each fish farm at every sampling time using a seine net of 1.5m diameter and 6mm mesh. Sampled fish were then transported in iced cool box at 8^{0}C to Maseno University, Zoology Department laboratory for analyses.

2.3 Laboratory procedures

2.3.1 Examination of fish specimens for *Diplostomum* parasites

Fish eyes were dissected and then examined for metacercariae with a stereoscopic microscope using procedures as described by [19] and [20]. The metacercariae extracted from each eye were counted as separate lots, and placed in a petri dish containing saline solution before storing in 95% ethanol.

2.3.2 Examination of fish for length–weight relationship

The specimens were mopped on filter paper to remove excess water from their body surfaces. Total and standard fish body lengths were then measured using a meter ruler and recorded in centimetres. The total length was measured as the distance from snout to the tip of the caudal fin while the standard length was measured as the distance from the snout to the caudal peduncle. The body weight was taken using a Table top weighing balance to the nearest 0.1g. Fish samples were recorded according to their collection sites as F1, F2 and F3.

2.4 Data analyses

Data was analyzed using SPSS software package. For the length-weight data, the least square method based on Type I linear regression model was used for the expression: log (W) = log (*a*) + *b*. log (TL). Where: W = Weight of fish (g); L = Total Length of fish (cm); a = exponent describing the rate of change of weight with length (= the intercept of the regression line on the Y axis); b = the slope of the regression line (also referred to as the allometric coefficient). The entire relationship between length (L) and weight (W) of fish was expressed by equation: $W = aL^b$ [21] with the "a" and "b" values having been obtained from the linear regression. The degree of adjustment of the model studied was assessed by the correlation coefficient (r^2). Student's t-test was applied to verify whether the declivity of regression (constant "b") presented a significant difference of 3.0, indicating the type of growth: Isometric (b = 3.0), positive allometric (b>3.0) or negative allometric (b<3.0). The values of the compiled growth exponent were used for the calculation of condition factor, K according to [22]:

$$K_n = \frac{100\,W}{L^b}$$

where: K_n = Condition factor; W = Total body weight (g); L = Total length of fish (cm) and b = regression coefficient. Mean K_n values obtained were compared with the standard K_n = 1.0 by Student's t-test. The independent-samples t-test was used to test for differences in the K_n values between parasitized and un-parasitized hosts. In all cases a statistical significance of 5% was adopted.

3. Results

Figures 1, 2, and 3 indicated that parasitized fish with greater standard lengths (> 10.1 cm) in all the farms had relatively lower K_n values compared to smaller sized fish (≤ 10.0 cm). In addition, independent-samples t-test conducted to compare K_n of parasitized and un-parasitized fish among the class groups revealed no significant difference in the relative condition factor values; t (4) =1.886, p = 0.1324 in farm I, t (5) = 0.09920, p = 0.9248 in farm II and t (7) = 0.1428, p = 0.8905 in farm III. According to results depicted in Table 1, parasitized individuals were on average bigger (greater mean total length) and heavier than non-parasitized fish with an exception of farm I. Mean relative condition factor values were significantly greater than K_n = 1.0 for parasitized individuals of farm I and farm III with an exception of farm II. However, all individuals combined exhibited relative condition factor values significantly greater than K_n = 1.0. Unpaired t test computed to determine any significant difference in the mean K-factor between parasitized and non-parasitized fish in general indicated that there was not statistical significance between the groups (p = 0.253) and the differences between condition means were likely due to chance.

Figure 1: Effect of *Diplostomum* spp. on Mean K_n – Factor of cultured *O. niloticus* in relation to fish class size in farm I.

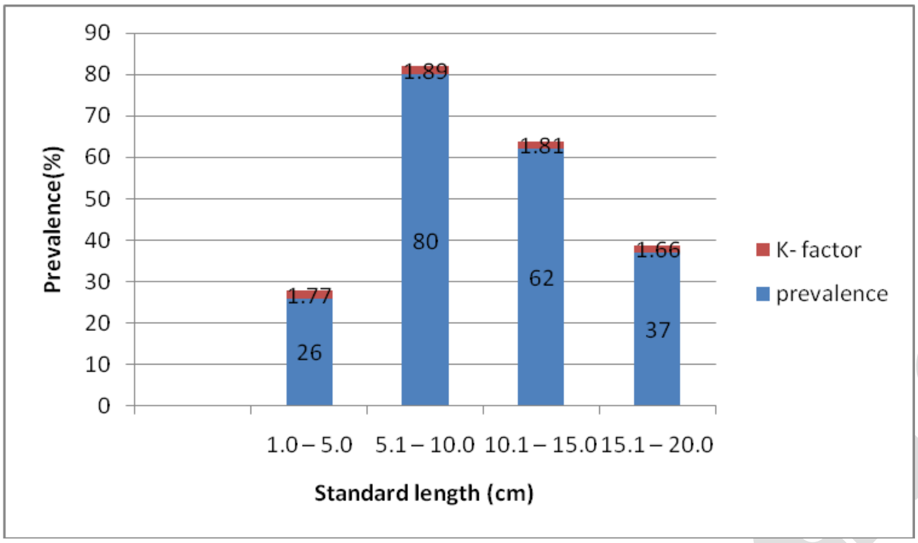

Figure 2: Effect of *Diplostomum* spp. on Mean K_n – Factor of cultured *O. niloticus* in relation to fish class size in farm II.

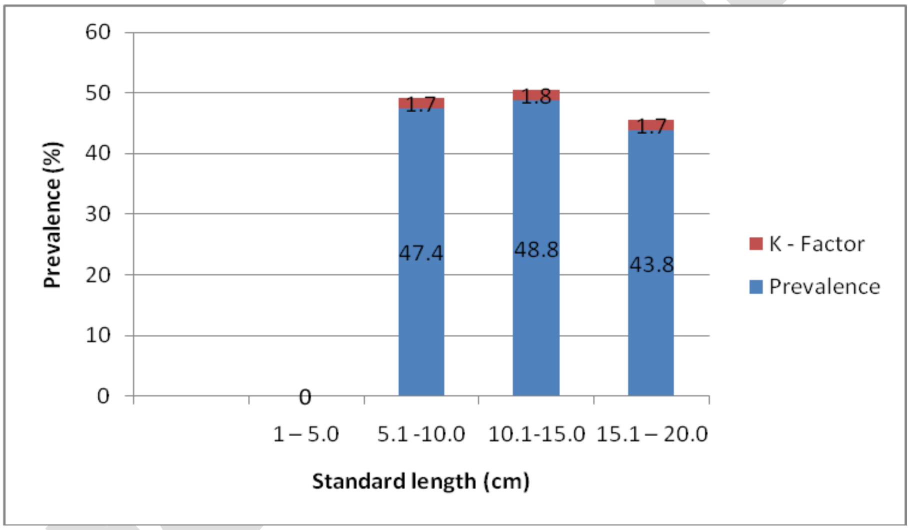

Figure 3: Effect of *Diplostomum* spp. on Mean K_n – Factor of cultured *O. niloticus* in relation to fish class size in farm III.

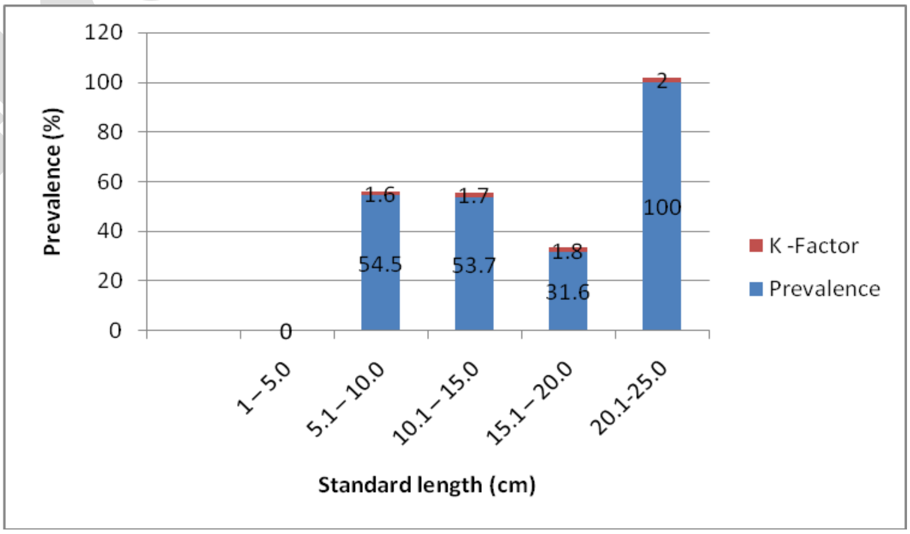

Table 1: Descriptive statistics and estimated parameters of length-weight relationships for parasitized and non-parasitized *O. niloticus* caught in three fish farms in Kibos area, Kisumu City.

Farm	Status	N	Total length characteristics			Mean Wt ± SE	Mean K_n ± SE	Student's t test	Parameter of the relationships			
			Mean Ls ± SE	Min.	Max.				a	b	r^2	t test
Farm I	Parasitized	67 (46.5%)	13.77±0.47	9.7	20	118 ± 7.74	1.10±0.38	p = 0.0017*	0.007	3.00	0.98	b = 3*
	Non-parasitized	77	19.44±3.52	6.3	17	161.25±25.43	1.00±0.16	p = 0.4456	0.006	3.18	0.99	b = 3*
	Both	144	19.3±0.61	6.3	20	118.75±7.74	1.07 ±0.10	p = 0.0166*	0.159	3.08	0.99	b = 3*
Farm II	Parasitized	31(39.7%)	20.14±4.84	7.4	19.6	150.78±8.59	0.99±0.12	p = 0.7561	0.006	2.66	0.90	b<3ns
	Non-parasitized	47	14.96±2.00	5.2	20	109.23±6.67	1.04±0.15	p = 0.8026	0.005	2.92	0.96	b=3*
	Both	78	17.84±0.4	5.2	19.6	138.41±9.10	1.12±0.07	p = 0.022*	0.208	2.86	0.91	b=3*
Farm III	Parasitized	72 (69.2%)	21.77±4.37	10.4	25.0	142.36±30.76	1.09±0.12	p = 0.004*	0.061	2.63	0.91	b<3ns
	Non-parasitized	32	12.33±3.18	8.9	21.5	131.79±5.09	0.94±0.13	p = 0.0781	0.001	3.14	0.99	b=3*
	Both	104	16.26±1.22	8.9	25.0	135.79±1.09	1.08±0.11	p = 0.012*	0.141	3.17	0.97	b=3*

Prevalence - in parenthesis; (**K_n**) Mean values of the relative condition factor; (**SE**) Standard error; (**Min**) Minimum; (**Max**) Maximum; (**N**) the sample size; (***a***) the intercept of the relationship; (***b***) the slope of the relationship; (**r^2**) coefficient of correlation; (**t**) growth t –test. *Significant (P<0.05), ns = not Significant (P>0.05).

Table 2: Summary of length-weight relationship of *Oreochromis niloticus* from 3 fish farms in Kibos area, Kisumu City.

Farm number	Number of fish examined	Exponential equation	r^2	Growth t test
Farm I	142	Wt = 0.15874 $(TL)^{3.0867}$	0.9960	b = 3*
Farm II	64	Wt = 0.2078 $(TL)^{2.8620}$	0.911	b= 3*
Farm III	64	Wt = 0.1406 $(TL)^{3.1662}$	0.97	b = 3*

*Significant (P<0.05)

Results from the log transformed data to study the length–weight relationships gave a regression equation of Log w = log a + b log L. Linear regression conducted on the data confirmed that there was a strong significant relationship between length and weight of fish with p values <0.001. In addition high degree of positive correlation between total length and total weight of all individuals was indicated by high values of correlation coefficient (r^2) ranging 0.90 to 0.99. This implies that the exponential model applied would provide reliable predictions of the weight of fish in the farms. The estimated values of the exponent *b* ranged from 2.63 to 3.18. Parasitized fish in farm II and III had 'b' values less than 3 (b<3; p<0.05) implying a negative allometric growth whereas non–parasitized fish in farm I and III showed positive allometric growth (b>3; p<0.05). In summary, the exponent *b* values were around the hypothetical value '3' showing isometric growth for the farmed fish (Table 2).

4. Discussion

Condition factor is a quantitative indicator of fish fitness reflecting recent feeding conditions and is obtained using the length-weight relation of the individual [3]. Analysis to determine the effect of *Diplostomum* on the growth condition of examined fish indicated that there was no statistical significance between parasitized and non-parasitized fish (p = 0.253; > 0.05) hence, there was not sufficient evidence to indicate that the relative condition factor (K_n) was different between the groups in the study area. On the contrary, parasitized individuals were, on average, heavier in weight and of larger sizes (greater mean standard length) than non-parasitized individuals (Table 1). This may be attributed to the fact that perhaps, these host species do not depend essentially on vision for localization and capture of food. Tilapiines exhibit a diversified feeding routine [23]. They are omnivorous grazers that feed on phytoplankton, periphyton, aquatic plants, small invertebrates, benthic fauna, detritus and bacterial films associated with detritus. They are also filter feeders where suspended particles such as phytoplankton and bacteria are entrapped on mucous buccal cavity [23]. As such, the touch of food on the lips of the fish can be enough for it to sense presence of food within its vicinity [24]. It may also be as a result of the recorded parasite intensity in the eyes ranging 5 to 14 parasites per fish, which probably did not affect the vision of the fish. Similarly, Marcogliese *et al.* [25] observed no significant effect of *Diplostomum* parasitism on the condition of fish despite the number of parasite intensity observed ranging 1–248 parasites per host.

Variation in condition factor by size (length) classes was not statistically significant ($p = 0.1324$ in farm 1; $p = 0.9248$ in farm II and $p = 0.8905$ in farm III; >0.05). Nevertheless, larger sized fish (> 10.1 cm) had relatively lower K_n values compared to smaller sized fish (≤ 10.0 cm). This could be attributed to the resources transferred to the gonads in the latter stages of the life history of a fish for purposes of reproduction or construction of the gonads. [13; 14; 26] similarly observed relatively lower values of condition factors for large sizes of fish, while relatively higher values of condition factors for rather small sized fish in *Brycinus nurse*, characid and tilapia fish species, respectively. A number of other factors (e.g. sex, seasons, environmental conditions, stress, and availability of food) also affect the growth condition of fish however; these were not considered in the present study paving way for more research to ascertain the influence of ecological factors, sex and diet to the health status of fish. In totality, fish specimens in this study were observed to be healthy as the condition factor values were higher than one ($K_n = 1$). On the contrary, the K_n values for fish species in this study (range 1.7–2.1) could not be compared to values of 2.25 obtained for *Brycinus nurse* fish species in Volta lake [26], 2.67 and 2.3 in Sassandra and Bagoe rivers in northern Nigeria [27]. Lower K_n values of fish in this study could be explained by the fact that pond fish culture predisposes fish to stress and diseases as a result of high stocking density compared to the natural water systems. It may also be concluded that fingerlings (<5cm) examined in this study were suiTable for commercial production.

4.1 Length-weight relationships

The length-weight relationship (LWR) of the sampled fish indicated that the weight of the fish increased logarithmically with an increase in length, with the 'b' values lying between 2.5 and 3.5. The regression coefficient for isometric growth is '3' and values greater or lesser than '3' is an indication of positive or negative allometric growth, respectively [28]. Similar to growth condition, the length-weight relationship in fish is affected by a number of factors including ecological factors such as temperature, food supply (quantity and quality), spawning conditions and other factors, such as sex, age, gonad maturity, stomach fullness, health, season and habitat [29].

Parasitized fish in farms II and III (Table 1) in the present study showed values of 'b' significantly lower than 3 ($p< 0.05$) which is an indication of negative allometric growth i.e. the fish grows but is slender. Negative allometric growth is an indication of slow growth which might be due to non-availability of food as suggested by [30]. Similarly, the K_n values of these fish specimens were lower (0.99 and 1.09 respectively) than values reported by [26] and [27], which ranged 0.98–3.41. Parasitized fish in farm I had the 'b' values at 3 indicating an isometric growth which characterize the fish as portraying unchanging body form and unchanging specific gravity [31]. Non-parasitized fish showed 'b' values greater than 3 (Table 1) implying a positive allometric growth. Rapid growth might be an indication of abundant food supply and other favourable conditions as suggested by [30]. The overall 'b' values of fish in all the farms were around the hypothetical value of '3' ranging between 2.8620 to 3.1662 (Table 2). These results are analogous with the range of 'a' values and 'b' values usually encountered in fin fishes, which lie between 2 and 4 according to [28]. Recently, Froese [32] confirmed the exponent 'b' should normally fall between 2.5 and 3.5.

5. Conclusion

In conclusion, findings from this study regarding the length–weight relationships of fish demonstrated that *Diplostomum* parasite species did not appear to have any effect on the condition factor of heavily infected *O. niloticus* as the computed K_n values were higher than 1. Regression coefficients indicated isometric growth for all the sampled fish as the 'b' values were approximately 3. However, *Diplostomum* can indirectly cause severe losses in fish populations. It is for this reason that we have to take parasitic infection in hatcheries and ponds seriously. In addition, the current study did not consider the diet, gonadal development and stomach fullness of the sampled fish. These factors may influence the length–weight relationships of fish and therefore, future studies pertaining to seasonal or annual data are necessary to verify this hypothesis.

Competing Interests

There are no "financial competing interests" or other "non-financial competing interests" involving political, personal, religious, ideological, academic, intellectual, and commercial or any other to declare in relation to this manuscript.

Authors' Contributions

VMN conducted the research, of which the results are reported in the manuscript as well as drafted the manuscript. BOA participated in reviewing the manuscript as well as statistical analysis. DMO supervised the entire work, read the manuscript and provided laboratory as well as financial support.

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