Morphometric Characters of Nile Tilapia (*Oreochromis niloticus*) in Thailand

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Abstract

The present study is conducted to describe the morphometric characteristics of a Thailand strain of *Oreochromis niloticus*. The total length of the observed fish ranged from 7.96 - 17.36 cm. Body measurement and proportions are extensively used for identification of this species. The following 18 measurements are determined for each fish: Total length (TL); Standard length (SL); Body depth (BD); Pre-dorsal length (PDL); Pre-pectoral length (PPCL); Pre-pelvic length (PPVL); Pre-anal length (PAL); Depth of caudal peduncle (DCP); Length of caudal peduncle (LCP); Head length (HL); Eye diameter (ED); Snout length (SNL); Upper jaw length (UJL); Lower jaw length (LJL); Caudal fin length (CFL); Pectoral fin length (PFL); Length of dorsal fin base (LDFB); Length of anal fin base (LAFB). The rate of growth of different morphological body parts of the fish in relation to its total length is studied. Additionally, the total length and body weight relationship is found to be a straight line in logarithmic scale expressed as Log BW = 3.026 Log TL - 1.839. The value of regression co-efficient obtained for the length-weight relationship is 3.026. This finding suggests that selection for growth using this equation is a good alternative for measuring weight in the field, when accurate weighing balances are not available. Hence, the present study provides the information of the various body parts measurements of Tilapia and establishes mathematical equations relating to these various morphometric relationships which can be utilized for the conversion of one measurement into another.

Keywords: Fish, Tilapia, *Oreochromis niloticus*, morphometry, Thailand

Introduction

Tilapia is an important commercial freshwater fish species worldwide and plays a major part in fisheries aquaculture [1]. It is applied to 3 genera of fish belonging to the Family Cichlidae: Oreochromis, Sarotherodon and Tilapia. It is also recommended by the Food and Agriculture Organization as a culture fish species, because of its capability in contributing to the increased production of animal protein in the world [2]. The cultivation of tilapia is becoming more and more popular due to its higher growth rate, higher fecundity, ease of manipulation, good consumer acceptance, ability to grow under suboptimal nutritional problems, and response to adverse environmental conditions such as low oxygen and high ammonia levels in the water [3]. Nile tilapia (*Oreochromis niloticus*) culture has increased in freshwater since its introduction to Thailand from Japan in 1960s. Following its introduction, this species has become widely distributed throughout natural and artificial water reservoirs. To date, management programs have been limited by the lack of methods to evaluate the status of this introduced species.

Previous studies of the Tilapia have focused almost entirely on its suitability for aquaculture [4], adaptation of salt water habit [5] and its meat quality [6]. Morphometry is a field concerned with studying variation and change in form i.e., the size and shape of an organism [7]. The size and shape are unique to the species and the variations in its features are probably related to many conditions. Additional, the size of fish is more important than its age, mainly because several factors in taxonomy, ecology and physiology are more size-dependent than age-dependent [2]. The morphometric investigation in fish reveals the relation between body parts, like length of head, snout, eye, body, fin and tail. This method remains the simplest, most direct way amongst the methods of species identification which does not sacrifice the animals [8]. The natural morphology or morphometric characters of Tilapias were reported in Turkey [1], Nigeria [2], Bangladesh [3], Sri Lanka [8], Scotland [9], Mexico [10], Egypt [11], and Pakistan [12]. Few studies have been conducted in Thailand. This study describes the measurements or distances between different points or landmarks according to Simon and coworkers [13]. These landmarks were linked closely to the body structure of fish, and were observed easily by sight. These parameters were statistically treated to establish their interrelationship and the formulae for length-related body measures.

Materials and methods

Samples of the freshwater fish, Nile tilapia (*Oreochromis niloticus*, n = 30), ranging from 7 - 17 cm, were purchased from a farm in Chachoengsao province, Thailand; the geographic coordinates of this site are Latitude N 13° 23' 22.452" and Longitude E 101° 3' 34.884". Fish were transferred to the Department of Pathobiology, Faculty of Science, Mahidol University, Bangkok, Thailand. The fish were kept in a glass flow through aquaria (50 × 50 × 120 cm) with continuous air and filled with 200 L of dechlorinated tap water [14]. The minimum and maximum atmospheric temperatures during the study period were 27.5 - 30.5 °C respectively. All morphometric characteristics were examined according to Simon and coworkers [13] by the same person in order to minimize artificial error. Digital photographs were taken of the left side of each fish on graph paper with a Sony Cyber Shot DSC-H5 (7.2 megapixels; Sony Electronics, Tokyo, Japan). The weight measurement was done using a digital scale. The measurement from 18 landmarks of the morphometric characters followed the description provided by Simon and coworkers [13] (**Table 1** and **Figure 1**). Finally, the distances on the graph paper were measured using a vernier caliper up to the nearest 0.01 cm.

Results

The body characters: SL, BD, PDL, PPCL, PAL, PPVL, DCP, LCP, HL, ED, SNL, UJL, LJL, CFL, PFL, LDFB, and LAFB were expressed as a percentage of the total length (TL) of the fish (**Table 2** and **Figure 2**). In the morphometric analysis, all the characters were assumed as Y and showed a positive correlation with the total length (x) using the regression formula (Y = a + bx), whereas the value of a and b for various Y are given in **Table 2**. Regression of various body parts against TL of fish were drawn by the least square method. A plot of weight against length on double logarithmic paper however yielded a straight line. The regression equation of the length-weight relationship (**Figure 3**) was expressed as;

$$\log BW = 3.026 \log TL - 1.839 \ (R^2 = 0.966) \quad (1)$$

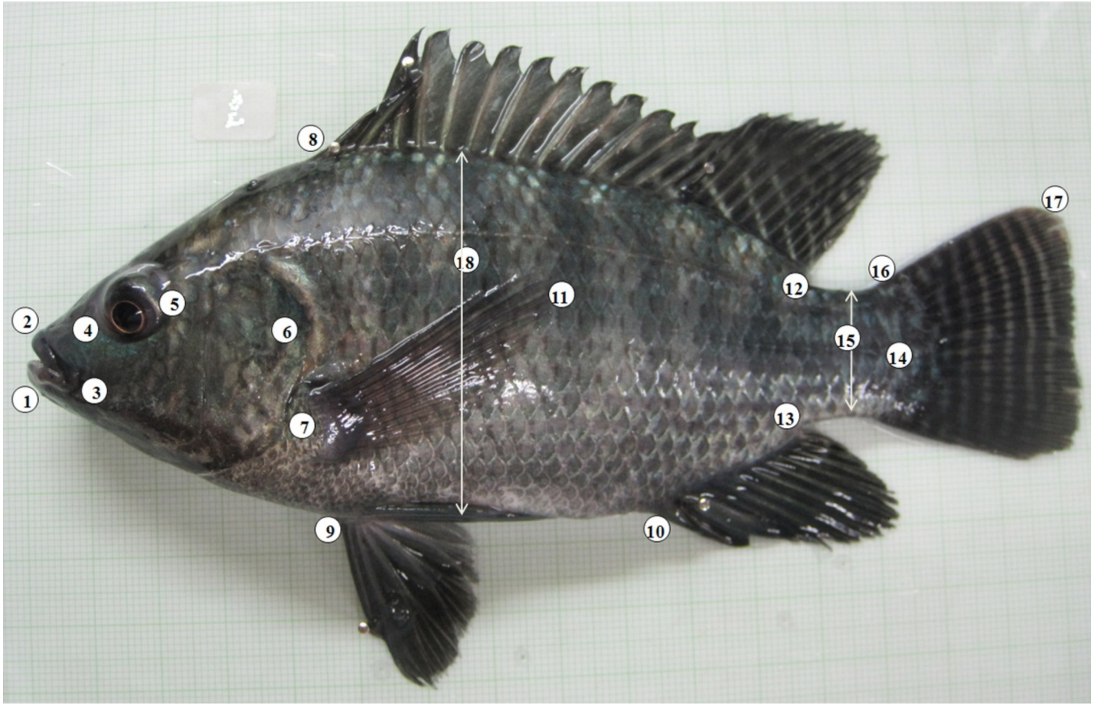

Figure 1 The 18 landmarks of morphometric measurement in *Oreochromis niloticus*.

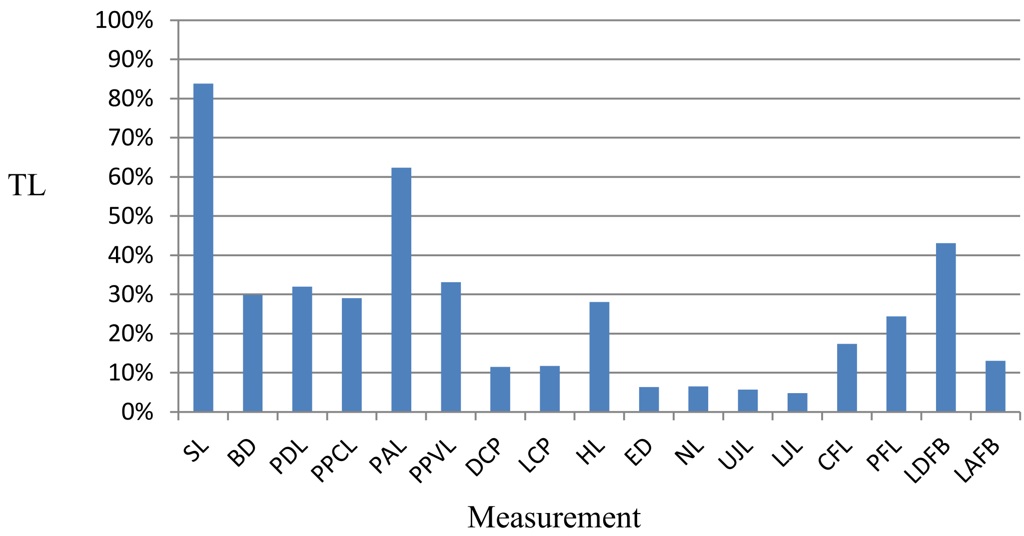

Figure 2 Growth of different morphometric body parts of tilapia when considering the total length (TL) as 100 %.

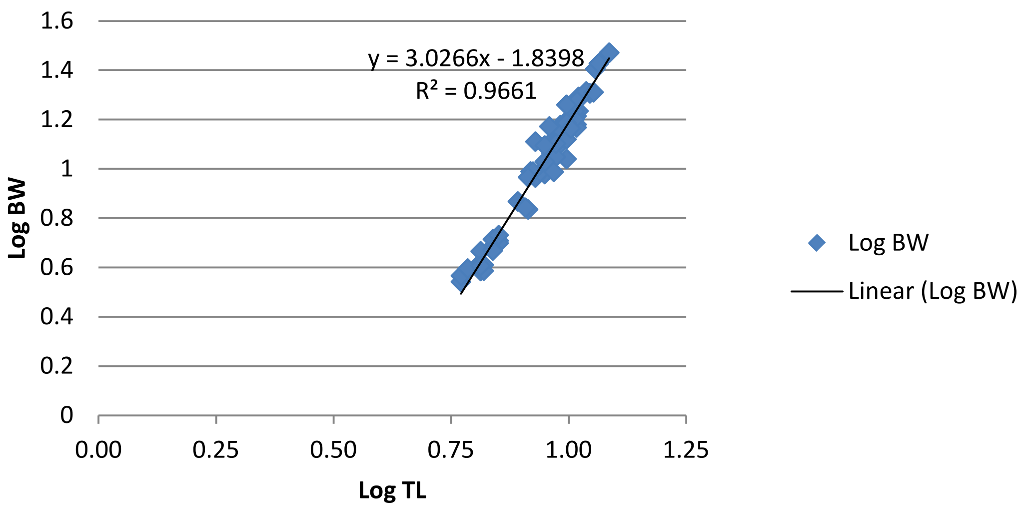

Figure 3 Logarithmic relationship between total length and body weight of *O. niloticus*.

Table 1 Definitions of morphometric measurements of *Oreochromis niloticus*.

Character	Acronym	Point	Description
Total length	TL	1 - 17	Tip of the snout to the end of tail
Standard length	SL	1 - 16	Tip of the snout to the tail base
Body depth	BD	(18)	Maximum depth measured from the base of the dorsal spine
Pre-dorsal length	PDL	2 - 8	Front of the upper lip to the origin of the dorsal fin
Pre-pectoral length	PPCL	2 - 7	Front of the upper lip to the origin of the pectoral fin
Pre-pelvic length	PPVL	2 - 9	Front of the upper lip to the origin of the pelvic fin
Pre-anal length	PAL	2 - 10	Front of the upper lip to the origin of the anal fin
Depth of caudal peduncle	DCP	(15)	The least depth of the tail base
Length of caudal peduncle	LCP	13 - 14	From base of the last anal fin ray to middle of caudal fin fold
Head length	HL	2 - 6	Front of the upper lip to the posterior end of the opercula membrane
Eye diameter	ED	4 - 5	The greatest bony diameter of the orbit
Snout length	SNL	2 - 4	Front of the upper lip to the anterior edge of the orbit
Upper jaw length	UJL	2 - 3	Straight line measurement between the upper lip and posterior edge of maxilla
Lower jaw length	LJL	1 - 3	Straight line measurement between the bottom lip and posterior edge of mandible
Caudal fin length	CFL	16 - 17	From tail base to tip of the caudal fin
Pectoral fin length	PFL	7 - 11	From base to tip of the pectoral fin
Length of dorsal fin base	LDFB	8 - 12	From base of first dorsal spine to base of last dorsal ray
Length of anal fin base	LAFB	10 - 13	From base of first anal spine to base of last anal ray

Table 2 Morphometric measurements of *Oreochromis niloticus* (n = 30).

Measurement	Min	Max	Mean ± SD	TL (%)	Y = a + bx	R^2
Total length (TL)	7.96	17.36	12.00 ± 3.22			
Standard length (SL)	7.21	14.71	10.17 ± 3.08	84.75%TL	y = 0.9384x - 1.0976	0.9605
Body depth (BD)	2.38	6.19	3.59 ± 1.21	29.91%TL	y = 0.3625x - 0.7614	0.9319
Pre-dorsal length (PDL)	2.71	5.95	3.84 ± 0.99	32.00%TL	y = 0.2928x + 0.3313	0.9002
Pre-pectoral length (PPCL)	2.31	5.07	3.49 ± 0.89	29.08%TL	y = 0.272x + 0.2226	0.9567
Pre-anal length (PAL)	5.45	10.97	7.48 ± 2.11	62.33%TL	y = 0.6454x - 0.2656	0.9709
Pre-pelvic length (PPVL)	2.63	5.88	3.98 ± 1.04	33.16%TL	y = 0.3118x + 0.2384	0.9347
Depth of caudal peduncle (DCP)	0.94	2.18	1.38 ± 0.42	11.50%TL	y = 0.1288x - 0.1676	0.9586
Length of caudal peduncle (LCP)	0.97	2.40	1.41 ± 0.43	11.75%TL	y = 0.1262x - 0.109	0.8896
Head length (HL)	2.24	4.80	3.37 ± 0.82	28.08%TL	y = 0.2492x + 0.3852	0.9449
Eye diameter (ED)	0.52	0.97	0.76 ± 0.11	6.33%TL	y = 0.0202x + 0.5174	0.3388
Snout length (SNL)	0.50	1.03	0.78 ± 0.14	6.50%TL	y = 0.0325x + 0.3915	0.5202
Upper jaw length (UJL)	0.46	1.07	0.68 ± 0.16	5.67%TL	y = 0.041x + 0.1869	0.6703
Low jaw length (LJL)	0.32	0.82	0.58 ± 0.13	4.83%TL	y = 0.0329x + 0.1868	0.6310
Caudal fin length (CFL)	1.48	2.69	2.09 ± 0.36	17.41%TL	y = 0.1023x + 0.8671	0.8117
Pectoral fin length (PFL)	1.98	5.23	2.93 ± 0.85	24.41%TL	y = 0.2407x + 0.0499	0.8274
Length of dorsal fin base (LDFB)	3.61	8.03	5.17 ± 1.56	43.08%TL	y = 0.475x - 0.5264	0.9633
Length of anal fin base (LAFB)	1.08	2.29	1.57 ± 0.39	13.08%TL	y = 0.1108x + 0.2374	0.8361

Note: Coefficient of determination (r^2), intercept (a), regression coefficient (b)

Discussion

In the present study, the morphometric characters of *O. niloticus* were calculated to find a relationship, with the total length indicating a linear relationship. Its linear relationship in this species has been reported by several researchers [3,12,15]. Among 18 morphometric characters, some parameters showed the high values of r, meaning these parameters were highly correlated with total length i.e., standard length (r^2 = 0.9605), body depth (r^2 = 0.9319), head length (r^2 = 0.9449), fins: dorsal (r^2 = 0.9633), pectoral (r^2 = 0.8274) anal (r^2 = 0.8361), caudal (r^2 = 0.8117). Thus, the increase of total length synchronized with the different degree of the increase to the above mentioned body parts. This result was similar to the previous reports [3,12,15]. The low values of r also means a low relationship between total length and some parameters i.e., eye diameter (r^2 = 0.3388), snout length (r^2 = 0.5202), upper jaw length (r^2 = 0.6703), and lower jaw length (r^2 = 0.6310), which might be due to the least growth changes in those parameters over the fish size. The morphometric differences between the populations may have appeared due to either genetic differences or environmental factors.

Various researchers have reported the length-weight relationship of Tilapia in different localities and times, as shown in **Table 3**. The present length-weight equation was within a similar range as the previous studies [15-18].

In the present study, the estimate of the parameter (b) was found to be 3.026, within the range for fish suggested by Froese [19]. Thus, the result can be considered to be an adequate estimation of the length-weight relationships.

The length-weight relationship of fish is important in fisheries biology, because it allows the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between the two. It is also useful for assessing the relative well being of the fish population. Length-weight data is often used as an indication of fatness, general well being and regional comparison [20]. Regression coefficients obtained from length-weight relationships which are indicative of isometric or allometric growths differ not only between species, but sometimes also between stocks of same species. The development of fish involves several stages, each of which has its own length-weight relationships. There may also be differences in the relationships due to sex, maturity, season and environmental conditions [15].

Table 3 Comparing length-weight relationship of the present study with past researches.

Country	Species	Equation (log BW = a + b log TL)	Researchers
Thailand	*O. niloticus*	Log BW = 3.026 Log TL - 1.839	Present study
Bangladesh	*O. niloticus*	Log BW = 2.6932 LogTL - 4.0895	[3]
Egypt	*O. niloticus*	Log BW = 2.7480 Log TL - 1.1537	[21]
India	*O. mossambicus*	(Male) Log BW = 2.5225 Log TL - 1.1682 (Female) Log BW = 2.126 Log TL - 0.5052	[22]
Italy	*O. niloticus*	Log BW = 2.506 Log TL(mm) - 3.568	[23]
Kenya	*O. niloticus*	(Male) Log BW = 3.32 Log TL - 2.17 (Female) Log BW = 3.19 Log TL - 1.97	[16]
Nigeria	*O. niloticus*	(Male) Log BW = 3.14 Log TL - 2.03 (Female) Log BW = 2.90 Log TL - 1.96	[15]
Pakistan	*O. mossambicus*	Log BW = 2.93 Log TL - 1.625	[12]
Pakistan	*O. niloticus*	Log BW = 4.55 Log TL - 4.07	[17]
USA	*O. niloticus*	Log BW = 2.992 Log TL(mm) - 4.6675	[18]

Conclusions

The present study provided important information in estimating the growth rate, age structure, and other components of fish population. This morphological data will be helpful for taxonomists, fisheries and biologists concerned with this fish species. Further studies are recommended with a larger sample size from the same and different habitats to validate these results.

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