Research Journal of Fisheries and Hydrobiology, 5(1): 1-8, 2010

Length – weight Relationships of Freshwater Fish Species in Kerian River Basin and Pedu Lake

Mansor Mat Isa, Che Salmah Md Rawi, Rosalina Rosla, Shahrul Anuar Mohd Shah
and Amir Shah Ruddin Md Shah

School of Biological Sciences, Universiti Sains Malaysia, Minden, 11800, Pulau Pinang, MALAYSIA

Abstract: The length-weight relationships of 12 freshwater fish species collected using various mesh size of gill nets and cast nets from Kerian River basin in Perak and Pedu Lake in Kedah were estimated. *Devario regina, Rasbora sumatrana, Puntius binotatus, Labiobarbus lineatus, Cyclocheilichthys apogon* and *Crossocheilus oblongus* were caught from the Kerian River and its tributaries. Meanwhile in the Pedu Lake, there were *Puntius schwanenfeldii, Notopterus notopterus, Chela sp., Mystacoleucus marginatus, Osteochilus microcephalus,* and *Puntius gonionotus.* Fish total length (TL) and standard length (SL) and weight were recorded. The values of constants *a* and *b* were determined from the length and weight data which transform into the linear equation of $lnW=lna+blnL$. These parameters were then fitted to the parabolic equation, $W=aL^b$. The length-weight relationships of fish from both areas were significantly different at P<0.001 and the growth exponents, *b*, for the fishes varied from 2.665 to 4.106. The values show that most of the fishes collected from the Kerian River basin were of positive allometric growth, while the fishes from the Pedu Lake were of negative allometric forms. Based on their scores of growth exponents, the fishes were grouped into light (*b*<3.0), heavy (*b*>3.0) or isometric (*b*=3) indicating poor, over and symmetric growths of length and weight respectively. *Crossocheilus. oblongus* (*b*=2.8854) in the Kerian River basin belonged to the light group as well as *Chela* sp. (*b*=2.6653), *M. marginatus* (*b*=2.7046) and *P. schwanenfeldii* (*b*=2.8635) from the Pedu Lake. The heavy group from the Kerian River basin were *L. lineatus* (*b*=2.9906), *D. regina* (*b*=3.3001), *C. apogon* (*b*=3.5162), *R. sumatrana* (*b*=3.6101) and *P. binotatus* (*b*=4.1063). Meanwhile, in the Pedu Lake, this group of fish included *O. microcephalus* (*b*=3.0541), *P. gonionotus* (*b*=3.2340) and *N. notopterus* (*b*=3.2500). The condition factor of *D. regina* reflecting its well being and degree of fatness, was compared in four Kerian River tributaries using the mean relative condition factor (*Kn*). Sungai Ijok provided a much better habitat for the fish with a *Kn* score of 1.2089±0.1882 followed by Sungai Mahang (1.0472±0.1671), Sungai Kangar (1.0212± 0.2295) and Sungai Selama (0.9105±0.1986). The fish habitat in Sungai Ijok was significantly different from those of Sungai Mahang and Sungai Selama and the habitats at the two latter rivers were statistically different from each other at P<0.05. The values of *a, b* and *Kn* varied with age and sex of the fish, wet and dry seasons, environmental conditions and water bodies as observed in the lotic and lentic environments of the Kerian River basin and Pedu Lake respectively.

Key wards: Freshwater fish species; Kerian River basin; Pedu Lake; length-weight relationships; allometric growth; light and heavy group; relative condition factor.

INTRODUCTION

Length-weight relationships of fishes which are crucial in the fisheries biology and assessments[9,12], estimate the fish's average weight with a given length category by using the mathematical relation[2,26]. The values are important for estimation of number of fish landed at a particular time and comparison of fish species populations caught from various places at similar or different times[26]. In addition, the length-weight relationship indicates the degrees of stabilization of taxonomic characters in fish species and very useful in the management and exploitation of fish populations[18].

Growth of fish, usually indicated through increase in length and weight[13] is the most appropriate characteristic to determine the population analysis at a particular time. The values are used for prediction of growth parameters and fish mortality rate which is essential for fish stock assessment[25]. At the same time, the relationship of length-weight estimates condition factor (c.f.) of the fish species[29,19,11,3,22,27,4] and fish

Corresponding Author: Mansor Mat Isa, School of Biological Sciences, Universiti Sains Malaysia, Minden, 11800, Pulau Pinang, MALAYSIA

biomass through the length frequency[10,27,1,4]. Condition factor refers to the well-being of a certain species and its degree of fatness, which depends on the weight of the fish sampled[17,6]. Different values of the c.f. of a fish indicate the state of sexual maturity, the degree of food sources availability, age and sex of some species[28] and the system of environment[5]. In addition, the effect of environmental changes on fish species is also reflected through the score of fish condition factor.

Presently, there are limited studies done on the freshwater fishes in Malaysia which emphasises on the length-weight relationship, condition factor and their relation to the environmental conditions. Therefore this study aims to describe the length-weight relationship of the 12 species of freshwater fish in the Kerian River Basin in Perak and Pedu Lake in Kedah. These two areas, maintained good stock of freshwater fish mainly for local consumption and as a source side income for residents in the areas. The Kerian river basin had undergone massive environmental changes due to development of infra structures and residential areas in various parts of the basin. Active sand mining are on going in several rivers such as Damak and Ijok, two of the Kerian River tributaries. In Pedu Lake, an exotic Tilapia fish was reared in cages as to increase the productivity of the lake. The growth parameters and condition factor of the major fish species, *Devario regina* captured from several rivers in the Kerian river basin were studied for evaluation of the status of the fish habitats in the rivers.

MATERIALS AND METHODS

Sampling Area: The fish samples were obtained from the two different locations *i.e.* the Kerian River Basin in Perak and Pedu Lake in Kedah.

The Kerian River Basin is located at the borders of two states; Kedah and Perak, at *5° 9' - 5°21' N* and *100° 36.5' - 100°47.8' E*. The river basin can be devided into three zones; upper, middle and lower zone (Fig. 1). The upper zone consisting of Mahang, Kangar, Upper Kerian and Selama rivers and the middle zone consists of Middle Kerian, Serdang and Ijok rivers. Bogak river is located in the lower zone. The Kerian River streams down to the Kerian Valley in Perak while Selama River meets Kerian River at the middle of the basin and flowing across forest, rubber and oil palm plantations. The Kerian River Basin supplies water to the people living downstream.

The Pedu Lake (Fig. 1) is located at the state of Kedah Darul Aman and lies at latitude 6° and 15', longitude of 100° and 46' at an altitude of 59.0 meters above the sea level. The Pedu Lake is a man-made lake with 64 km^2 in water surface area and surrounded by tropical rainforest. The Pedu Lake acts as a water storage for human consumption as well as for irrigations of paddy fields on the flat plains of Kedah.

Sampling of Fish: Monthly samplings of fish species in the Kerian River Basin were conducted from May 2008 to December 2008. Eight rivers were selected as sampling sites; Sungai Mahang, Sungai Kangar, Sungai Selama, Sungai Kerian (upper stream),in the upper zone, Sungai Kerian- middle and Sungai Serdang in the middle zone and Sungai Bogak and Sungai Ijok in the lower zone (Fig. 1). The fish were extracted from the water using a pair of cast nets with mesh size of 2cm-streched, 2.5m long and 2.5m radius. A scoop net with a frame of 30cm x 40cm and 0.3cm mesh size, was used especially in areas of shallow, narrow and fast flowing water with rocky and pebble bottom.

Meanwhile at the Pedu lake the sampling was conducted from April 2008 to December 2008 by using various mesh size of gill nets ranging from 2.5, 3.1, 4.4, 5.0, 6.3, 7.5, 8.8 and 10cm. The sampling stations were shown in Fig. 1. The gill net was put up at 0600 hrs. and collected at 1800 hrs. for day catching. Meanwhile for the night catching, the net was placed at 1800hrs and collected at 0600 hrs.

The fish obtained from both sampling locations were identified using Mohsin and Ambak[16] and the FISHBASE (www.fishbase.com) online fish identification sheet. The identification was done *in-situ* when possible. The length measurements of the samples were recorded as total length (TL), standard length (SL) in cm and the fish was weighed (W) to the nearest 0.1g.

Length-Weight Relationships (LWR): The LWR was estimated by using the equation $W=aL^b$[20]. The value of constants *a* and the slope *b* were estimated from the *ln* transform values of length and weight *i.e.* $\ln W = \ln a + b \ln L$, the least square linear regression[30]. The condition factor was calculated by using the formula $c.f.=100W/L^3$[17]; where *W*=weight of fish and *L*=total length of fish. All data on LWR of different fish species were subjected to t-test analysis at $P<0.001$[30].

Fish Grouping: The body shape/weight of fish species was determined using Smith[24], where the analysed samples were classified into three groups *i.e.* light, isometric and heavy. The light group was determined when the value of $b<3.0$. In this group, the length growth is not proportionate to the increase in weight. When the weight gain is more than an increase in length, the fish falls in heavy group with $b> 3.0$. The ideal value of $b = 3.0$ indicates the fish are having the isometric growth of equal increment of both parameters[21].

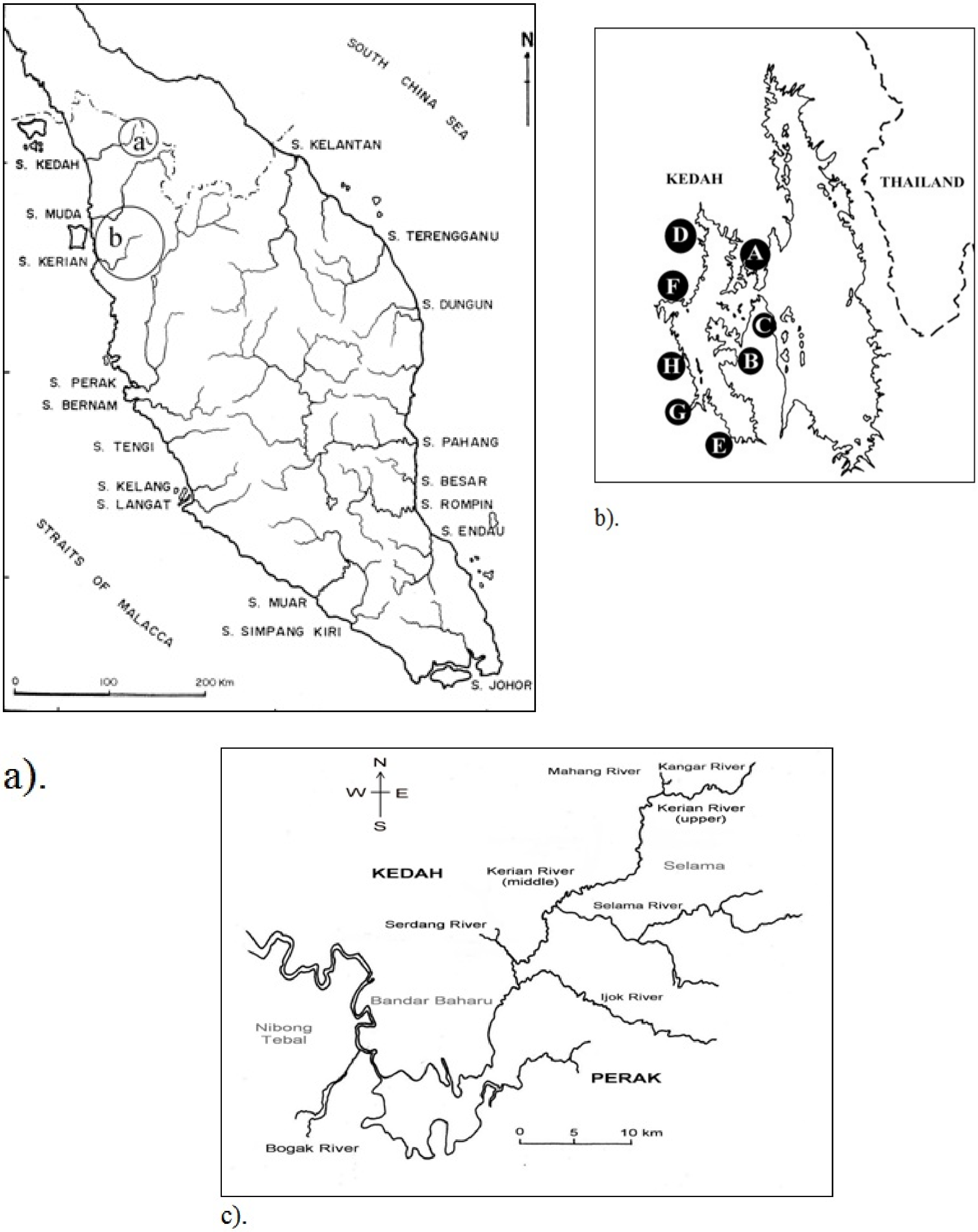

Fig. 1: Map of the Malay Pennisular (a) showing sampling station in Pedu Lake (b) in Kedah and the Kerian River Basin (c) in Perak. Mahang, Kangar and Kerian upper and Selama rivers are in the Upper zone. Kerian river (middle) and Serdang rivers are in the middle and Ijok and Bogak rivers in the lower zone of the basin.

Relative Condition Factor (*Kn*): The relative condition factor $Kn=100*W/W'$; where *W*= observed weight of individual fish in grams and *W'* is aL^b (expected weight of fish), *b* is the value calculated from the equation $W=aL^b$[6]. The relative condition factor, *Kn*, was used to compare the condition of fish between rivers or different sampling sites in the Kerian River Basin. *Devario regina* was selected for this purpose using the ANOVA. The significant *Kn's* were futher analysed using the Tukey Test to compare the well being of the species from different sampling sites at P=0.001[30].

RESULTS AND DISCUSSION

The length-weight distribution of the 12 freshwater species in the Kerian River basin and Pedu Lake were tabulated in Table 1. Six major fish species collected from each of the Kerian River basin and Pedu Lake were chosen for the detailed analysis. The lengths ranged from 4.9 to 47.0cm while the weights were between 1.0 and 850.0g. *Puntius schwanenfeldii* had the highest number of fish sample, n=246 with the maximum TL=47.0cm and W=850.0g. *Puntius gonionotus* was the n=32, with sizes ranging from 10.1 to 30.8cm in TL. *Devario regina* was the smallest size group, ranging from 4.9 to 10.8cm in TL and weight ranging between 1 and 11g. The largest species was *Notopterus notopterus* with the TL ranging from 15.4 to 26.4cm and weight ranging between 31 and 158g.

Length-Weight Relationships (LWR): The linear relationship $ln\ W = ln\ a + b\ ln\ L$ by the least square method[31] was used to obtain the constant values of *a* (intercept) and *b* (slope) in the parabolic equation of $W = aL^b$. The example of the parabolic form of growth (Fig. 2a) and the linear form (Fig 2b) of *P. binotatus* in the Kerian Rivers was $W = 0.0011\ L^{4.1063}$ and $lnW= -6.8306+4.1063Ln\ TL$ respectively, while Fig. 3a and Fig. 3b showed the example of the LRW of *P. schwanenfeldii* in Pedu Lake, $W=0.0122L^{2.992}$, $lnW=-4.4029+2.992lnTL$ respectively.

Fish Grouping: The regression analysis yielded the values of *b* (Table 2) ranging from 2.66 (*Chela* sp.) to 4.1063 (*L. lineatus*). The pattern of growth, increasing length and weight of various species of fish showed that the greater the length, the heavier the weight. This positive pattern of growth was also reflected by the increase of the values of *b*. After grouping, the fish species from the Kerian River basin were mostly fell into heavy category as compared to those from the Pedu Lake. This situation might be related to the distinct nature of the rivers and lakes. The running water in the rivers has greater supply of food whereas the lakes usually have limited variation of food content in the water.

Relative Condition Factor (*Kn*) of *Devario regina*: The values of mean relative condition factor (*Kn*) of *D. regina* (Table 2) in four rivers were ranged from 0.9105±0.1986 in Sungai Selama to 1.2090±0.1882 in Sungai Ijok while the length ranging from 6.0cm to 6.5cm and the weight ranging between 9.3g and 10.8g (Table 3).

The Tukey test was subsequently performed at P<0.05 to assess differences of fish condition which strongly related to the suitability of habitats in the four rivers. There were significant differences of mean *Kn* values between Sungai Ijok (1.2090 ± 0.1882) and Sungai Mahang (1.0472 ± 0.1671) where the $q_c > q_t$ = 3.8836>3.74, Sungai Ijok and Sungai Selama (0.9105 ± 0.1986) where $q_c > q_t$ = 6.8219>3.74 and Sungai Mahang and Sungai Selama where $q_c > q_t$ = 4.8326>3.74. Meanwhile, the habitat in Sungai Ijok has no difference to that of Sungai Kangar (1.0212 ± 0.2295) as the value of $q_c < q_t$ = 3.2567<3.74 and not statistically significant at P<0.05. Similarly, Sungai Kangar and Sungai Selama ($q_c < q_t$ = 2.2647<3.74) and Sungai Kangar and Sungai Mahang ($q_c < q_t$ = 0.5528<3.74), both were without statistical significance at P<0.05.

Discussion: The length-weight distributions of fishes from both locations; the Kerian River basin and Pedu Lake showed considerably large variations in fish sizes indicating that the samplings with gill nets were carried out efficiently. Additional collection using cast nets and scoop net increased catching efficiency with consistent effort which reduced the bias of sampling especially in the Kerian River and its tributaries with flowing water. Selection of mesh size of nets also contributed to the minimum-maximum length of fish caught (4.9-47cm) hence the weight which ranged from 1 to 850g. 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[8,6].

The slopes (*b*) of the fish L-W regression lines from both Pedu Lake and Kerian River basin fell within 2.8 and 4.1. According to Pervin and Mortuza[18], these values usually ranged from 2.5 to 4.0 for many fish species. When *b = 3*, the fish grows isometrically resulting in ideal shape of fish such as observed for *L. lineatus* and *O. microcephalus* in both areas in this study. When the value of *b* is less than 3.0, the fish experiences a negative allometric growth[18,26]. *Crossocheilus oblongus* from Kerian River and *Chela* sp., *M. marginatus* and *P. schwanenfeldii* from Pedu Lake suffered from this pattern of growth.

Table 1: Estimated parameters of the length-weight relationships for 12 fish species in Kerian River and Pedu Lake. n= number of samples, min= minimum, max= maximum, a= intercept of regression line, b= slope of regression line, S.E = Standard Error, Cl= confidence level, R^2= regression coefficient, PA= positive allometric, IS= isometric, NA= negative allometric.

Locations		Family/Species	n	Total Length (cm) min	max	Weight (g) min	max	ln a	b	S.E. of b	95% of C.I.	R^2
Kerian River	*Cyprinidae*	*Devario regina*	112	4.9	10.8	1	11	-5.1673	3.3001	0.130	3.074-3.588	0.88*
		Rasbora sumatrana	77	5.1	11.6	1	16	-5.9915	3.6102	0.155	3.300-3.919	0.88*
		Puntius binotatus	76	5.0	12.6	1	32	-6.8124	4.1063	0.120	3.868-4.344	0.94*
		Labiobarbus lineatus	58	6.5	23.0	3	135	-4.6565	2.9906	0.082	2.826-3.155	0.96*
		Cyclocheilichthys apogon	46	5.7	14.0	1	39	-5.7138	3.5162	0.133	3.248-3.784	0.94*
		Crossocheilus oblongus	46	8.3	15.0	4	25	-4.5469	2.8855	0.152	2.701-3.312	0.91*
Pedu Lake	*Cyprinidae*	*Puntius schwanenfeldii*	246	6.7	47.0	3	850	-4.0864	2.8635	0.048	2.769-2.958	0.94*
		Chela sp.	88	10.6	22.6	57	54	-4.1477	2.6653	0.140	2.388-2.943	0.81*
		Mystacoleucus marginatus	65	8.2	11.5	6	17	-3.7723	2.7046	0.188	2.329-3.081	0.77*
		Osteochilus microcephalus	35	13.0	21.0	19	82	-4.8929	3.0541	0.223	2.601-3.507	0.85*
		Puntius gonionotus	32	10.1	30.8	12	429	-5.1499	3.2340	0.073	3.086-3.382	0.99*
	Notopteridae	*Notopterus notopterus*	120	15.4	26.4	31	158	-5.6268	3.2500	0.084	3.082-3.417	0.93*

*significant p<0.001

Table 2: Fish grouping in Kerian River and Pedu Lake based on the value of *b*, slope of the linear equation; *b*<3.0 = light group (NA) while *b*>3.0 = heavy group (PA).

Sampling Site	Group	Fish species	*b*, slope of regression	Growth pattern	$W=aL^b$
Kerian River	Light	*Crossocheilus oblongus*	2.8854	NA	$W=0.0106L^{2.8855}$
	Isometric	*Labiobarbus lineatus*	2.9906	IS	$W=0.0095L^{2.9906}$
	Heavy	*Devario regina*	3.3001	PA	$W=0.0057L^{3.3001}$
	Heavy	*Cyclocheilichthys apogon*	3.5161	PA	$W=0.0033L^{3.5162}$
	Heavy	*Rasbora sumatranus*	3.6101	PA	$W=0.0025L^{3.6102}$
	Heavy	*Puntius binotatus*	4.1062	PA	$W=0.0011L^{4.1063}$
Pedu Lake	Light	*Chela sp.*	2.6652	NA	$W=0.0158L^{2.6653}$
	Light	*Mystacoleucus marginatus*	2.7045	NA	$W=0.0230L^{2.7046}$
	Light	*Puntius schwanenfeldii*	2.8634	NA	$W=0.0168L^{2.8635}$
	Isometric	*Osteochilus microcephalus*	3.0541	IS	$W=0.0075L^{3.0541}$
	Heavy	*Puntius gonionotus*	3.2340	PA	$W=0.0058L^{3.2340}$
	Heavy	*Notopterus notopterus*	3.2500	PA	$W=0.0036L^{3.2500}$

Table 3: Growth performance of *Devario regina* (TL, W, *b*) and their values of mean relative factor with standard deviation (*Kn* ± s.d) collected from four different sampling sites in the Kerian River basin.

Sampling sites	TL=Total Length (cm) min	max	W=Weight (g) min	max	Mean *Kn*±s.d.	b, slope of regression
Sungai Ijok	6.0	10.0	3.0	12.0	1.2090±0.1882	2.7651
Sungai Kangar	4.9	9.7	1.0	11.0	1.0212±0.2295	3.5746
Sungai Mahang	6.5	10.8	2.0	9.0	1.0472±0.1671	3.2116
Sungai Selama (upstream)	6.5	9.3	3.0	8.0	0.9105±0.1986	3.1582

When the value of *b* is more than 3.0, the fish grow following the positive allometric pattern. Several fish species such as *D. regina, C. apogon, R. sumatrana* and *P. binotatus* in Kerian River and *P. gonionotus* and *N. notopterus* in Pedu Lake had positive allometric growth. As the values of *b* increases, the size of the fish also increases because the fish usually grows proportionately in all directions. However, the changes in fish weight in general are actually greater than the changes in its length. However, the body shape of fish tends to change as the length increases. The value of *b* then becomes greater than 3 as the fish

Table 4: The Tukey Test result comparing the mean *Kn* of the rivers, S.E: standard error, q_c: calculated value by dividing the difference between error mean square (s^2) with n = number of data in each rivers, q_t: critical value from *F*-Table, *sl*: significance level (P), *v*: error degree of freedom (*df*) and *k*: total number of means being tested.

Comparison between rivers A and B	Difference (*Kn A- Kn B)*	S.E	q_c	q_t (*sl,v, k*) q_t (0.05, 60, 4)	Conclusion
Sg.Ijok vs Sg. Kangar	0.1878	0.0577	3.2567	3.74	NS
Sg.Ijok vs Sg. Mahang	0.1618	0.0417	3.8836	3.74	*
Sg. Ijok vs Sg. Selama	0.2985	0.0438	6.8219	3.74	*
Sg. Kangar vs Sg. Selama	0.1107	0.0489	2.2647	3.74	NS
Sg. Mahang vs Sg. Kangar	0.0260	0.0470	0.5528	3.74	NS
Sg. Mahang vs Sg. Selama	0.1367	0.0283	4.8326	3.74	*

* significant at P<0.05; NS = not significant at P<0.05

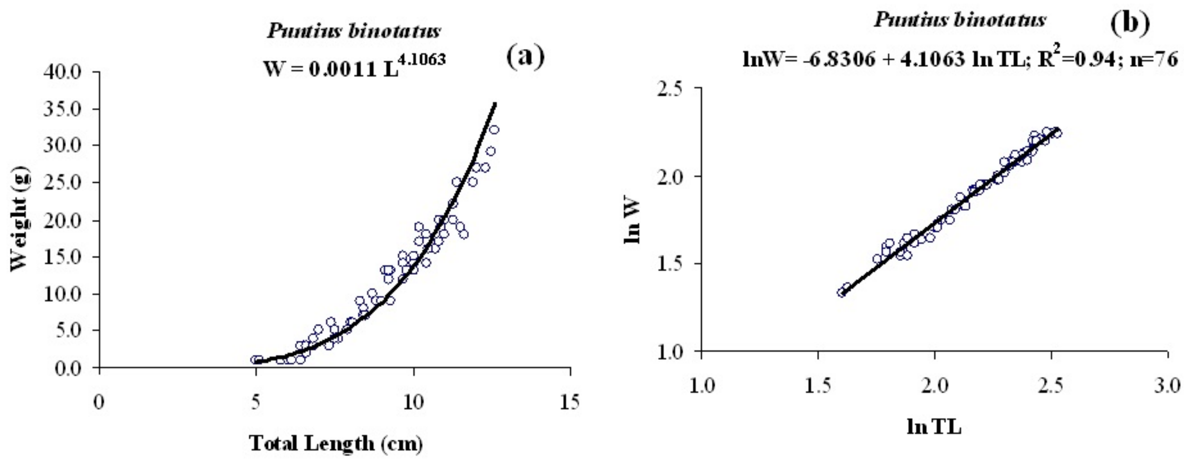

Fig. 2: Length-weight relationships of *P. binotatus* from the Kerian River Basin, parabolic form (a); $W = 0.0011 L^{4.1063}$ and linear form (b); $lnW = -6.8306 + 4.1063\ lnTL$.

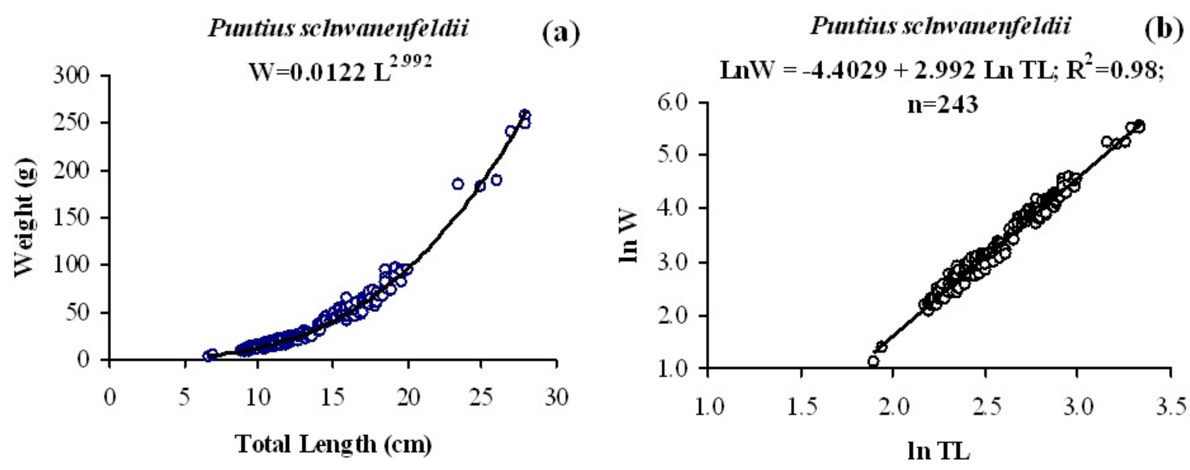

Fig. 3: Length-weight relationships of *P. schwanenfeldii* from Pedu Lake, parabolic form (a); $W=0.0122\ L^{2.992}$ and linear form (b); $lnW = -4.4029 + 2.992\ lnTL$.

becomes fatter, or when the *b* value is lower than 3, the fish is slimmer[13].

The slope of the regression lines of length and weights (*b*) in Table 2 show 4 species of fish from the Kerian River Basin were in the heavy groups while only 3 species from the Pedu Lake experienced the same growth pattern. One species from both areas had grown isometrically and the rest of them were placed in the light group. This grouping which reflects the pattern of growth of fish was widely accepted[21,4]. However, based on the length-weight relationship of 16 species of freshwater fishes from Sabah in Malaysia, Smith[24] adopted two groups; flattened group when the values of *b* ranged from 2.65 to 2.75 and heavy bodied when *b* approached 2.91 to 3.06.

In his study in Sabah, Smith[24] reported that *R. sumatrana* had negative allometric growth with a slope of *b* = 2.748 and was placed in the flattened group. However, in the Kerian River basin *R. sumatrana* fell in the heavy group with a *b* value of 3.6102 (R^2 = 0.8779, P<0.05). Many factors could contribute to the differences of growth of fish such as differences of habitat, fish activities, food habits and seasonal growth rates[14,15]. Other factors such as temperature, trophic level and food availability in the community were also important. At least some of the factors listed were likely to be different in habitats of *R. sumatrana* in Sabah and in Peninsular Malaysia particularly in Kerian River hence affecting the growth performance of the species. Certainly, *Rasbora* was reported to be more predominant in acidic, unproductive forest streams and blackwaters[14] such as found in the Kerian River and the European cyprinids prefer more productive waters. On the other hand, *O. microcephalus* from both Sabah[24] and Pedu Lake belonged to a similar group. The conditions of fish habitats therefore strongly influenced the growth performances of fish inhabiting the area.

Since the length-weight relationships is very useful in assessing the well-being of fish[13], the value of *b* has a strong relationship with the mean *Kn* values as observed in four sampling sites in the Kerian River basin; Sungai Ijok (K*n* = 1.2090 ± 0.1882), Sungai Kangar (1.0212 ± 0.2295), Sungai Mahang (1.0472 ± 0.1671) and Sungai Selama (0.9105 ± 0.1986). The differences in the scores resulted in habitat differences in each river which were statistically significant at P<0.05.

The mean *Kn* values of *D. regina* varied significantly (P<0.05) in the four rivers of the Kerian river basin. For that reason, *D. regina* in Sungai Ijok, Sungai Mahang and Sungai Selama may not belong to the same population. Infact, they could have originated from different river systems with dissimilar food availability. However there was no significant difference of mean *Kn* between Sungai Ijok and Sungai Kangar, Sungai Kangar and Sungai Selama and also between Sungai Kangar and Sungai Mahang indicating fairly similar habitats and food availability in these rivers.

When studying a freshwater fish, *Labeo boga,* Pervin and Mortuza[18] found that this species' length and weight grew according to the cube law, having high value of *b*. They agreed that appetite condition and gonadal content of the female contributed to high value of *Kn*. Differences between sexes due to feeding intensity[23,18] and depth of water influence the *Kn* value to some extent. Fish living in deep water (sea) which are characterized by permanent darkness, low temperature and low productivity and having intense pressure, tend to have a negative allometric growth as compared to the coastal species inhibiting lesser depths[26].

In conclusion, the present studies found that each species of fish inhabiting the Pedu Lake and Kerian River Basin had different length and weight relationship due to factors such as differences in length and body weight, differences in food availability in lotic and lentic environments and other environmental conditions. More fish species in the Kerian River basin had positive allometric growth as compared to those in the Pedu Lake. The growth performance of *D. regina* was significantly different in Sungai Ijok, Sungai Mahang and Sungai Selama which translated into dissimilar habitat suitability and productivity. More studies on fish population biology in near future are vital for better understanding on factors influencing fish growth in various habitas in Malaysian water bodies.

ACKNOWLEDGMENT

We would like to thank Universiti Sains Malaysia for providing physical facilities to carry out this research. This study would not have been possible without the support, cooperation and active involvement of the staff of School of Biological Sciences and the final year students, Saiful and Mohd Khairun Kamarudin, who had tirelessly collected the fresh water fish species in the fields. These projects were funded by the Research Grants 1001/PBIOLOGI/815019 for the Kerian River basin and 1001/ PBIOLOGI//815008 for Pedu Lake.

REFERENCES

1. Ayoade, A.A. and A.O.O. Ikulala, 2007. Length weight relationship, condition factor and stomach contents of *Hemichromis bimaculatus*, *Sarotherodon melanotheron* and *Chromidotilapia guentheri* (Perciformes: Cichlidae) in Eleiyele Lake, Southwestern Nigeria. Rev. Biol. Trop., 55(3-4): 969-977.
2. Beyer, J.E., 1987. On length-weight relationship. Part 1: Computing the mean weight of the fish of a given length class. Fishbyte, 5: 11-13.
3. Binohlan, C. and D. Pauly, 1998. The length-weight table. In Fishbase 1998: concepts, design and data sources. Froese, R. and Pauly, D. (eds.). ICLARM, Manila, pp: 121-123.

4. Cherif, M., R. Zarrad, H. Gharbi, H. Missaoui, and O. Jarboui, 2008. Length-weight relationships for 11 fish species from the Gulf of Tunis (SW Mediterranean Sea, Tunisia). Pan-American J. of Aquatic Sciences, 3(1): 1-5.
5. Dhakal, A. and B.R. Subba, 2003. Length-weight relationship of *Lepidocephalichthys guntea* of Pathri Khola, Morang District. Our Nature, 53-57.
6. Fafioye, O.O. and O.A. Oluajo, 2005. Length-weight relationships of five fish species in Epe lagoon, Nigeria. African J. Biotechnology, 4(7): 749-751.
7. FISHBASE (www.fishbase.com).
8. Frota, L.O., P.A.S. Costa and A.C. Braga, 2004. Length-weight relationship of marine fishes from the central Brazilian coast. NAGA, ICLARM Q. 27(1&2): 20-26.
9. Garcia, C.B., J.O. Buarte, N. Sandoval, D. Von Schiller, P. Najavas, 1989. Length-weight Relationships of Demersal Fishes from the Gulf of Salamanca. Colombia Fishbyte, 21: 30-32.
10. Gayanilo Jr., F.C., P. Sparre and D. Pauly, 1997. The FAO-ICLARM Stock Assessment Tools (FiSAT). FAO Computeriszed Information Series (Fisheries). No.8. Rome, FAO.
11. Goncalves, J.M.S., L. Bentes, P.G. Lino, J. Riberio, A.V.M. Canario and K. Erzini, 1996. Weight-length relationships for selected fish species of the small scale demersal fisheries of the south and south-west coast of Portugal. Fish. Res., 30: 253-256.
12. Haimovici, M. and G. Velasco, 2000. Length-weight relationships of marine fishes from souther Brazil. The ICLARM Quartely, 23(1): 14-16.
13. Jobling, M., 2002. Environmental factors and rates of development and growth. In Handbook of Fosh Biology and Fisheries, 1. Hart, P.J.B, and Reynolds, J.D. (eds.). Blackwell Publishing, pp: 107-109.
14. Lowe-McConnell, R.H., 1987. Ecological studies in tropical fish communities. Cambridge University Press, London, pp: 159-173.
15. Mizuno, N. and J.I. Furtado, 1982. Ecological notes on fishes. *In:* Tasek Bera. The Ecology of a freshwater swamp. Furtado, J.I., and Mori, S. (eds.). Monographiae Biologicae, no. 47. The Hague: Dr W. Junk, pp: 321-354.
16. Mokhsin, A.K.M. and M.A. Ambak, 1983. Freshwater fishes of Peninsular Malaysia. Penerbit Universiti Pertanian Malaysia.
17. Pauly, D., 1983. Some simple methods for the assessment of tropical fish stocks. FAO. Fisheries Techn. Pap. (234) FAO, Rome.
18. Pervin, M.R. and M.G. Mortuza, 2008. Notes on length-weight relationship and condition factor of freshwater fish, *Labeo boga* (Hamilton) (Cypriniformes: Cyprinidae). Univ. j. zool. Rajshahi Univ., 27: 97-98.
19. Petrakis, G. and K.I. Stergiou, 1995. Weight-length relationships for 33 fish species in Greek waters. Fish. Res., 21: 465-469.
20. Ricker, W.E., 1973. Linear regression in fisheries research. J. Fish. Res. Board Can., 30: 409-434.
21. Salam, A., M. Naeem and S. Kauser, 2005. Weight length and condition factor relationship of a freshwater wild *Puntius chola* from Islamabad, Pakistan. J. of Biol. Sciences, 8(8): 1112-1114.
22. Schneider, J.C., P.W. Laarman and H. Gowing, 2000. Length-weight relationships. Chapter 17. *In*: Manual of fisheries survey methods II: with periodic updates. Schneider, J.C. (ed). Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor., pp: 1-16.
23. Shafi, M. and M.M. Quddus, 1974. Length-weight relationship and condition factor in *Hilsa hilsa* (Hamilton) (Clupeiformes: Clupeidae). Bangladesh J. Zool., 2(2): 179-185.
24. Smith, K.M.M., 1996. Length/weight relationships of fishes in a diverse tropical freshwater community, Sabah, Malaysia. J. of Fish Biology, 49: 731-734.
25. Sparre, P. and S.C. Venema, 1998. Introduction to Tropical Fish Stock Assessment, Part 1: Manual. FAO Fisheries Technical Paper 306/1, pp: 433.
26. Thomas, J., S. Venu and B.M. Kurup, 2003. Length- weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the West Coast of India. NAGA, WorldFish Center Quaterly, 26(2): 17-21.
27. Tsoumani, M., R. Liasko, P. Moutsaki, I. Kagalou, and I. Leonardos, 2006. Length-weight relationships of an invasive cyprinid fish (*Carassius gibelio*) from 12 Greek lakes in relation to their trophic states. J. Appl. Ichthyol., 22: 281-284.
28. Williams, J.E., 2000. The coefficient of condition of fish. Chapter 13. *In*: Manual of Fisheries Survey Methods II: with periodic updates. Schneider, J.C. (ed.). Michigan Dep. of Natural Resources, Fisheries Special Report 25, Ann Arbor.
29. Wooton, J.R., 1990. Ecology of teleost fishes. Chapman & Hall, London, England.
30. Zar, J.H., 1984. Biostatistical analysis. Prentice Hall, New Jersey, pp: 718.
31. Zar, J.H., 1999. Biostatistical analysis. Prentice Hall, New Jersey, pp: 210-214.