Research Journal of Biological Sciences 4 (9): 994-1009, 2009
ISSN: 1815-8846

The Physical-Chemical and Morphological Study of Haruan *Channa striatus* in Peninsular Malaysia

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Abstract: Haruan, the local name for snakehead *Channa striatus*, indigenous to Malaysia, is a tropical and air breathing carnivorous fresh water fish in the family Channidae, which have important economics value as consumption's fish and medicine value. In this study, a total of 120 specimens of Haruan *Channa striatus* were collected from the sampling stations in Johor, Kedah, Kelantan, Pahang, Perak and Terengganu. The result of physical-chemical parameters of the natural habitat were mainly Dissolved Oxygen (DO) within range from 2.62-33.70 mg L^{-1}; pH between 5.16-6.90; temperature within 29.43-31.86°C; turbidity of the water between -10.00 to 14.57 NTU; conductivity of 0.06-0.97 mS cm^{-1} and salinity of 0-20 ppt. In the mixed populations, length weight relationships indicated the pattern of negative allometric type of growth (b<3). The result shows that the length of frequency distribution by populations from Johor, Kedah, Kelantan, Pahang, Perak and Terengganu were 25.97±2.88, 29.97±4.75, 31.52±3.32, 27.74±3.16, 30.34±2.87 and 29.53±6.67 cm TL, respectively. Variation in twenty four morphometric characteristics of Haruan *C. striatus* were examined by multivariate analysis. The discriminant analysis and the Unweighted Pair Group Method with Arithmeric averaging (UPGMA) cluster analysis based on Mahalanobis distance between group centroids showed that populations at Kelantan, Perak and Terengganu had quite similar morphological distant, while Johor, Kedah and Pahang were rather different. Such measurements are useful in the management of different cultures of Haruan *C. striatus* for Good Agriculture Practices (GAP) in farming technology, as well as the basic for Good Manufacturing Practices (GMP) production.

Key words: Haruan, *Channa striatus*, multivariate analysis, morphometric, meristic, stock identification, population structure

INTRODUCTION

Haruan, the local name for snakehead *Channa striatus*, indigenous to Malaysia, is a tropical and air breathing carnivorous fresh water fish in the family Channidae. There are altogether 30 species in the family reported in the world and eight of them were found in Malaysia including Toman *C. micropeltes*, Bujuk *C. lucius* and Haruan *C. striatus*. Members of the family are also found in all ASEAN countries namely Myanmar, Thailand, Laos, Cambodia, Vietnam, Brunei, Philippines, Indonesia and Singapore (Mat Jais, 1997).

Haruan in particular has the diploid chromosome number of *C. striatus* was 2n = 44 (Donsakul and Magtoon, 1991). The Haruan is a wild species found in small rivers, lakes, pools and shallow water body and in their natural habitats can survive in harsh environments with low dissolved oxygen and high ammonia (Marimuthu and Haniffa, 2007). Such Haruan *C. striatus* is known to exhibit high levels of cannibalism as juveniles, where the fish was associated with heterogeneous size variation, limited food availability, high population densities, limited refuge areas and light conditions (Qin and Fast, 1996). The fish for many decades had been known traditionally as remedy for wound healing. People in Malaysia and most other countries consumed Haruan *C. striatus* as source of protein to induce healing after giving birth and now becoming supplementary among caesarean mothers and illnesses such as cancer and diabetic gangrene (Mat Jais *et al*., 1994; Mat Jeis, 1997). Haruan *C. striatus* are in great demand in the local domestic markets and

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detailed knowledge on the population structure of Haruan *C. striatus* is needed for sound management and successful commercial fishing of this species.

Morphometric analysis has been very useful for separated rating species, populations and races in the past have been widely used for the identification of different fish stocks. Such morphometric study of fish populations are very important for understanding the interactive effect of environment, selection and heredity on the body shapes and sizes within a species (Saini *et al*., 2008). Meristic characters are the number of discrete, serially repeated, countable structures that are fixed in embryos or larvae. Studies of morphologic variation between populations continue to have an important role to play in stock identification, while stable difference in shape between groups of fish may reveal different growth, mortality or reproductive rates that are relevant for the definition of stocks (Turan *et al*., 2006). Length-Weight Relationships (LWR) provide basic information in fisheries biology, being useful to determine the weight of an individual fish of known length or total weight from length-frequency distribution and to compare specific growth among different regions. This relationship was initially used to obtain information on the growth condition of fish and to find out whether the somatic growth was isometric or allometric (Heydranejad, 2009).

Given the growing polar importance of Haruan *C. striatus*, detailed morphometric studies on this species are required and provide an important first step in what well surely become as specification and standard in a Good Agriculture Practices (GAP) for farming technology. Therefore, the present study aimed to determine the morphometric differences in six populations selected in Peninsular Malaysia. The objective of the present study was to find out the data and information of aspects, which include the relationship of length-weight relationships; size-frequency distribution, measurement morphometric and meristic study and water quality of different geographical populations in several populations in Peninsular Malaysia elucidate morphometric variations in this species to support and standard in Good Agriculture Practices for farming technology. Morphometric variations between stocks can provide a basis for stock structure and might be useful for studying short-term, environmentally induced variation, for example, in fisheries management (Begg *et al*., 1999).

MATERIALS AND METHODS

Sample collections: In this study, a total of 120 specimens of Haruan *C. striatus* (20.60-44.10 cm total body length) were collected from the sampling stations namely Sungai Petani, Kedah (N 5°38'33.33" and E 100°28'09.27"); Bagan Datoh, Perak (N 3°57'51.31" and E 100°45'13.51"); Kuantan, Pahang (N 3°49'48.45" and E 103°19'15.53"); Pontian, Johor (N 1°29'14.93" and E 103°23'57.85"); Kuala Terengganu, Terengganu (N 5°19'29.40" and E 103°08'27.29") and Tanah Merah, Kelantan (N 5°48'21.80" and E 102°09'17.17") in part of Peninsular Malaysia. These stations were selected base on geographical distances and previous studied (Ambak *et al*., 2006). The fish were transported to the laboratory for further analysis, excepted for Kedah and Terengganu were done on the spot at the stations.

In the laboratory, the fish were placed in an aquarium and the next day the fish were killed on the spot with ice (Nuove Technologie Del Freddo Ice Makers). After morphometric and meristic were done, the heart, liver, eggs (if available) and fillet were preserved in 95% ethanol (HmbG Chemicals, 2.5L) for further genetic marker analysis. The specimens were deposited at Faculty of Medicine and Health Sciences, University Putra Malaysia from July 2007 to January 2008. Distribution of fish into six groups in accordance with the total length of the body was done namely Johor 21.90-31.80 cm (20 specimens); Kedah 22.00-40.40 cm (20 specimens); Kelantan 24.50-37.70 cm (20 specimens); Pahang 23.20-35.50 cm (20 specimens); Perak 24.20-35.40 cm (20 specimens) and Terengganu 20.60-44.10 cm (20 specimens).

Water parameters: Physical-chemical measurements were analyzed at the lower source of the water body (between 0.3-0.5 m depth of below water surface) at stations including pH, conductivity (mS cm^{-1}), turbidity (NTU), dissolved oxygen (mg L^{-1}), temperature (°C) and salinity (ppt) using a Horiba U-10 Water Quality Checker. Physical-chemical variables measured of these stations are shown in Fig. 1.

Morphological identification: In total 5 meristic characters and 24 morphometric measurements were selected for comparisons. These are standard length, dorsal fin rays (D), Pectoral fin rays (P_1), Pelvic fin rays (P_2), anal fin rays (A), Caudal fin rays (C), total number in percentage of Standard Length (SL), Pre-Anal Length (PAL), Pre-Pelvic Length (PPelL), Pre-Pectoral Length (PPecL), Caudal Peduncle Length (CPL), Caudal Peduncle Depth (CPD), Body Depth (BD), Head Length (HL), Head Width (HW), Head Depth (HD), Dorsal-Fin Base Length (DFBL), Anal-Fin Length (AFL), Pelvic-Fin Length (PelFL), Pectoral-Fin Length (PecFL), Caudal-Fin Length (CFL), Caudal-Fin Height (CFH), Fork Length (FL), Total Length (TL), Pre-Dorsal Length (PDL), Dorsal Spine Length

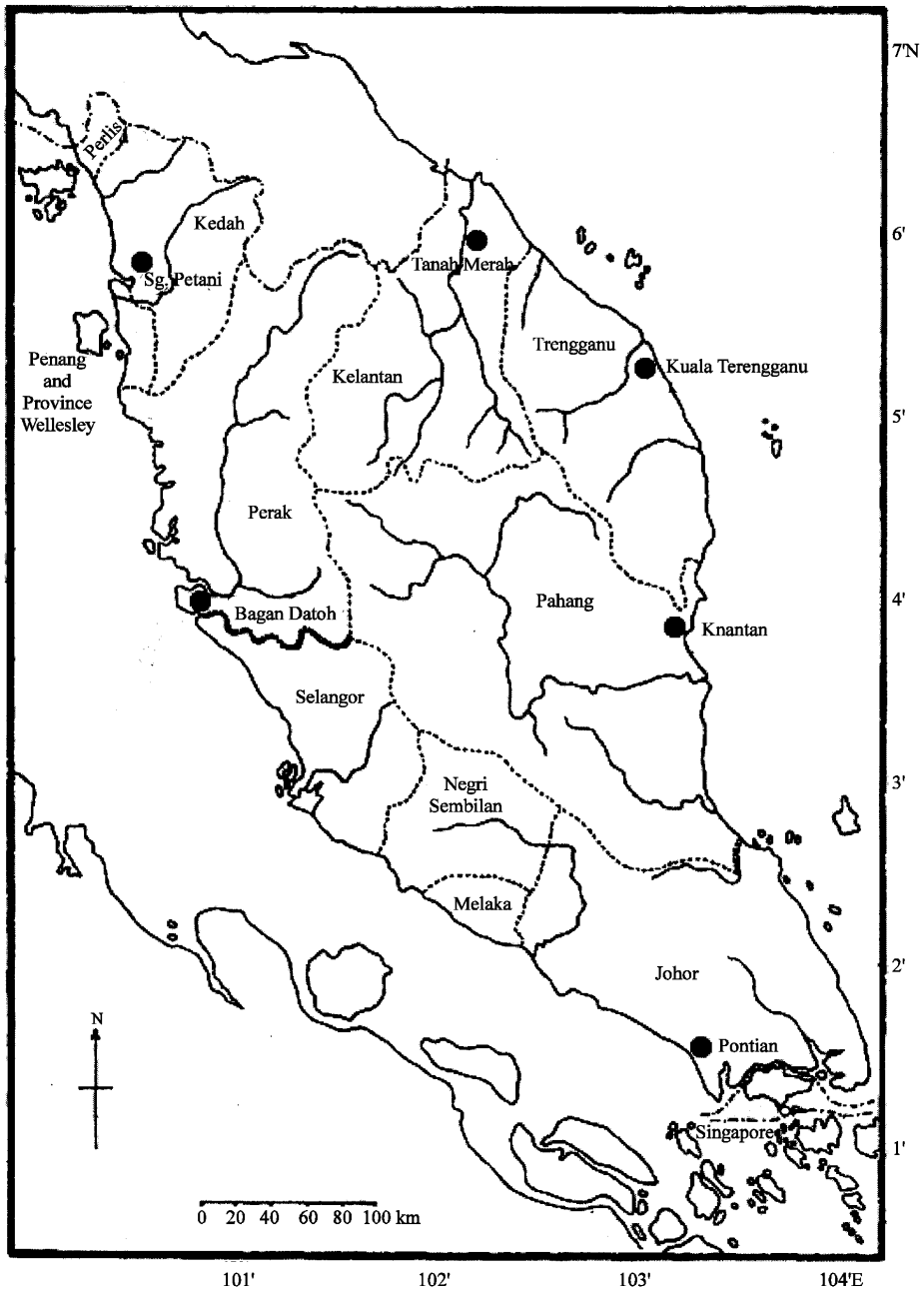

Fig. 1: Map showing distribution of Peninsular Malaysia and the sampling stations (●) of Haruan *Channa striatus* used in this study namely Johor, Kedah, Perak, Kelantan, Pahang and Terengganu

(DSL), Snout Length (SnL), Eye Diameter (ED), Pre-Orbital Length (POL) and Upper Jaw Length (UPL). All the characters were measured to the nearest centimeters using vernier caliper (American Scientific LLC, 150×0.02 mm) and weighted (Ohaus Ts400 Precision Standard Toploading Balance) to nearest gram. Standard length was expressed as percentages of the standard. Head measurements were expressed as percentages of the head length. All method of meristic counts and morphometric measurements are given in Fig. 2.

Data and statistical analysis: In the present study, there were significant linear correlations between all morphometric characters and standard length of fish. All individual morphometric data were thus corrected, using the following equation (Elliott *et al*., 1995):

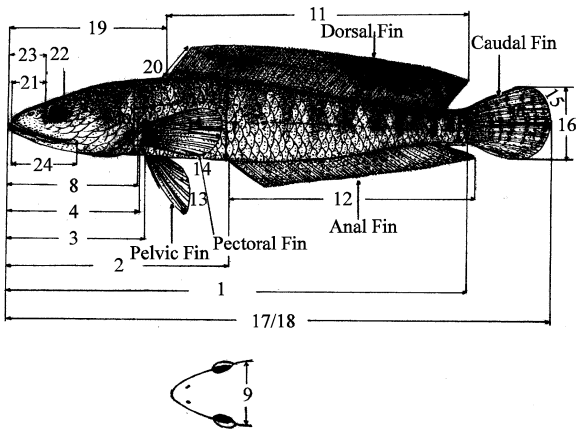

Fig. 2: An outline drawing of Haruan *Channa striatus* showing the various body measurements studies. 1. Standard Length (SL). 2. Pre-anal Length (PAL). 3. Pre-pelvic Length (PPelL). 4. Pre-pectoral Length (PPecL). 5. Caudal Peduncle Length (CPL). 6. Caudal Peduncle Depth (CPD). 7. Body Depth (BD). 8. Head Length (HL). 9. Head Width (HW). 10. Head Depth (HD). 11. Dorsal-fin Base Length (DFBL). 12. Anal-fin Length (AFL). 13. Pelvic-fin Length (PelFL). 14. Pectoral-fin Length (PecFL). 15. Caudal-fin Length (CFL). 16. Caudal-fin Height (CFH). 17. Fork Length (FL). 18. Total Length (TL). 19. Pre-dorsal Length (PDL). 20. Dorsal Spine Length (DSL). 21. Snout Length (SnL). 22. Eye Diameter (ED). 23. Pre-orbital Length (POL). 24. Upper Jaw Length (UPL)

$$M_s = M_o (Ls/SL)^b$$

Working formula for each specimen for given morphometric character is:

$$Log_{10} M_s = log_{10} M_o + b \log_{10} L - b \log_{10} L_s$$

Where:

M_s = The standardized character measurement
M_o = The observed character measurement
L = The mean standard length for all fish from six collections
L_s = Standard length of the specimen
b = The slope of the regression of the $log_{10}M_o$ on $log_{10}L_s$ for all fish

The standardized data were rechecked by correlation against size to see whether the size dependence had been removed. The standardized data were used in all statistical analysis.

Standardized data were analyzed by univariate and multivariate methods. Differences among geographic sample were tested by one-way Analysis of Variance (ANOVA) followed by post hoc multiple comparison test of specific means using Tukey's Honestly Significant Difference (HSD) multiple comparison test for unequal sample sizes (Sokal and Rohlf, 1994; Zar, 1998). The tests were considered significant at 0.05 probability level. Raw meristic counts with observable variation within samples were compared using Kruskal-Wallis nonparametric test considering the difference in the median as well as the distribution.

The length weight relationships were calculated from Total Length (TL) and Body Weights (BW) of 120 individuals were measured. To establish the length-weight relationship, the commonly used relationship was applied by Ricker (1975) and Quinn and Deriso (1999) was applied:

$$W = aL^b$$

Where:

W = The total weight (g)
L = The total length (cm)
a = A intercept (condition factor)
b = The exponent

The parameters a and b were estimated by least squares linear regression on log-log data transformed data:

$$Log_{10} W = Log_{10} a + b \, Log_{10} L$$

The coefficient of determination (r^2) was used as an indicator of the quality of the linear regression (Scherrer, 1984). In addition, 95% confidence limits of the parameter b and the statistical significance level of r^2 were estimated. The value b = 3 indicates that the fish grows symmetrically or isometrically (provided its specific gravity remains constants). Values other than 3 indicate allometric growth: if b>3, the growth is called positive allometric and if b<3, it is called negative allometric.

Discriminant Function Analysis (DFA) were performed to identify the characters that were important in distinguishing population groups and to formulate classification functions for each location. Based on these functions, DFA reclassifies individual fish into groups, which are then compared with a prior group of that individual to get the percentage of classification success. Mahalanobis Distances (D^2), as an indication of morphologic distance, were calculated between samples from DFA (Hair *et al*., 1995) to investigate the phenotypic relationship between populations a dendrogram was constructed based on Mahalanobis Distances (D^2) using UPGMA cluster analysis of arithmetic averages. All

analyses were conducted with the statistics packages NTSYSv.2.1 (Rohlf, 2000), XLSTAT (Addinsoft, XLSTAT Version 2009.4.05) and SPSS v.16.0.

RESULTS

Table 1 presents data on the water physical-chemical parameters of Haruan *C. striatus* habitats on six populations in Peninsular Malaysia. An analysis of variance (one-way ANOVA) showed that all physical-chemical parameters pH, conductivity (mS cm^{-1}), turbidity (NTU), temperature (°C), dissolved oxygen (mg L^{-1}) and salinity (ppt) were highly significant ($p<0.05$) between distributions. Water temperatures through the Johor ranged from about 29-30°C (Fig. 1). The average temperatures of Kedah and Kelantan were about 30-32.9°C with similar ranges. The averages temperatures of Pahang, Perak and Terengganu were about 28 and 33.9°C (Table 1), respectively. Differences were observed in the relative locations of Johor (M = 29.4, SD = 0.53), Kedah (M = 30.9, SD = 0.69), Kelantan (M = 31.9, SD = 0.50), Pahang (M = 30.9, SD = 0.69), Perak (M = 33.1, SD = 0.70) and Terengganu (M = 30.6, SD = 1.61); the differences were significant ($F_{5.36} = 14.336$, $p = 0.000$). Post-hoc Tukey HSD tests was showed in Table 1. The average of conductivity ranged from 0.02-0.80 mS cm^{-1}; while there was a significant effect of conductivity by distribution at the $p<0.05$ level for the six stations. Turbidity readings, measured in Nephelometric Turbidity Units. The turbidity of Haruan *C. striatus* resources at Kelantan were significantly higher than those in other stations and averaged bout six times higher than other stations. The differences were significant ($F_{5.36} = 15.138$, $p = 0.000$). In contrast, dissolved oxygen (mg L^{-1}), pH and salinity (ppt) range were 2.00-33.70 mg L^{-1}, 4.10-7.24, 0.00-0.20 ppt, respectively.

A total of 120 specimens of Haruan *C. striatus*, made up of 20 each from six station sites, were examined and analysed. The range and mean values of different morphometric characters during the study are given in Table 2. Mean standard length of Haruan *C. striatus* was 24.76±3.64 cm and the details weighted of Haruan

Table 1: Physical-chemical parameters six stations of water resources in selected part of Peninsular Malaysia

Parameters	Distribution	N	Range (cm)	Mean±SD	F_{value}	Sig.
Temp (°C)	Johor	7	29.00-30.00	29.43±0.53^{a}	14.336	0.000*
	Kedah	7	30.00-32.00	30.85±0.69^{b}		
	Kelantan	7	31.50-32.90	31.86±0.50^{b,c}		
	Pahang	7	30.00-32.00	30.85±0.69^{b}		
	Perak	7	32.10-33.90	33.10±0.70^{c}		
	Terengganu	7	28.00-33.00	30.57±1.61^{a,b}		
Cond (mS cm^{-1})	Johor	7	0.04-0.05	0.04±0.05^{a}	23.402	0.000*
	Kedah	7	0.08-0.80	0.30±0.22^{b}		
	Kelantan	7	0.04-0.43	0.09±0.14^{a}		
	Pahang	7	0.02-0.09	0.06±0.02^{a}		
	Perak	7	0.54-0.55	0.54±0.00^{c}		
	Terengganu	7	0.54-0.55	0.55±0.00^{a}		
Turb (NTU)	Johor	7	9.00-15.00	12.71±2.36^{b}	15.138	0.000*
	Kedah	7	1.10-8.00	5.33±2.27^{b,c}		
	Kelantan	7	17.00-82.00	45.14±28.91^{c}		
	Pahang	7	4.00-21.00	14.57±6.83^{b}		
	Perak	7	-10.00	-10.00±0.00^{a}		
	Terengganu	7	1.00-18.00	5.57±6.02^{a,b}		
DO (mg L^{-1})	Johor	7	7.00-13.00	8.55±2.13^{a}	30.682	0.000*
	Kedah	7	29.00-33.00	31.38±1.60^{b}		
	Kelantan	7	2.62-4.76	3.77±0.81^{a}		
	Pahang	7	3.40-6.60	4.47±1.29^{a}		
	Perak	7	2.97-33.70	8.32±11.22^{a}		
	Terengganu	7	2.00-11.00	7.57±3.13^{a}		
pH	Johor	7	6.00-6.90	6.18±0.55^{b,c}	7.702	0.000*
	Kedah	7	4.10-6.00	5.15±0.83^{a}		
	Kelantan	7	5.44-5.99	5.70±0.18^{a,b}		
	Pahang	7	5.10-6.80	6.13±0.55^{a,b,c}		
	Perak	7	6.58-7.24	6.98±0.22^{c}		
	Terengganu	7	5.60-8.20	6.55±1.08^{b,c}		
Sal (ppt)	Johor	7	0.00-0.00	0.00±0.00^{a}	2.574	0.000*
	Kedah	7	0.00-0.00	0.00±0.00^{a}		
	Kelantan	7	0.00-0.00	0.00±0.00^{a}		
	Pahang	7	0.00-0.00	0.00±0.00^{a}		
	Perak	7	0.20-0.20	0.00±0.00^{b}		
	Terengganu	7	0.00-0.00	0.00±0.00^{a}		

*Highly significant at ($p<0.05$); NS = Not Significant at ($p>0.05$); Mean±SD Subjected to Tukey HSD Post-hoc test; Mean±SD in column with dissimilar superscript letter is significantly different ($p = 0.05$); Cond = Conductivity (mS cm^{-1}); Turb = Turbidity (Nephelometric Turbidity Units); Temp = Temperature (°C); DO = Dissolved Oxygen (mg L^{-1}); Sal = Salinity (ppt)

Table 2: Analysis of Variance (One-way ANOVA) of twenty four morphometric characteristics (cm) showed four characteristics were significantly different ($p<0.05$) among distribution namely Johor, Kedah, Kelantan, Pahang, Perak and Terengganu in part of Peninsular Malaysia

Morphometric characteristics	Distribution	N	Range (cm)	Mean±SD	F_{value}	Sig.
SL (cm)	Johor	20	18.20-25.50	22.07±2.39^{a}	5.891	0.000*
	Kedah	20	18.70-31.20	25.07±3.22^{a,b,c}		
	Kelantan	20	22.10-32.10	27.18±2.66^{c}		
	Pahang	20	19.10-26.60	23.40±2.16^{a,b}		
	Perak	20	21.10-29.40	25.83±2.27^{b,c}		
	Terengganu	20	17.50-37.50	25.04±5.75^{a,b,c}		
PAL (cm)	Johor	20	9.70-13.80	11.77±1.25^{a}	4.663	0.001*
	Kedah	20	7.20-13.80	12.44±2.65^{a,b}		
	Kelantan	20	11.10-17.00	14.09±1.51^{b}		
	Pahang	20	9.80-13.70	11.75±1.06^{a}		
	Perak	20	11.30-15.80	13.50±1.34^{a,b}		
	Terengganu	20	8.60-19.20	13.02±3.02^{a,b}		
PPelL (cm)	Johor	20	6.00-8.10	7.01±0.67^{a}	4.443	0.001*
	Kedah	20	6.40-9.70	8.20±0.99^{b}		
	Kelantan	20	2.20-10.10	8.57±1.67^{b}		
	Pahang	20	6.20-8.70	7.58±0.67^{a,b}		
	Perak	20	6.70-9.60	8.27±0.73^{b}		
	Terengganu	20	5.60-11.90	8.11±1.73^{a,b}		
PPecL (cm)	Johor	20	5.70-7.60	6.57±0.64^{a}	8.531	0.000*
	Kedah	20	6.10-9.10	7.67±0.89^{b,c}		
	Kelantan	20	6.70-9.70	8.34±0.78^{c}		
	Pahang	20	5.80-8.40	7.13±0.69^{a,b}		
	Perak	20	6.40-8.90	7.87±0.67^{b,c}		
	Terengganu	20	5.60-10.90	7.50±1.59^{b,c}		
CPL (cm)	Johor	20	1.30-2.10	1.65±0.21^{a}	5.878	0.000*
	Kedah	20	1.40-2.70	2.03±0.38^{a,b}		
	Kelantan	20	1.40-8.10	2.52±1.36^{b}		
	Pahang	20	1.10-1.9	1.65±0.25^{a}		
	Perak	20	1.20-2.20	1.75±0.28^{a}		
	Terengganu	20	1.50-3.50	2.04±0.46^{a,b}		
CPD (cm)	Johor	20	1.40-2.10	1.79±0.22^{a}	10.718	0.000*
	Kedah	20	1.60-3.20	2.33±0.38^{c,d}		
	Kelantan	20	1.70-4.10	2.50±0.46^{d}		
	Pahang	20	1.60-2.20	1.95±0.19^{a,b}		
	Perak	20	1.70-2.50	2.20±0.24^{b,c,d}		
	Terengganu	20	1.50-3.30	2.15±0.50^{b,c}		
BD (cm)	Johor	20	3.00-4.10	3.56±0.33^{a}	1.440	0.215^{ns}
	Kedah	20	3.00-4.50	3.69±0.95^{a}		
	Kelantan	20	2.40-9.50	3.90±1.39^{a}		
	Pahang	20	2.50-4.10	3.32±0.43^{a}		
	Perak	20	3.00-4.00	3.56±0.26^{a}		
	Terengganu	20	17.50-37.50	25.04±5.75^{a,b,c}		
HL (cm)	Johor	20	3.50-7.40	6.11±0.94^{a}	5.511	0.000*
	Kedah	20	5.80-9.00	7.43±0.81^{b}		
	Kelantan	20	3.80-9.10	7.56±1.28^{b}		
	Pahang	20	5.80-7.70	6.82±0.53^{a,b}		
	Perak	20	4.40-8.60	7.33±0.93^{b}		
	Terengganu	20	5.40-10.30	7.27±1.41^{b}		
HW (cm)	Johor	20	2.70-4.10	3.42±0.37^{a}	5.791	0.000*
	Kedah	20	3.20-5.40	4.19±0.57^{b,c}		
	Kelantan	20	3.60-7.80	4.31±0.87^{c}		
	Pahang	20	3.10-4.40	3.72±0.35^{a,b}		
	Perak	20	3.30-4.80	4.11±0.36^{b,c}		
	Terengganu	20	2.70-6.30	3.84±0.93^{a,b,c}		
HD (cm)	Johor	20	2.30-3.20	2.77±0.27^{a}	7.461	0.000*
	Kedah	20	3.00-3.80	3.34±0.26^{b}		
	Kelantan	20	2.90-4.20	3.44±0.29^{a,b}		
	Pahang	20	2.60-3.50	3.08±0.28^{b}		
	Perak	20	2.70-3.80	3.38±0.27^{b}		
	Terengganu	20	2.30-5.00	3.17±0.77^{b}		
DFBL (cm)	Johor	20	9.40-17.80	14.05±2.34^{a}	2.863	0.018*
	Kedah	20	12.40-20.50	16.22±2.04^{a}		
	Kelantan	20	3.50-19.60	16.49±3.54^{a}		
	Pahang	20	12.50-18.10	14.83±1.49^{a}		
	Perak	20	13.10-18.80	16.49±1.57^{a}		
	Terengganu	20	10.40-25.40	16.05±4.04^{a}		

Table 2: Continue

Morphometric characteristics	Distribution	N	Range (cm)	Mean±SD	F_{value}	Sig.
AFL (cm)	Johor	20	2.50-11.00	8.75±1.91^{a}	5.755	0.000*
	Kedah	20	8.10-12.90	10.76±1.28^{b}		
	Kelantan	20	8.70-15.80	11.25±1.58^{b}		
	Pahang	20	8.60-11.40	9.93±0.76^{a,b}		
	Perak	20	8.10-12.50	10.98±1.15^{b}		
	Terengganu	20	7.70-17.50	10.72±2.82^{b}		
PelFL (cm)	Johor	20	1.80-7.60	2.71±1.19^{a}	1.760	0.127^{ns}
	Kedah	20	2.10-3.90	2.89±0.40^{a}		
	Kelantan	20	2.10-9.80	3.25±1.57^{a}		
	Pahang	20	2.10-3.00	2.61±0.24^{a}		
	Perak	20	2.00-3.10	2.56±0.31^{a}		
	Terengganu	20	1.60-4.20	2.66±0.61^{a}		
PecFL (cm)	Johor	20	2.30-4.40	3.51±0.52^{a}	3.523	0.005*
	Kedah	20	2.90-6.00	4.18±0.79^{b}		
	Kelantan	20	3.10-4.90	4.15±0.46^{a,b}		
	Pahang	20	3.10-4.20	3.66±0.33^{a,b}		
	Perak	20	2.30-4.70	3.76±0.62^{a,b}		
	Terengganu	20	2.60-5.90	3.78±0.94^{a,b}		
CFL (cm)	Johor	20	3.00-5.40	3.91±0.56^{a}	2.833	0.019*
	Kedah	20	3.30-5.70	4.39±0.55^{a}		
	Kelantan	20	3.60-5.10	4.37±0.36^{a}		
	Pahang	20	3.10-4.40	3.92±0.35^{a}		
	Perak	20	3.30-4.70	4.11±0.42^{a}		
	Terengganu	20	2.70-6.30	4.03±0.92^{a}		
CFH (cm)	Johor	20	2.60-4.70	3.56±0.57^{a}	4.340	0.001*
	Kedah	20	3.10-5.30	4.05±0.59^{a,b,c}		
	Kelantan	20	3.10-5.40	4.22±0.67^{b,c}		
	Pahang	20	3.20-4.90	3.76±0.40^{a,b}		
	Perak	20	3.10-4.70	3.86±0.46^{a,b,c}		
	Terengganu	20	2.60-6.80	4.36±0.98^{c}		
FL (cm)	Johor	20	21.90-31.80	25.97±2.88^{a}	4.548	0.001*
	Kedah	20	22.00-40.40	29.95±4.77^{b}		
	Kelantan	20	24.50-37.70	31.51±3.32^{b}		
	Pahang	20	23.20-35.50	27.74±3.15^{a,b}		
	Perak	20	24.20-35.40	30.33±2.87^{b}		
	Terengganu	20	20.60-44.10	29.52±6.66^{a,b}		
TL (cm)	Johor	20	21.90-31.80	25.97±2.88^{a}	4.561	0.001*
	Kedah	20	22.00-40.40	29.97±4.75^{b}		
	Kelantan	20	24.50-37.70	31.51±3.29^{b}		
	Pahang	20	23.20-35.50	27.74±3.15^{a,b}		
	Perak	20	24.20-35.40	30.33±2.87^{b}		
	Terengganu	20	20.60-44.10	29.52±6.66^{a,b}		
PDL (cm)	Johor	20	5.60-9.80	6.90±0.98^{a}	1.640	0.155^{ns}
	Kedah	20	5.80-27.70	8.58±4.59^{a}		
	Kelantan	20	1.90-10.00	8.39±1.69^{a}		
	Pahang	20	6.10-8.70	7.40±0.65^{a}		
	Perak	20	6.40-9.40	8.12±0.71^{a}		
	Terengganu	20	5.90-11.60	7.96±1.71^{a}		
DSL (cm)	Johor	20	0.70-1.80	1.15±0.25^{a}	8.188	0.000*
	Kedah	20	1.10-2.30	1.75±0.34^{c}		
	Kelantan	20	1.10-2.10	1.50±0.30^{b,c}		
	Pahang	20	0.90-2.00	1.43±0.24^{b}		
	Perak	20	1.10-1.90	1.42±0.20^{a,b}		
	Terengganu	20	0.80-2.00	1.40±0.39^{a,b}		
SnL (cm)	Johor	20	1.00-1.60	1.27±0.16^{a}	5.893	0.000*
	Kedah	20	1.10-1.70	1.41±0.18^{a,b}		
	Kelantan	20	1.20-2.20	1.61±0.27^{c}		
	Pahang	20	1.10-1.80	1.42±0.18^{a,b,c}		
	Perak	20	1.30-1.70	1.51±0.11^{b,c}		
	Terengganu	20	1.00-2.40	1.52±0.35^{b,c}		
ED (cm)	Johor	20	0.60-0.90	0.71±0.08^{a}	12.121	0.000*
	Kedah	20	0.70-1.10	0.90±0.11^{c}		
	Kelantan	20	0.60-1.00	0.92±0.08^{c}		
	Pahang	20	0.60-0.90	0.78±0.93^{a,b}		
	Perak	20	0.60-1.00	0.88±0.10^{c}		
	Terengganu	20	0.70-1.00	0.86±0.11^{b,c}		

Table 2: Continue

Morphometric characteristics	Distribution	N	Range (cm)	Mean±SD	F_{value}	Sig.
POL (cm)	Johor	20	1.20-1.70	1.43±0.16^{a}	4.130	0.002*
	Kedah	20	1.40-1.80	1.61±0.13^{a,b}		
	Kelantan	20	1.50-2.40	1.76±0.21^{b}		
	Pahang	20	1.10-1.90	1.56±0.19^{a,b}		
	Perak	20	1.40-1.90	1.67±0.12^{b}		
	Terengganu	20	0.30-2.50	1.60±0.46^{a,b}		
UPL (cm)	Johor	20	2.00-2.90	2.42±0.24^{a}	8.749	0.000*
	Kedah	20	2.10-4.00	3.02±0.48^{c}		
	Kelantan	20	2.70-3.70	3.16±0.27^{c}		
	Pahang	20	2.00-3.10	2.61±0.30^{a,b}		
	Perak	20	2.30-3.50	2.90±0.35^{b,c}		
	Terengganu	20	2.00-4.40	2.92±0.66^{b,c}		
W (g)	Johor	20	87.23-232.74	152.50±46.19^{a}	3.331	0.008*
	Kedah	20	117.30-232.74	196.04±65.43^{a,b}		
	Kelantan	20	134.10-357.80	243.13±56.16^{b}		
	Pahang	20	105.83-270.54	170.02±42.54^{a,b}		
	Perak	20	118.12-289.12	216.86±46.48^{a,b}		
	Terengganu	20	76.70-675.67	215.30±162.48^{a,b}		

*Highly significant at ($p<0.05$); NS = Not Significant at ($p>0.05$); Mean±SD Subjected to Tukey HSD Post-hoc test; Mean±SD in column with dissimilar superscript letter is significantly different ($p = 0.05$); PDL = Pre-Dorsal Length; DSL = Dorsal Spine Length; SnL = Snout Length; ED = Eye Diameter; POL = Pre-orbital Length; UPL = Upper Jaw Length; W = Weight

Table 3: Meristic characteristics of Haruan *C. striatus* among six populations namely Johor, Kedah, Kelantan, Pahang, Perak and Terengganu in part of Peninsular Malaysia

	Distribution											
	Johor		Kedah		Kelantan		Pahang		Perak		Terengganu	
Meristic characteristics	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range
D^{ns}	41	40 - 41	41	41-41	41	41- 41	41	41-41	41	41-41	41	41-41
P_1^{ns}	15	14-15	15	13-15	15	15- 15	15	15-16	15	15-15	15	14-15
P_2^{ns}	10	10	10	10-10	10	10-10	10	8-11	10	10-10	10	10-10
A^{ns}	25	23-25	25	25-25	25	25-25	25	25-25	25	25-25	25	25-25
C^{ns}	11	10 - 11	11	11-11	11	11-11	11	11-12	11	11-11	11	11-11

*Highly significant at ($p<0.05$); NS = Not Significant at ($p>0.05$); D = Dorsal Fin Rays; P_1 = Pectoral Fin Rays; P_2 = Pelvic Fin Rays; A = Anal Fin Rays; C = Caudal Fin Rays

C. striatus collected during the study are given in Table 2. Analysis of Variance (one-way ANOVA) showed that out of twenty four morphometric, twenty one characteristics (SL = Standard Length, PAL = Pre-Anal Length, PpelL = Pre-pelvic Length, PpecL = Pre-pectoral Length, CPL = Caudal Peduncle Length, CPD = Caudal Peduncle Depth, HL = Head Length, HW = Head Width, HD = Head Depth, DFBL = Dorsal-Fin Base Length, AFL = Anal-Fin Length, PecFL = Pectoral-Fin Length, CFL = Caudal-Fin Length, CFH = Caudal-Fin Height, FL = Fork Length, TL=Total Length, DSL = Dorsal Spine Length, SnL = Snout Length, ED = Eye Diameter, POL = Pre-Orbital Length and UPL = Upper Jaw Length) were highly significant ($p<0.05$) between Johor, Kedah, Kelantan, Pahang, Perak and Terengganu (Table 2). The graph of the means boxplots from twenty four morphometric characteristic also show twenty one (A, B, C, D, E, F, H, I, J, K, L, N, O, P, Q, R, T, U, V, W, X) morphometric characteristic that were significant different for mean value of the morphometric characters between Johor, Kedah, Kelantan, Pahang, Perak and Terengganu (Table 2). The physical morphology, meristic counts were relatively homogenous among the specimens although slight and there is no significant variation in the distribution in the number of Dorsal fin rays (D), Pectoral fin rays (P_1), Pelvic fin rays (P_2), anal fin rays (A) and Caudal fin rays (C) (Table 3) (Kruskal-Wallis test, $p<0.05$).

Result from the analysis length-weight relationship of Haruan *C. striatus*, without differentiating sexes among six stations is to be known that the growth of Haruan *C. striatus* were negative allometric with value b = 0.047 whereas b<3 and statistically significant, $p<0.05$ (Fig. 3). The calculated equations for the length-weight relationship was $W = 19.920L^{0.047}$ or $Log_{10}W = 1.285+0.047 Log_{10}L$ ($r^2 = 0.789$).

If the analysis length-weight relationship were differentiated by stations the value b is between 0.039-0.065. Haruan *C. striatus* were catch in all 6 stations have growth polar negative allometric (b<3) and were shown in Table 4. The length-weight equations were calculated as for Johor, $W = 19.309L^{0.044}$ or $Log_{10}W = 1.286+0.044 Log_{10}L$ ($r^2 = 0.490$); Kedah, $W = 17.355L^{0.064}$ or $Log_{10}W = 1.239+0.064 Log_{10}L$ ($r^2 = 0.785$);

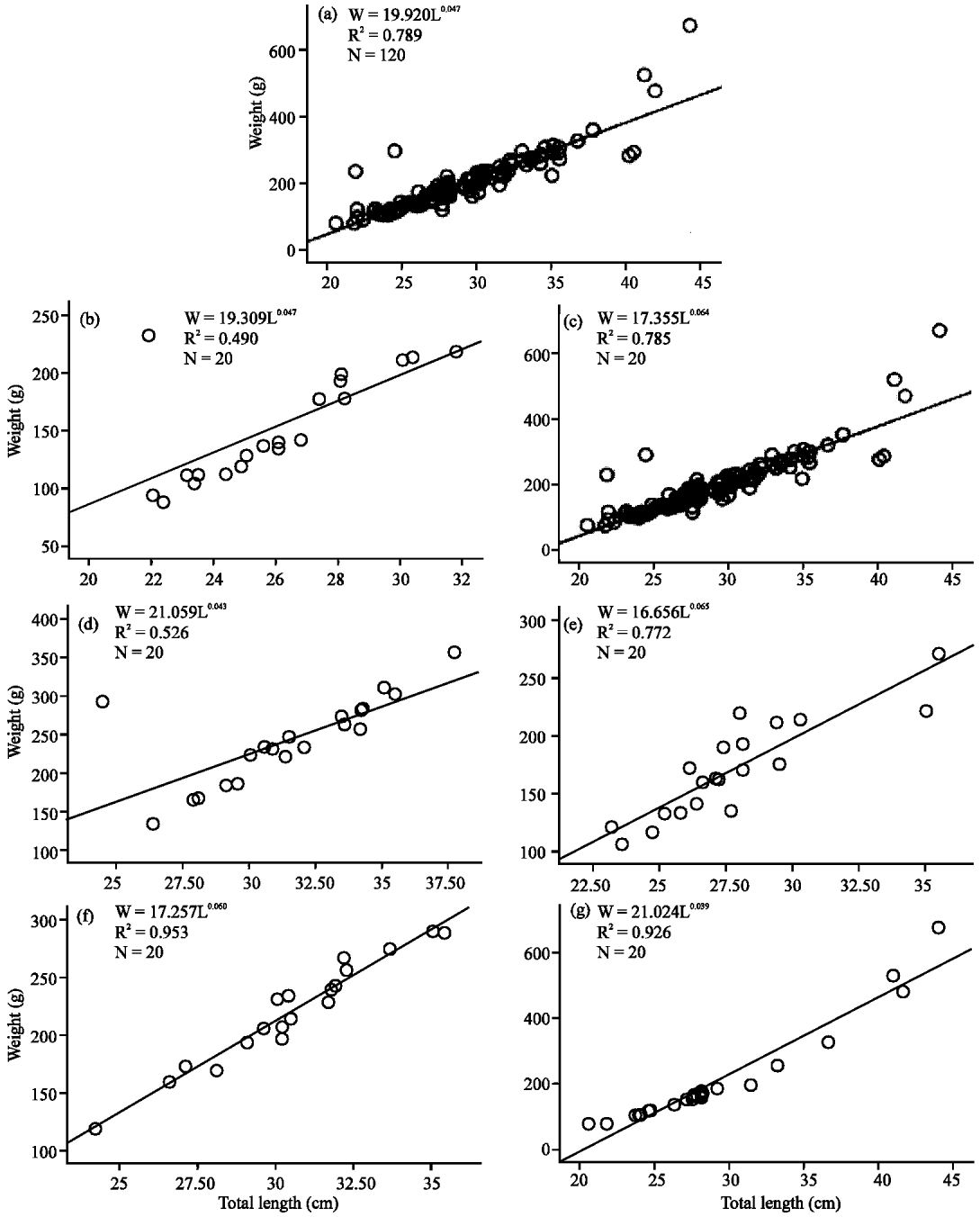

Fig. 3: Relationships between total length (cm) and weight (g) Haruan *C. striatus*, where a) is total of among six populations, b) Johor, c) Kedah, d) Kelantan, e) Pahang, f) Perak and g) Terengganu

Kelantan, $W = 12.059L^{0.043}$ or $Log_{10}W = 1.323+0.043\ Log_{10}L$ ($r^2 = 0.526$); Pahang, $W = 1.222L^{0.065}$ or $Log_{10}W = 1.222+0.065\ Log_{10}L$ ($r^2 = 0.772$); Perak, $W = 1.237L^{0.060}$ or $Log_{10}W = 1.237+0.060\ Log_{10}L$ ($r^2 = 0.953$) and Terengganu $W = 21.024L^{0.039}$ or $Log_{10}W = 1.323+0.039\ Log_{10}L$ ($r^2 = 0.926$) (Fig. 3), respectively. Figure 4 shows the length-frequency histogram of Haruan *C. striatus*. The result showed that the length of frequency distribution by populations from Johor, Kedah, Kelantan, Pahang, Perak and Terengganu were 25.97±2.88 cm TL, 29.97±4.75 cm TL, 31.52±3.32 cm TL, 27.74 ±3.16 cm TL, 30.34±2.87 cm TL and 29.53±6.67 cm TL, respectively.

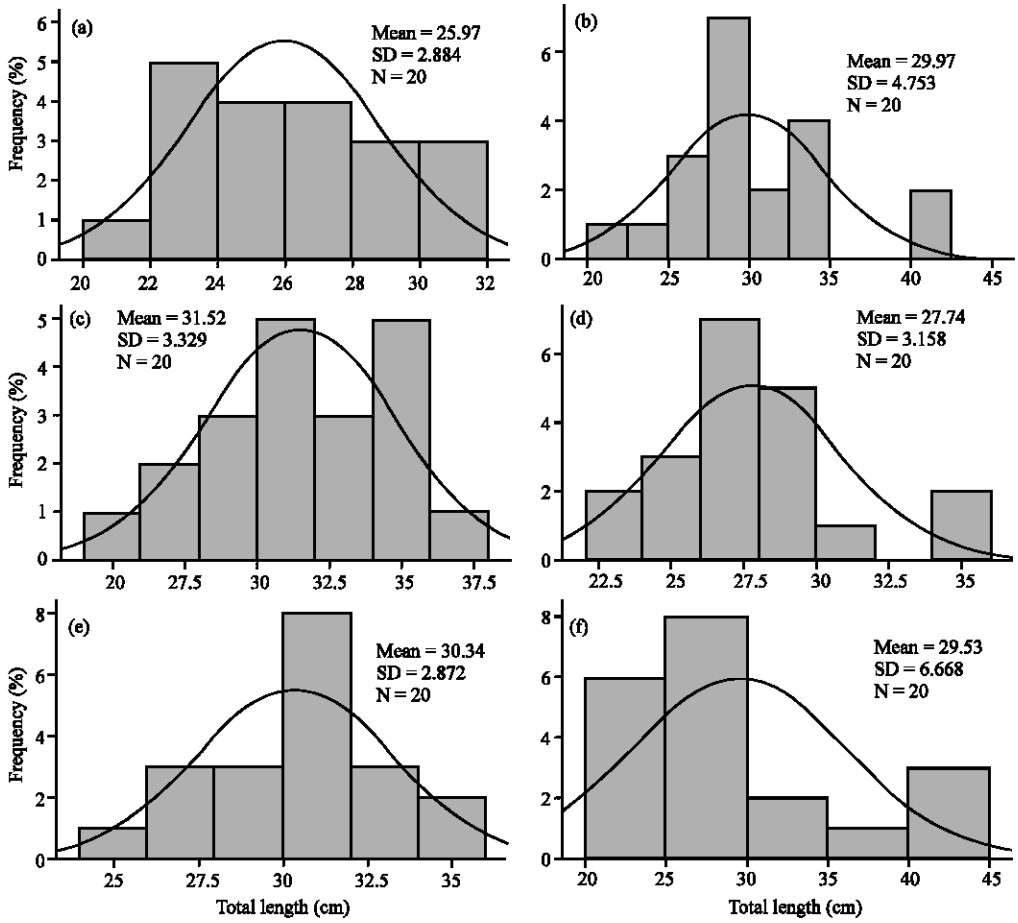

Fig. 4: Total length frequency distribution, where is a) Johor, b) Kedah, c) Kelantan, d) Pahang, e) Perak and f) Terengganu

Derived discriminant function in DFA (Addinsoft, XLSTAT Version 2009.4.05) using twenty four of the size-correction morphometric characters identified ED as significant contributors, which were found to be useful in population differentiation in order of importance (Wilk's Lambda = 0.653, approx. F (5,114) = 12.121, $p<0.0001$), while BD had the least contribution ($p = 0.215$) (Table 5). As revealed by the respective eigenvectors, first function is weighted most positive heavily by CPD, HD, CFH, TL, PDL, DSL and ED, while second function showed a contrast between positive weighted by SL, PAL, PPelL, AFL and SnL. About 39.49% of all discriminatory power is explained by the first function and therefore it is clearly the most important discrimination function. As detected by the respective eigenvalues, the first two Canonical Variables (CV) were able to explain 69% of the total variance in the data. The first Canonical Variable (CV1) was accounted responsible 39.49% of the variation among-groups, the second (CV2) accounted for 29% (Table 6) and had eigenvalues of 2.132 and 1.568, respectively. While 3-5 Canonical Variable accounted for 15, 13 and 4% of the residual variation, respectively and therefore were excluded from the remaining analysis. Morphological differences were greatest in function 1, where Johor, Kedah, Kelantan, Pahang, Perak and Terengganu, group centroid values were -2.698, 1.972, 0.816, -0.487, 0.190 and 0.206, respectively (Fig. 5). In function 2, group centroid values for where Johor, Kedah,

Table 4: Relationship between total length (cm) and weight (g) six stations selected in the part of Peninsular Malaysia

Distribution	N	a	b	r^2
Johor	20	19.309	0.044	0.490
Kedah	20	17.355	0.064	0.785
Kelantan	20	21.059	0.043	0.526
Pahang	20	16.657	0.065	0.772
Perak	20	17.257	0.060	0.953
Terengganu	20	21.024	0.039	0.926

N: Sample size, a and b: Parameters of the length-weight relationship: r^2: Coefficient of determination

Table 5: Summary results of the discriminant function analysis of standardized morphological data of Haruan *C. striatus*

Characters	Wilk's Lambda	F	p-value
SL	0.795	5.891	<0.0001
PAL	0.830	4.663	0.001
PPelL	0.837	4.443	0.001
PPecL	0.728	8.531	<0.0001
CPL	0.795	5.878	<0.0001
CPD	0.680	10.718	<0.0001
BD	0.941	1.440	0.215
HL	0.805	5.511	0.000
HW	0.797	5.791	<0.0001
HD	0.753	7.461	<0.0001
DFBL	0.888	2.863	0.018
AFL	0.798	5.755	<0.0001
PelFL	0.928	1.760	0.127
PecFL	0.866	3.523	0.005
CFL	0.889	2.833	0.019
CFH	0.840	4.340	0.001
FL	0.833	4.561	0.001
TL	0.833	4.561	0.001
PDL	0.933	1.640	0.155
DSL	0.736	8.188	<0.0001
SnL	0.795	5.893	<0.0001
ED	0.653	12.121	<0.0001
POL	0.847	4.130	<0.002
UPL	0.723	8.749	<0.0001

Table 6: The eigenvectors for the first five canonical discriminant funtions, eigenvalue and cumulative proportion percent of the total variance accounted for and variability percentage from a DFA on measurement of 24 morphometric characters from six stations Haruan *Channa striatus* in Peninsular Malaysia

Characters	F1	F2	F3	F4	F5
SL	-0.021	0.011	0.003	0.003	0.024
PAL	-0.041	0.057	0.007	-0.006	-0.060
PPelL	-0.008	0.025	0.018	-0.019	-0.041
PPecL	-0.032	0.114	-0.124	0.203	0.107
CPL	0.017	0.025	0.252	0.009	-0.020
CPD	0.438	0.145	0.043	0.181	0.093
DB	-0.083	-0.101	0.045	0.034	-0.076
HL	0.045	-0.023	0.074	0.032	0.030
HW	-0.001	-0.055	-0.153	0.103	-0.099
HD	0.144	-0.088	-0.086	-0.108	-0.096
DFBL	-0.019	0.000	0.018	0.011	-0.030
AFL	0.007	0.015	-0.057	-0.077	0.008
PelFL	-0.046	-0.040	0.032	0.038	0.058
PecFL	0.008	-0.169	-0.005	-0.094	0.172
CFL	-0.129	-0.069	0.051	0.170	-0.113
CFH	0.034	-0.039	0.050	-0.164	-0.037
FL	0.000	0.000	0.000	0.000	0.000
TL	0.013	-0.026	-0.003	-0.001	0.009
PDL	0.013	-0.013	0.009	-0.014	-0.013
DSL	0.175	-0.202	-0.064	-0.086	0.065
SnL	-0.131	0.483	-0.001	-0.365	0.393
ED	0.418	0.185	-0.029	-0.087	-0.610
POL	-0.085	0.068	-0.036	0.125	0.065
UPL	0.091	-0.016	0.139	-0.146	-0.080
Eigenvalue	2.132	1.568	0.791	0.686	0.221
Variability (%)	39.492	29.057	14.652	12.704	4.096
Cumulative (%)	39.492	68.549	83.200	95.904	100.000

Kelantan, Pahang, Perak and Terengganu were -0.875, -2.035, 1.300, -0.404, 1.280 and 0.787, respectively. The plot of first two canonical variables failed to show significant separation of samples with group means located close to each other especially Perak, Kelantan and Terengganu

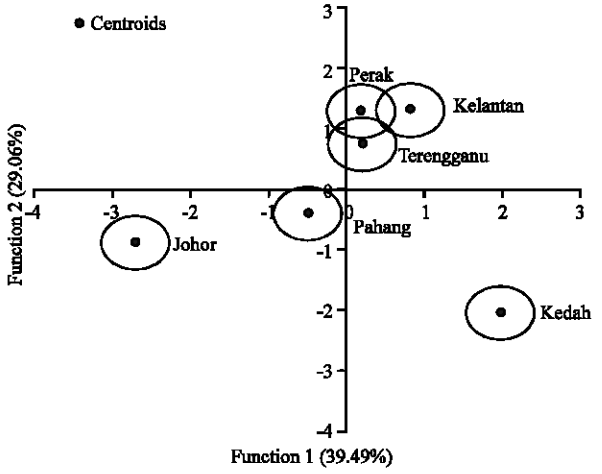

Fig. 5: Scatterplot of the centroid values (mean of discriminate functions) separating into their groups

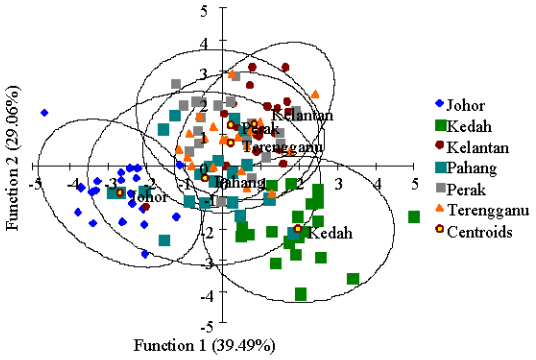

Fig. 6: Ninety five percent confidence ellipses of CV scores of morphometric characters, the first Canonical Variables (CV1) accounts for 39.49% and second (CV2) accounts for 29.06% of the between group variability

with 95% confidence ellipses for the six populations overlapping greatly (Fig. 6). However, Johor, Pahang and Kedah were clearly separated from others group, particularly from Perak, Kelantan and Terengganu.

When comparing Mahalanobis Distance (D^2), between each pair of samples on the basis of twenty four morphometric variables (Table 7), Terengganu was fairly similar to those from Perak and Kelantan.

In contrast, Pahang was also clearly distant from Kelantan, Perak and Terengganu. Johor and Kedah were also separated from the others populations. These relationships among the populations were more clearly shown by cluster analysis (Fig. 7).

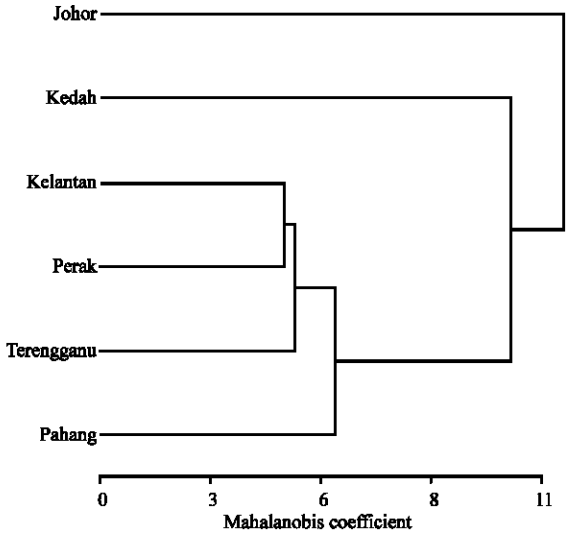

Fig. 7: Cluster diagrams using the UPGMA algorithm on the matrix of Mahalanobis distance between populations

Table 7: Squared Mahalanobis distance between pairs of populations (below diagonal) and the probability value (above diagonal) (asterisk indicate tests that are not significant at the level $\alpha = 0.003$ with sequential Bonferroni adjustment)

Groups	Johor	Kedah	Kelantan	Pahang	Perak	Terengganu
Johor	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Kedah	23.361	-	<0.0001	<0.0001	<0.0001	<0.0001
Kelantan	18.004	14.232	-	<0.0001	0.003	0.001
Pahang	9.302	11.358	10.807	-	0.011*	0.002
Perak	16.325	16.157	6.870	5.975	-	0.000
Terengganu	15.009	14.280	7.364	7.032	8.381	-

Table 8: Proportion of Haruan *C. striatus* correctly classified into groups by classification functions based on a prior knowledge of their original locations

		Groups					
Groups	Correct (%)	Johore	Kedah	Kelantan	Pahang	Perak	Terengganu
Johor	90.00	18	0	0	1	0	1
Kedah	95.00	0	19	0	1	0	0
Kelantan	85.00	1	0	17	0	1	1
Pahang	65.00	1	2	0	13	3	1
Perak	80.00	0	0	1	3	16	0
Terengganu	85.00	0	0	1	1	1	17
Total	83.33	20	21	19	19	21	20

The derived classification functions could correctly classify only an average of 83.33% into their respective *a priori* groups (Table 8). While the best classification success was observed for Haruan *C. striatus* from Kedah (95%), the lowest success was Haruan *C. striatus* from Pahang (65%) whereas those for Johor, Kelantan, Perak and Terengganu were 90, 85, 80 and 85%, respectively.

DISCUSSION

In this study, physical-chemical measurements were obtained during the catch of Haruan *C. striatus* on the site among six stations. However, Haruan *C. striatus* was caught first before water measurements were taken. These were done to confirm Haruan *C. striatus* populations and one of typical habitats of Haruan *C. striatus* found in Malaysia. Base on the result, there were significant different physical-chemical parameters in environmental Haruan *C. striatus*. The ranges of physical-chemical parameters sample showed pH of 5.10-7.24, while pH levels in Perak were higher than other distribution. According to Lee and Ng (1994) and Ali (1990), Haruan *C. striatus* are commonly found in highly adaptability water pH >5, ranged at pH values of 4.25-9.40 and 5.0-9.4 in year 1986, respectively. However, conductivity of 0.02-0.80 mS cm^{-1} and also have significant differences $p<0.05$ (Tukey's HSD post-hoc) among the six distributions. According to the previous study (Mat Jais, 1997) and (Lee and Ng, 1994), found and recorded, conductivity range 0.07-0.30 mS cm^{-1} and 20.8-20.9 μS cm^{-1}, respectively. The turbidity measured on all the samples were <1 Nephelometric Turbidity Unit (NTU) except for distribution of Perak, -10.00 NTU. Turbidity range from -10.00-82.00 NTU, Dissolved Oxygen of 2.00-33.70 mg/L^{-1}, there was significant differences HSD post-hoc $p<0.05$ both turbidity and Dissolved Oxygen among the six distributions. However, this study was recorded at temperature ranges between 28-33.90°C, while previous study done by Mat Jais (1997) was recorded at 25-30°C. According to Lee and Ng (1994) and Haruan *C. striatus* able to tolerate temperatures of 11-40°C, while (Ali, 1990) reported 22.8-40.9°C and able to survive in slightly brackish water. There was significant differences <0.05 (Tukey's HSD post-hoc) among the six distributions. Salinity was 0.0% in all of distributions.

According to Table 1, Haruan *C. striatus* were one of the fish that can withstand living in low water condition, low oxygen level and with pH level were slightly acidic. A variation in the environmental such as temperature-salinity were probability effect on survival, growth, morphometry beside other environmental factors and were important source in manipulated to determine relationship physiological in fish. Temperature usually has a greater effect on fish growth than salinity (Rombough, 1996) and can affect virtually all aspects of fish reproduction (Van der Kraak and Pankhurst, 1996) and larval development including hatching size, efficiency of yolk utilization, growth, feeding rate, time to metamorphosis, digestion rates and metabolic demand (Blaxter, 1969; Rombough, 1996). Historically, the morphology of fishes has been the primary source of information for taxonomic and evolutionary studies. There are numerous characters available for morphological study. These characters were most commonly divided into categories; morphometric and meristic, where it is

also have long been used to stocks identifications (Turan *et al*., 2004). The differences in the morphological and meristic characters of specimen were supposed to be in association with environmental ecosystems from which they originated (Cakic *et al*., 2002; Franicevic *et al*., 2005).

There were revealed significant differences in morphometrics between six populations of Haruan *C. striatus* in Peninsular Malaysia. However, all six populations had similar average lengths and this will be affecting allometric polar growth of Haruan *C. striatus* in Peninsular Malaysia. The average size of both the populations was very similar and probably the average physical-chemical parameters were significantly similar in Peninsular Malaysia beside other environmental factors.

There was a clear morphological distinction between certain characters in both populations. It is often difficult to explain the causes of morphological differences between populations (Cadrin, 2000). These differences may be genetically related differences or they might be associated with phenotypic plasticity in response to different environmental factors in each area (Murta, 2000) and also could be expected for distant sampling localities. Significant differences between six populations showed that out of twenty four morphometric, twenty one characteristics (SL = Standard Length, PAL = Pre-Anal Length, PpelL = Pre-Pelvic Length, PpecL = Pre-Pectoral Length, CPL = Caudal Peduncle Length, CPD = Caudal Peduncle Depth, HL = Head Length, HW = Head Width, HD = Head Depth, DFBL = Dorsal-Fin Base Length, AFL = Anal-Fin Length, PecFL = Pectoral-Fin Length, CFL = Caudal-Fin Length, CFH = Caudal-Fin Height, FL = Fork Length, TL = Total Length, DSL = Dorsal Spine Length, SnL = Snout Length, ED = Eye Diameter, POL = Pre-orbital Length and UPL = Upper Jaw Length) were highly significant ($p<0.05$) between Johor, Kedah, Kelantan, Pahang, Perak and Terengganu (Table 2). Thus, morphological variation can reflect genetic differences between stock or environmental differences between localities.

The growth polar among Haruan *C. striatus* populations selected in Peninsular Malaysia was negative allometric type of growth where the value of b values is 0.047 and there were no significant between populations. These was against (Ali, 1990) where Haruan *C. striatus* at Perak was the value of $b>3.092$ in order of positive allometric type of growth in year 1985 and 1987. The value of b-value must be equal to 3 if fishes have to maintain their shape as they grow, but there is no theory that says in which case the b-value can be expected to be negatively or positively allometric. The biological interpretation of the numerical values of the parameters a and b is not straight forward, except that when growth is isometric, a can be interpreted as a condition factor. When growth is allometric, the role of a as the condition factor is questionable (Khaironizam and Rashid, 2002). The declines in growth differences may be condition indicate low availability or poorer quality of food and pressure stress. Analysis of Length Weight relationships of fish species is often to determine the effect of different treatments some population, where biomass often estimated measurement can be time-consuming in the fish population (Martin-Smith, 1996). In addition, the data on length and weight can also provide important clues to climatic and environmental changes and change in human subsistence practices (Samat *et al*., 2008). Length and weight measurement in conjunction with age data can give information on the stock composition, age at maturity, life span, mortality, growth and production (Fafioye and Oluajo, 2005).

The size structure among populations Haruan *C. striatus* in the investigated areas consists of relatively higher percentage in Perak than other populations selected. Perak attained a greater size indicating a size dimorphism. According to size structure obtained, there was a possibility based on measurement of size showed that Haruan *C. striatus* can still grow. These have been proved with (Froose and Pauly, 2009) where the measurement of Haruan *C. striatus* that have been recorded was 100 cm. Size structure (frequency) of any fish is important to know the status of the population structure of that fish in nature including traits as the river health, stock condition and breeding period of the fish (Nurul Amin *et al*., 2005; Ranjan *et al*., 2005).

This study was to investigate morphological variation among six stations of Haruan *C. striatus* populations from various geographic in Peninsular Malaysia. Although, the majority of the morphometric variations in Haruan *C. striatus* were between-individuals-within-regions, at least some of the variation related to size had a geographic basis (Eastham *et al*., 2002). Results from both univariate and multivariate analysis provide congruent evidence for the existence of significant morphological variation in Haruan *C. striatus* among selected population's localities of Peninsular Malaysia. Derived classification functions provided moderate percentage of classification success (ranging from 65-95%), indicating that morphological characters used in these analysis provide discriminatory power for the Haruan *C. striatus* populations studied. Therefore, morphological characters measurement is a helpful tool for discrimination of fish population. Morphometrics measurements combining with imagine analysis is steps ahead to produce a better understanding fish stock structures (Pollar *et al*., 2007). Among five eigenvalues in

discriminating the populations, the first canonical variables is clearly most important variation among region groups, where the other function is comparatively much smaller. The other functions were excluded from the remaining analysis except for first two functions. The first two canonical variables accounted 68.5% of total observed variance among the twenty four morphometrics variables; only positive weighted were selected. Discriminant analysis was successful in grouping population (Fig. 6). The standardized coefficients (loadings) for the functions (Table 6) reflect the correlation between the original variable and the function can be thought of as the proportion of the variance that is shared (Hair *et al*., 1995). The first Canonical Variables (CV1) were dominated by positive weighted (large loading) for CPD, HD, CFH, TL, PDL, DSL and ED, the SL, PAL, PPelL, AFL and SnL for canonical variables. The rest of the morphometrics also contributed significant to variation but were not good enough identified of individual populations. These findings showed ED were significant identified contributor that were found mostly to be use useful in population differentiation from other morphometric characters, in order of important (Wilk's Lambda = 0.653, approx. $F(12.121) = 3.115$, $p<0.0001$). Such differences between the populations may be related to different habitats characteristics, such as temperature, turbidity, food availability, water depth and flow. These findings also showed there are none of the meristic characters of significant variation in Haruan *C. striatus*.

The canonical variates analysis and cluster among six populations, although there are the occurrence of some overlapped between individuals of some populations, it is clear that these are separated from each other and that populations located in the same geographical regions are grouped together. Populations from Kelantan, Pahang and Perak are close together to each other and are grouped together.

Although, there are overlapping among individuals Johor, Kedah and Terengganu but it is clearly separated groups from Kelantan, Pahang and Perak. The detected differentiations for these groupings are probably the geographical proximities and also similar climatic conditions of locations. The results of cluster analysis based on Mahalanobis Distance (D^2) again confirms this separation between geographic populations which are located a cline from Johor, Kedah and Terengganu were separated from other populations in Peninsular Malaysia. The previous study genetic variation using Random Amplified Polymorphic DNA also confirms that several populations on Haruan *C. striatus* in Peninsular Malaysia (Ambak *et al*., 2006). However, these phenotype morphometric will be compared and carries on to the further studies using genetic, Polymerase Chain Reaction-Restriction Fragment Length Polymorphism (PCR-RFLP) analysis mitochondrial DNA cyto b gene.

CONCLUSION

The results indicate that significant heterogeneity in morphology exist among some of the studied populations of Haruan *C. striatus*. Observed morphological variation probability occurred due to factors such as partial isolation of the populations, environmental and local adaptations. The length-weight relationships, size-frequency distribution compositions, morphometric and meristic result distinguishing among populations in Peninsular Malaysia that probability are useful in fisheries management, as well as standardization for a Good Agriculture Practices (GAP) in farming technology, as well as the basis for Good Manufacturing Practices (GMP) production (Begg *et al*., 1999). This result will be verified and associated in our future genetic study.

ACKNOWLEDGEMENTS

This research was supported by Biosatellite Program directly under National Biotechnology Centre, MOSTI in collaboration with UPEN Pahang BSP©/BTK/006 and University Putra Malaysia for facilities.

REFERENCES

Ali, A.B., 1990. Some ecological aspects of fish populations in tropical ricefields. J. Hydrobiologia, 190 (3): 215-222. DOI: 10.1007/BF00008188. http://www.springerlnk.com/content/q282217570122656.

Ambak, M.A., A.A. Bolong, P. Ismail and B.M. Tam, 2006. Genetic variation of snakefish fish (*Channa striata*) populations using random amplified polymorphic DNA. Biotech., 5 (1): 104-110. DOI: 10.3923/biotech.2006.104.110. http://scialert.net/abstract/?doi=biotech.2006.104.110.

Begg, G.A., K.D. Friedland and J.B. Pearce, 1999. Stock identification and its role in stock assessment and fisheries management: An overview. Fish. Res., 43 (1-3): 1-8. DOI: 10.1016/S0165-7836(99)00062-4.

Blaxter, J.H.S., 1969. Development: Eggs and Larvae. In: W.S Hoar and D.J. Randall (Eds.). Fish Physiology, Academic Press, New York, 3: 177-152. ISBN: 0123504015.

Cadrin, S.X., 2000. Advances in morphometric identification of fishery stocks. J. Rev. Fish Biol. Fisheries, 10 (1): 91-112. DOI: 10.1023/A:1008939104413. http://www.springerlink.com/content/k723k7666087jv72.

Cakic, P., M. Lenhardt, D. Mickovic, N. Sekulic and J. Budakov, 2002. Biometric analysis of Syngnathus abastev populations. J. Fish. Biol., 60 (6): 1562-1569. DOI: 10.1111/j.1095-8649.2002.tb02448.x. http://www3.interscience.wiley.com/journal/118942602/abstract.

Donsakul, T. and W. Magtoon, 1991. Chromosome study of five species channid fishes (Channa, family Channidae), from Thailand. In: Proceeding of the 29th Kasetsart University Annual Conference: Animal Science, Veterinary Science, Aquaculture, Kesetsart Univ., Bangkok (Thailand), Feb. 4-7. FOA of the United Nations, pp: 561-574. http://www.fao.org/agris/search/display.do?f=./1997/v2317/TH9621220.xml;TH9621220.

Eastham, C.P., M.K. Nicholls and N.C. Fox, 2002. Morphological variation of the saker (*Falco cherrug*) and the implications for conservation. J. Biodiversity and Conservation, 11 (2): 305-325. DOI: 10.1023/A:1014566024582. http://www.springerlink.com/content/x49v2f1aeg3pdluc.

Elliott, N.G., K. Haskard and J.A. Koslow, 1995. Morphometric analysis of orange rough (*Hoplostethus atlanticus*) off the continental slope of southern Australia. J. Fish. Biol., 46 (2): 202-220. DOI:10.1111/j.1095-8649.1995.tb05962.x. http://www3.interscience.wiley.com/journal/119959467/abstract.

Fafioye, O.O. and O.A Oluajo, 2005. Length-weight relationships of five fish species in Epe lagoon, Nigeria. Afr. J. Biotechnol., 4 (7): 749-751. http://www.academicjournals.org/AJB/abstracts/abs2005/Jul.

Franicevic, M., G. Sinovcic, V. Cikes and B. Zorica, 2005. Biometry analysis of the Atlantic bonito, *Sarda sarda* (Bloch, 1973) in the Adriatic Sea. Acta Adriatica, 46 (2): 213-222. http://jadran.izor.hr/acta/eng/v46_2_8.htm.

Froose, R. and D. Pauly, 2009. *Channa striata* in Malaysia. FishBase, pp: 343. World Wide Web electronic publication. http://fishbase.org/Country/CountrySpeciesSummary.cfm?c_code=458&id=343.

Hair, Jr., F. Joseph, R.E. Anderson, R.L. Tatham and W.C. Black, 1995. Multivariate Data Analysis: With Readings. 4th Edn. Englewood Cliffs, New Jersey, USA. Prentice-Hall, Inc, pp: 799. ISBN: 9780139133107.

Heydranejad, M.S., 2009. Length-weight relationships for six freshwater fish species in Iran. Chin. J. Oceanol. Limnol., 27 (1): 61-62. DOI: 10.1007/s00343-009-0061-8. http://www.springerlink.com/content/q81172748635 5492.

Khaironizam, M.Z. and Y.N. Rashid, 2002. Length-weight relationship of mudskippers (Gobiidae: Oxudercinae) in the Coastal areas of Selangor, Malaysia. World/Fish Center Quarterly (NAGA), 25 (3 and 4): 20-21. http://www.worldfishcenter.org/naga/Naga25-3&4/contents.htm.

Lee, P.G. and P.K.L. Ng, 1994. The systematics and ecology of snakeheads (Pisces: Channidae) in Penisular Malaysia and Singapore. J. Hydrobiologia, 285 (1-3): 59-74. DOI: 10.1007/BF00005654. http://www.springerlink.com/content/r583g4041j5x3h87.

Mat Jais, A.M., R. McCulloch and K. Croft, 1994. Fatty acid and amino acid composition in Haruan as potential role in wound healing. Gen. Pharmacol., 25 (5): 947-950. PMID: 7835642. http://www.ncbi.nlm.nih.gov/pubmed/7835642.

Mat Jais, A.M., 1997. Haruan *Channa striatus* as a component of health food. Proceedings of the seminar of the Asian Food Technology, pp: 39-43.

Marimuthu, K. and M.A. Haniffa, 2007. Embryonic and larval development of the striped shakehead *Channa striatus*. Taiwania, 52 (1): 84-92. http://tai2.ntu.edu.tw/udth/bin/taiwania.exe/eabs?id=568.

Martin-Smith, K.M., 1996. Length-weight relationships of fishes in a diverse tropical freshwater community, Sabah, Malaysia. J. Fish. Biol., 49 (4): 731-734. DOI:10.1111/j.1095-8649.1996.tb00069.x. http://www3.interscience.wiley.com/journal/119203482/abstract.

Murta, A.G., 2000. Morphological variation of horse mackerel (*Trachurus trachurus*) in the Iberian and North African Atlantic: Implications for stock identification. ICES J. Mar. Sci., 57 (4): 1240-1248. DOI: 0.1006/jmsc.2000.0810. http://icesjms.oxfordjournals.org/cgi/content/abstract/57/4/1240.

Nurul Amin, S.M., A. Arshad, G.C. Haldar, S. Shohaimi and R. Ara, 2005. Estimation of size frequency distribution, sex ratio and length-weight relationship of Hilsa (*Tenualosa ilisha*) in Bangladesh water. Res. J. Agric. Biol. Sci., 1 (1): 61-66. http://www.insipub.com/rjabs_august_2005.html.

Pollar, M., M. Jaroensutasinee and K. Jaroensutasinee, 2007. Morphometric analysis of *Tor tambroides* by stepwise discriminant and neural network analysis. World Acad. Sci. Eng. Technol., 33 (4): 16-20. http://www.waset.org/journals/waset/v33.php.

Qin, J. and A.W. Fast, 1996. Size and feed dependent cannibalism with juvenile snakehead *Channa striatus*. Aquaculture, 144 (4): 313-320. DOI: 10.1016/0044-8486(96)01299-9.

Quinn II, T.J. and R.B. Deriso, 1999. Quantitative Fish Dynamics. Oxford University Press, New York, pp: 542. ISBN: 0-19-507631-1.

Ranjan, J.B., W. Herwig, S. Subodh and S. Micheal, 2005. Study of the length frequency distribution of sucker head, *Garra gotyla gotyla* (Gray, 1830) in different rivers and seasons in Nepal and its applications. Kathamandu Univ. J. Sci. Eng. Technol., 1 (1): 1-14. http://www.ku.edu.np/kuset/index.php?go=vol1no1.

Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of Fisheries Research Board, Canada, 191: 382. ISBN: 0-662-01440-5.

Rohlf, F.J., 2000. NTSYS-pc: Numerical Taxonomy and Multivariate Analysis System, version 2.1. Exeter Software, Setauket, New York. http://www.exeter-software.com/cat/ntsyspc/ntsyspc.html.

Rombough, P.J., 1996. The Effects of Temperature on Embryonic and Larval Development. 1st Edn. In: Wood, C.M. and D.G. McDonald (Eds.). Society for Experimental Biology Seminar Series 61: Global Warming Implications for Freshwater and Marine Fish. Cambridge University Press, pp: 177-223. ISBN: 0521495326.

Saini, A., A. Dua and V. Mohindra, 2008. Comparative morphometrics of two populations of giant river catfish (*Mystus seenghala*) from the Indus river system. Integrative Zool., 3 (3): 219-226. DOI: 10.1111/j.1749-4877.2008.00099.x. http://www3.interscience.wiley.com/journal/121421222/abstract.

Samat, A., M.N. Shukor, A.G. Mazlan, A. Arshad and M.Y. Fatimah, 2008. Length-weight relationship and condition factor of *Pterygoplichthys pardalis* (Pisces: Loricariidae) in Malaysia Peninsula. Res. J. Fish. Hydrobiol., 3 (2): 48-53. http://www.insipub.com/rjfh_july-dec_2008.html.

Scherrer, B., 1984. Biostatisque. 1st Edn. Morin, Montr'eal, Paris, pp: 850. ISBN: 9782891050937.

Sokal, R.R. and F.J. Rohlf, 1994. Biometry: The Principles and Practice of Statistics in Biological Research. 2nd Edn. W.H. Freeman Publication, New York, pp: 344-354. ISBN: 978-0716712541.

Turan, C., D. Erguden, F. Turan and M. Gurlek, 2004. Genetic and morphologic structure of *Liza abu* (Heckel, 1843) populations from the rivers Orontes, Euphrates and Tigris. Turk. J. Vet. Anim. Sci., 28 (4): 729-734. http://mistug.tubitak.gov.tr/bdyim/abs.php?dergi=vet&rak=0302-19.

Turan, C., M. Oral, B. Ozturk and E. Duzgunes, 2006. Morphometric and meristic variation between stocks of bluefish (*Pomatomus saltatrix*) in the Black, Marmara, Aegean and northeastern Mediterranean seas. Fish. Res., 79 (1-2): 139-147. DOI: 10.1016/j.fishres.2006.01.015.

Van Der Kraak, G. and N.W. Pankhurst, 1996. Temperature Effects on the Reproductive Performance of Fish. 1st Edn. In: Wood, C.M. and D.G. McDonald (Eds.), Society for Experimental Biology Seminar Series 61: Global Warming Implications for Freshwater and Marine Fish. Cambridge University Press, pp: 159-176. ISBN: 0521495326.

Zar, J.H., 1998. Biostatistical Analysis. 4th Edn. Englewood Cliffs, New Jersey, USA. Prentice-Hall, Inc, pp: 159-194. ISBN: 9780130815422.