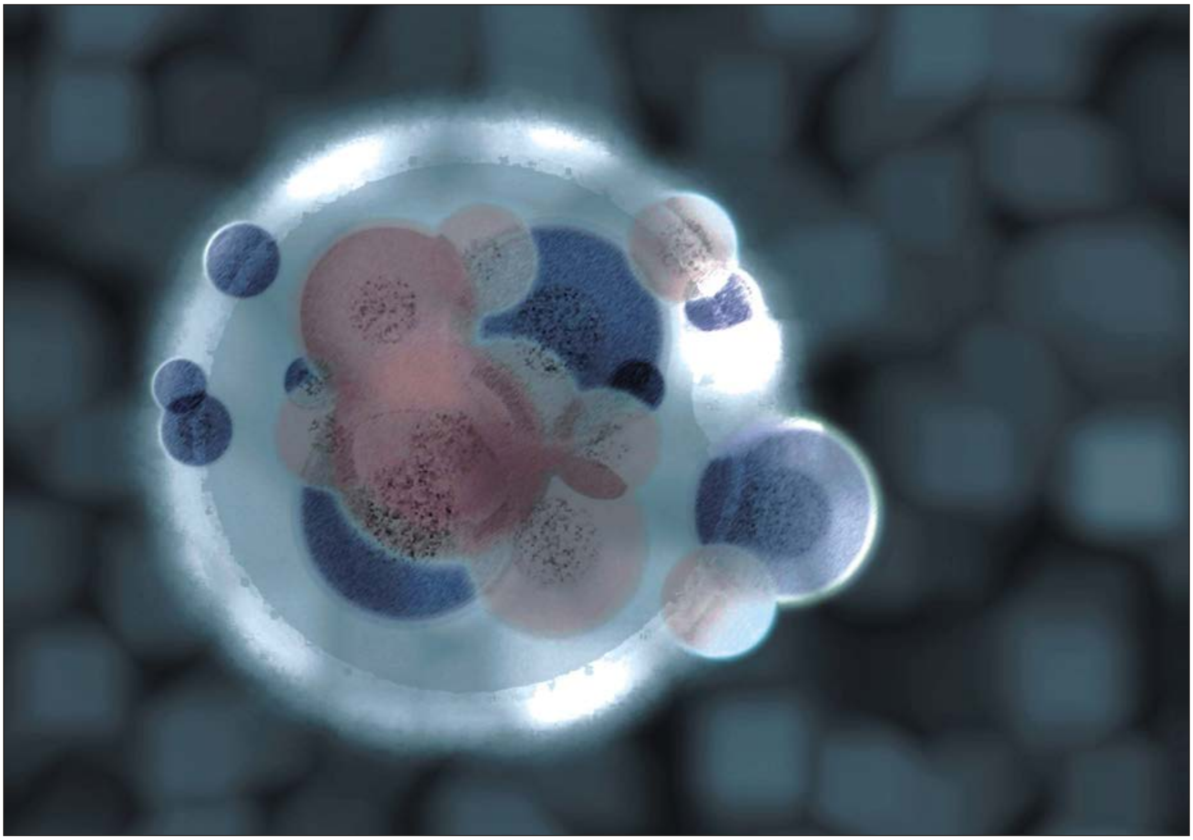

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Condition, Length-Weight Relationship, Sex Ratio and Gonadosomatic Index of Indian Mackerel (*Rastrelliger kanagurta*) Captured from Kuantan Coastal Water

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Abstract: This study described the Condition factor, Length-Weight relationship, Gonadosomatic index and sex ratio of Indian mackerel (*Rastrelliger kanagurta*) which is an important fish in the Kuantan coastal water, Malaysia. Data were obtained from December 2011-May 2012 and a total of 1064 Indian mackerel specimens were studied in this research. The result showed that male Indian mackerel was significantly more than female (χ^2 = 7.91; p<0.01) in the population in the Kuantan coastal area. Length-Weight relationship of each month was significant (p<0.01) with all coefficients of determination (R^2) values being higher than 0.72. The allometric coefficients (b) of length-weight relationship varied between 2.5128 (April) and 3.0807 (May). A negative allometric growth of Indian mackerel was observed in January, March and April. An isometric growth was observed in December and February while a positive allometric growth was observed only in May. The b-value of the length-weight relationship of Indian mackerel in April was very low compared to other month. The condition factor ranged from 1.0499-1.1320 and was significant difference between months (p<0.05). The significantly lowest mean condition factor was found in December and the highest in February and April. Overall higher mean condition factor was observed in smaller fish of both sex. The overall mean condition factor of female was better than male. Gonadosomatic index of Indian mackerel in February was higher than those observed in March and April and followed by May. Gonadosomatic index rapidly increased after January and reached at peak in February and decline after February. A positive relationship was observed between gonadosomatic index and condition factor of Indian mackerel. The peak spawning season of Indian mackerel in Kuantan coastal water was from February to April. The spawning season of Indian mackerel in Kuantan coastal water falls within the period between end of January and end of May.

Key words: *Rastrelliger kanagurta,* condition factor, length-weight relationship, gonadosomatic index, sex ratio

INTRODUCTION

Fisheries industry plays an important role in the economy of many countries including Malaysia. In Malaysia, fisheries sector contributed 1.2% to GDP (Gross Domestic Product) in 2008 which was increased by 1.3% in 2009. However, the world fisheries have been showing poor capture production since the last decade (FAO, 2011). In 2000, the global capture production was about 950 million MT and in 2010 the capture production was decreased nearly 900 million MT. However, the total capture production in Malaysia has increased in the last decade. Since, year 2000 (1.2 million MT) the total capture production in Malaysia has increased by 10% (FAO, 2011).

Marine fisheries sector is of fundamental importance to Malaysia in terms of revenue generation, employment and food security. In 2009, the total production of marine fisheries was nearly 2 million MT and it valued nearly 9000 million Malaysian Ringgit which contributed 1.3% to the Malaysian GDP (Gross Domestic Product). Besides this, this sector provided nearly 150 thousand jobs directly and/or indirectly (DOF, 2009). In Malaysian about 60-70% of total animal protein is supplied by marine fisheries (Lihan *et al*., 2006) which is dominated by a wide variety of fish species (e.g., Indian mackerel, slimy mackerel, yellow striped scad, bleeker smoothbelly sardinella, smoothbelly sardinella, kawakawa, longtail tuna and torpedo scad, etc.).

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Among variety of fishes, Indian mackerel is one of the important fish in Malaysia. Indian mackerel is coastal pelagic species, often found in a large shoal at a depth range of 20-90 m (Pauly *et al*., 1996). Adults Indian mackerel feed on macro plankton such as larval shrimps and fish. Spawning occurs in several batches with eggs fertilized externally. Both eggs and larvae of Indian mackerel are pelagic (Collette, 2001). It is widely consumed in many parts of Malaysia due to it's abundance, ease in the capture and low market price. In 2010, the capture production of Indian Mackerel was 186225 MT and it accounts for 10% of total capture fish production. However, in Malaysia, total capture production of many marine fishes is decreasing day by day. Therefore, management of wild population is necessary for an urgent basis to obtain sustainable capture production.

Understanding population dynamics in particular their stock condition, growth, spawning seasons, recruitment, mortality, etc. are prerequisite before identifying proper management techniques on any wild fish stock. There is some information about wild population of Indian mackerel. Unfortunately, such information of most fishes including Indian mackerel on the east coast of peninsular Malaysia especially in the Kuantan area is lacking. As a starting point, this research quantifies some population parameters namely condition factor and its temporal variation, length-weight relationship, gonadosomatic index of Indian mackerel populations in the Kuantan coastal water, Malaysia. The objectives of this study were (1) to determine length-weight relationship of *Rastrelliger kanagurta*, (2) to determine the condition factor of Indian mackerel and (3) to determine gonodosomatic index and spawning season of Indian mackerel.

MATERIALS AND METHODS

Area of capture and sample collection: All fishes were collected early in the morning from Kompleks Lembaga Kemajuan Ikan Malaysia (LKIM), Kuantan, Pahang, Malaysia. All fishing vessels used purse seine nets to catch Indian mackerel and Fig. 1 shows the area of capture of Indian mackerel based on the information received from fisherman. Fishing vessels were equipped with icing systems and fish were kept at lower temperature to keep fresh. In this experiment, all fish samples were collected before sorting to avoid biasness on size. After collection, they were immediately preserved with ice in the ice box and transported to the laboratory. Samples were collected monthly for a period of 6 months (December to May, 2012). A total of 1064 Indian mackerel was sampled in this study.

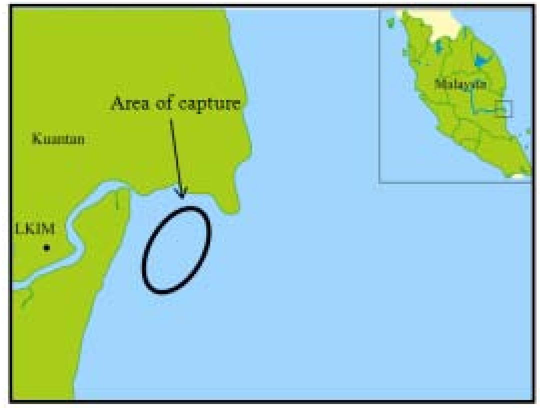

Fig. 1: Map showing area of Indian mackerel capture

Sample measurement: Upon arrival at the laboratory, total Length (L) and Standard Length (SL) of fishes were measured using a special measuring board with a meter rule calibrated in centimeters, Fish length was measured to the nearest centimeter. Body weight (W) of 2 decimal points was measured after blot drying with a piece of clean tissue. After recording length and weight of fish, it was dissected to collect gonad and determine the sex. All gonads were weighted with a digital balance. In some cases, the gonad was not developed. In those cases the sex of fish was unidentified. The length-weight relationship was calculated using the Equation (Pauly, 1983, 1993):

$$W = aL^b$$

where, W is the weight of fish (g), coefficient *a* is the intercept in the y-axis, regression coefficient b is an exponent and L is the total length of fish (cm). The value of b indicates isometric growth when close to 3. The statistical significance level of R^2 was estimated and the parameters a and b were estimated by linear regression analysis based on the natural logarithms:

$$\log W = \log a + b\log L$$

Additionally the coefficient of determination r^2 were estimated. The Fulton's Condition factor (K) for each experimental fish has been calculated using the formula:

$$K = \left(\frac{W}{L^3}\right) \times 100$$

where, K is the Condition factor, W is the Weight of fish, L is the Total length of fish (cm).

Gonadosomatic index (GSI) was calculated using the Equation:

$$GSI = \frac{Gonadweight(g)}{Bodyweight(g)} \times 100$$

Statistical analysis: All regressions and correlation were statistically analyzed using SPSS (version 16.0) which was also applied to differing between months on condition factors and gonadosomatic index. Difference between monthly condition factors and gonadosomatic index were analyzed through the analysis of variance (ANOVA) and the difference between sex ratio was analyzed through the Chi-square (χ^2) test.

RESULTS

Length-Weight relationship: Monthly of Length-Weight Relationships (LWR) of Indian mackerel were presented in Table 1 and Fig. 2. LWRs of Indian mackerel in all months were found to be linear. LWRs showed that the allometric coefficients vary between 2.5128 (April) and 3.0807 (May). LWRs of each month was significant (p<0.01) with all coefficients of determination (R^2) values being higher than 0.72. A negative allometric growth of Indian mackerel was observed in January ($W = 0.0155L^{2.8839}$, $r^2 = 0.8484$, $p<0.01$) (Fig. 2b), March ($W = 0.0135L^{2.9298}$, $r^2 = 0.8193$, $p<0.01$) (Fig. 2d) and April ($W = 0.0483L^{2.5128}$, $r^2 = 0.7261$, $p<0.01$) (Fig. 2e). An isometric growth was observed in December ($W = 0.0098L^{3.0244}$, $R^2 = 0.8841$, $p<0.01$) (Fig. 2a) and February ($W = 0.0113L^{3.0015}$, $R^2 = 0.8141$, $p<0.01$) (Fig. 2c) while a positive allometric growth was observed only in May ($W = 0.0086L^{3.0807}$, $R^2 = 0.8840$, $p<0.01$) (Fig. 2f).

Condition factor: The condition factor (K) ranged from 1.0499-1.1320 (Fig. 3). Condition factor was significantly different between months (p<0.05). The significantly lowest mean K value was found in December and the highest was in February and April. The mean condition factor in February was comparatively slightly higher than in April, although they were statistically same (p>0.05). The mean condition factors in January, March and May were significantly lower than in February and April and significantly higher than in December. The mean condition factor (K_m) in relation to size class for both sexes is shown in Fig. 4. Overall higher K_m was observed in smaller fish of both male and female. Overall K_m of female was better than male.

Sex ratio: Out of the total of 1064 specimens of *R. Kanagurta* collected from December 2011 to May 2012, only 329 were able to determine the sex. Out of 329,

Table 1: Monthly descriptive statistics and estimated parameters of length-weight relationship of Indian mackerel from December 2011 to May 2012

		Total length (cm)		Regression parameters			
Month	n	Minimum	Maximum	a	b	r^2	Significance (p value)
December 2011	208	12.0	20.3	0.0098	3.0244	0.8841	*
January 2012	170	14.6	21.9	0.0152	2.8839	0.8484	*
February 2012	105	21.6	25.5	0.0113	3.0015	0.8141	*
March 2012	208	18.0	25.6	0.0135	2.9298	0.8193	*
April 2012	160	18.6	22.1	0.0483	2.5128	0.7261	*
May 2012	213	16.2	21.4	0.0086	3.0807	0.8840	*

*Indicates significant at p<0.01

Table 2: Reported a and b values of different fish in different locations

Species	a	b	Location	References
Rastrelliger kanagurta	0.0000014	3.38	Calicut, India	Sivadas *et al.* (2006)
Euthynnus alletteratus	0.022	2.906	Tunisia	Hejjej *et al.* (2011)
Euthynnus alletteratus	0.031	2.815	Tunisia	Hejjej *et al.* (2011)
Abudefduf luridus	0.0344	2.813	Santa Maria	Morato *et al.* (2001)
Bothus podas	0.0082	3.124	Santa Maria	Morato *et al.* (2001)
Chromis limbata	0.0142	3.058	Santa Maria	Morato *et al.* (2001)
Coris julis	0.0058	3.175	Santa Maria	Morato *et al.* (2001)
Diplodus sargus	0.0111	3.181	Santa Maria	Morato *et al.* (2001)
Merlangius merlangus	0.0067	3.025	Black Sea	Kalayci *et al.* (2007)
Mullus barbatus	0.0111	2.963	Black Sea	Kalayci *et al.* (2007)
Gobius niger	0.0166	2.869	Black Sea	Kalayci *et al.* (2007)
Alosa pontica	0.0046	3.124	Black Sea	Kalayci *et al.* (2007)
Spicara smaris	0.0063	3.150	Black Sea	Kalayci *et al.* (2007)
Sardinella madereusis	0.0478	3.580	Nigeria	Abowei (2009)
Aspitrigla gurnardus	0.0064	3.120	Adriatic Sea	Vallisneri *et al.* (2010)
Eutrigla gurnardus	0.007	3.040	Adriatic Sea	Vallisneri *et al.* (2010)
Chelidonichthys lastoviza	0.0144	2.930	Adriatic Sea	Vallisneri *et al.* (2010)
Chelidonichthys lucerna	0.0093	3.010	Adriatic Sea	Vallisneri *et al.* (2010
Lepidotrigla cavillone	0.0070	3.240	Adriatic Sea	Vallisneri *et al.* (2010)

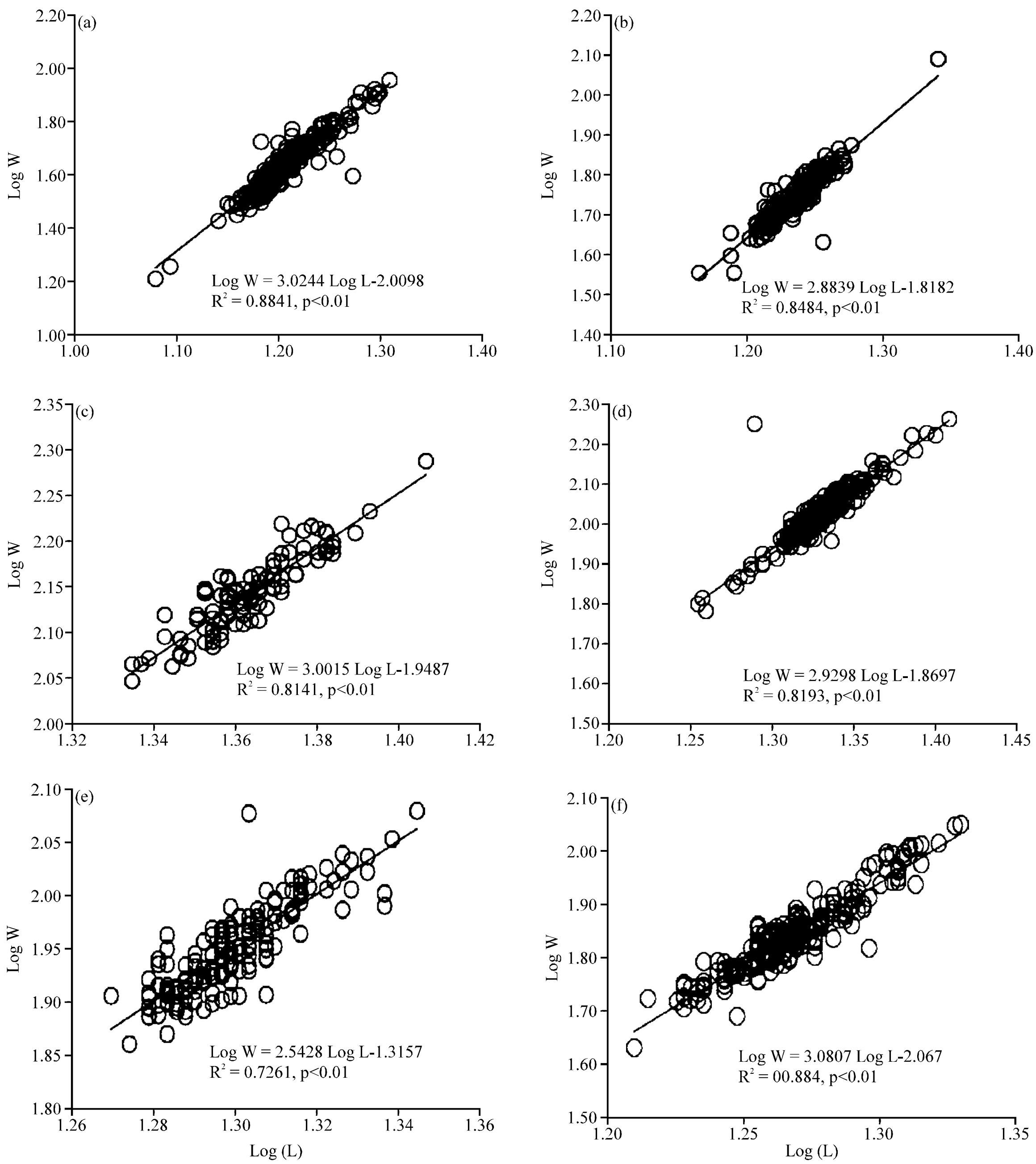

Fig. 2: Relationship between total length (cm) and body weight (g) in (a) December 2011, (b) January 2012, (c) February 2012, (d) March 2012, (e) April 2012 and (f) May 2012

190 (57.75%) were males and 139 (42.25%) were females. Overall the sex ratio differed significantly ($\chi^2 = 7.91$; $p<0.01$). Male was significantly more than female in the Indian mackerel population in the Kuantan coastal area.

Gonadosomatic index: Monthly changes of mean gonadosomatic index (GSI) of Indian mackerel are presented in Fig. 5. The lowest GSI of Indian mackerel was observed in December and January. GSI of Indian mackerel in February was higher than March and April and followed by May. GSI rapidly increased after January and reached at peak in February (1.1958%). After February GSI was declining again. A positive relationship was observed between GSI and condition factor of Indian mackerel (Fig. 6).

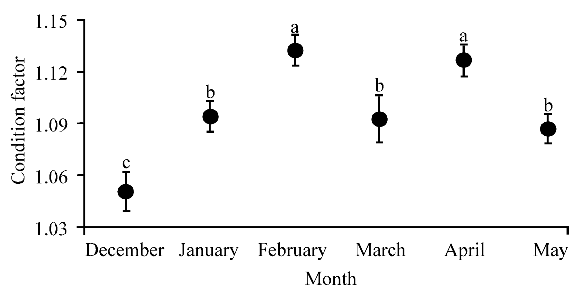

Fig. 3: Monthly mean (±95% confidence intervals) condition factor. Mean with no letter in common differ significantly ($p<0.05$)

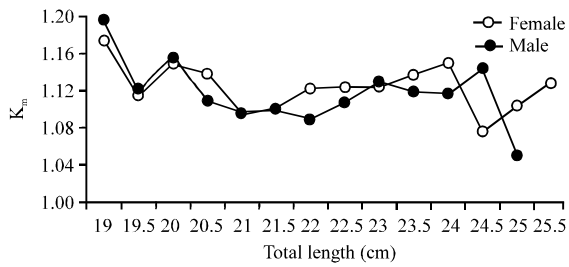

Fig. 4: Mean condition factor (K_m) per length class (total length) for both sexes

DISCUSSION

Length-weight relationship is very useful in fisheries science for both applied and basic use to (1) estimate weight from length observations because direct weight measurements can be time consuming in the field (Beyer, 1987; Martin-Smith, 1996; Sinovcic *et al.*, 2004); (2) calculate, growth, biomass and production of a population (Le Cren, 1951; Pauly, 1983) and (3) compare the life history of fishes of different localities (Petrakis and Stergion, 1995); (4) determine the relative condition of small fish compared to large fish and (5) set yield equations for estimating number of fish landed and compare the population in space and time (Beverton and Holt, 1957). Besides these, length-weight relationships allow conversion of length-growth equations to weight-growth equivalents in yield-per-recruit and related models.

The exact relationship between length and weight differs among species of fish according to their inherited body shape and within a species according to the condition (robustness) of individual fish (Schneider *et al.*, 2000). So the equation derived from the Equation logW-loga+blogL differs every time. In the present study, the coefficient b of length-weight relationship was

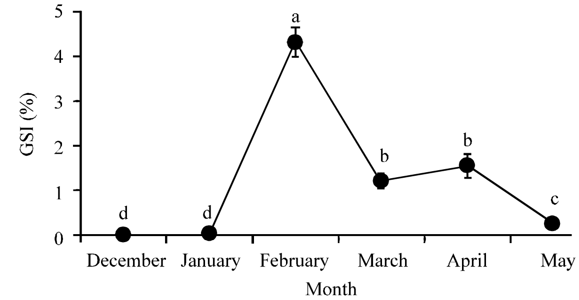

Fig. 5: Monthly changes of mean (±95% confidence intervals) gonadosomatic index (GSI) of Indian mackerel in the coastal water of Kuantan. Mean with no letter in common differ significantly ($p<0.05$)

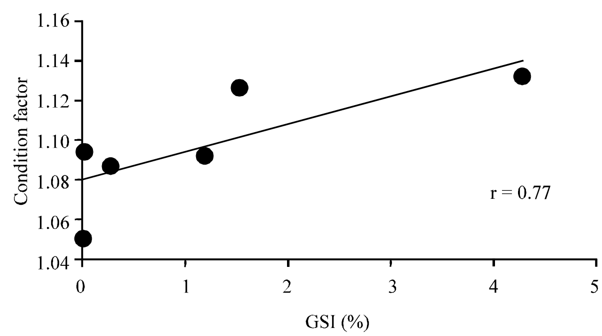

Fig. 6: Relationship between GSI and Condition Factor

ranged between 2.5128-3.0807 which was in the acceptable range (Bagenal and Tesch, 1978). The b value of most fish is around 3 (Table 2) but it can vary from 2-4 (Bagenal and Tesch, 1978). There is no previous study in the Kuantan coastal water comparing the b value of Indian mackerel. However, Sivadas *et al.* (2006) reported 3.38 as the b value of Indian mackerel in Calicut, India (Table 2).

In this study, the b-value of the LWR in April was very low (2.5128) compared to other month. However, this might be influenced by environmental or habitat factors. For example, differences in the water temperature, availability of food, etc. are known to influence the growth. According to Tesch (1971) length-weigh relationship of fish are affected by many factors including season, habitat, gonad maturity, sex, diet, health and preservation techniques. In this study, environmental or habitat factors were not analysed. However, more research is needed including analyzing environmental or habitat factors to understand the cause of low b value in April in Kuantan coastal water.

Condition factor is a quantitative parameter that indicates the state of the fish (fatness, maturity and spawning gonadal development and general well-being of the fish) and determine present and future population success by influencing growth, reproduction and survival (Wootton, 1990). Condition factor shows the population's condition (welfare) during the various stages of the life cycle. The condition factor normally decreases at the start of the spawning period due to very high metabolic rates. According to Mde and Ambrosio (2002) normally condition factor increases during the reproductive period and normalization occurs immediately after spawning. However, the study of the condition factor is very important for understanding the life cycle including spawning season of fish species and contributes to adequate management. In the present study, the condition factor of Indian mackerel was lower in December and January. Condition factor of Indian mackerel in February, March and April were higher than the other months. Condition factor of Indian mackerel in May was still higher than December and January. In the present study, it was also observed that the condition factor was positively correlated with gonadosomatic index of Indian mackerel. Based on condition factor and gonadosomatic index, it can be concluded that the peak spawning season of Indian mackerel in the Kuantan coastal water is from February to April. However, the spawning season of Indian mackerel in Kuantan coastal water may fall within the period between end of January and end of May.

CONCLUSION

This study provided a basic information on the length-weight relationship and condition factor of *R. Kanagurta* that would be useful for fisheries management. This data can be specifically used to impose adequate regulations for sustainable fishery management in the Kuantan coastal water, Malaysia. In this study, the b-value of the length-weight relationship of Indian mackerel in April was very low compared to other month. This might be influenced by environmental or habitat factors. Therefore, more research is needed including analyzing environmental or habitat factors to understand the cause of low b value in April in Kuantan coastal water. The peak spawning season of Indian mackerel in the Kuantan coastal water was from February to April. The spawning season of Indian mackerel in the Kuantan coastal water may fall within the period between the end of January and end of May.

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