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Population Characteristics of *A. japonicus* from the Kedah Coastal Waters of Peninsular Malaysia

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ABSTRACT

The study was an attempt to examine the size frequency distribution, length-weight relationship and morphometric variation of the *Acetes japonicus* from four different sides of Kedah coastal waters between March to May 2007 by using SPSS and PRIMER software. The average total length of the females from Batu Lintang and male of Tg. Dawai were the highest with the values of 17.07 and 13.93 mm, respectively. The growth co-efficient (b) values ranged between 2.0 to 4.0, indicating varieties of the growth pattern (negative allometric, isometric and positive allometric) for *A. japonicus*. The highest correlation of length-length relationship in female and male were found in the population of Kuala Sala. The morphological characteristics showed variation among populations. The highest similarity of morphometric characteristics was between Batu Lintang and Tg. Dawai for all groups (female, male, combined sexes).

Key words: Growth, morphometric variation, *A. japonicus*, Malaysia

INTRODUCTION

The shrimp of the genus *Acetes*, family Sergestidae, is a minor planktonic crustacean group. It is locally known as udang geragau, udang baring, bubok and udang siring in Malaysia. It supports a considerable subsistence fishery (Amin and Arshad, 2010). The fishing area is confined mainly to the western coast from Perlis to Johor, in which Malacca, Perak, Selangor and Penang as the major fishing centres (Omori, 1975). In east Malaysia (Sabah and Sarawak), information on *Acetes* fisheries is limited to those reported by Amin and Arshad (2010).

Five species of sergestid shrimps viz. *Acetes indicus, A. japonicus, A. intermedius, A. vulgaris* and *A. serrulatus* were identified from the different coastal region of Malaysia (Amin and Arshad, 2010). *A. indicus* was identified from the coastal waters of Klebang Besar (Malacca) and Kuala Gula (Perak). The widely distributed shrimp *A. japonicus* was identified from the coastal waters of Klebang Besar (Malacca), Kuala Gula (Perak), Pantai Bersih (Pulau Pinang), Kuala Sala (Kedah) and Sungai Berembang (Perlis). *A. intermedius* was recorded for the first time (Arshad *et al*., 2007) from the coastal waters of Klebang Besar (Malacca), Seberang Takir (Terengganu) and Bintulu (Sarawak). However, *A. vulgaris* and *A. serrulatus* were restricted in the coastal waters of Pontian (Johor Bahru).

Length-weight relationships are used for estimating growth study, age determination and population characterization. Length-weight regression equation has been widely used for estimation of average weight of fish of given length size and in stock assessment models and estimation of the condition factors of fish (Tsoumani *et al*., 2006; Goncalves *et al*., 1997). The length-weight relationship can also be used in setting yield equations for estimating the number of fish landed and in comparing the population in space and time (Beverton and Holt, 1957; Okgerman, 2005). Recently, some studies on *Acetes* have been reported from Malaysia (Amin *et al*., 2009a, b; Arshad *et al*., 2007, 2008; Dania *et al*., 2010; Oh *et al*., 2010; Amani *et al*., 2011). However, there is no information available from Kedah Coastal waters on *Acetes*. Therefore, the present study on population characteristics of *A. japonicus* in the coastal waters of Kedah, Peninsular Malaysia has been undertaken.

MATERIALS AND METHODS

Sampling sites: Samples of *A. japonicus* were collected from the different coastal waters of Kedah, Malaysia (Fig. 1) between March and May 2007. Sampling sites were Sungai Udang (5°48'820" N and 100°22'170" E), Batu Lintang (5°37'384" N and 100°23'739" E), Tanjung Dawai (5°40'749" N and 100°22'051" E) and Kuala Sala (5°58'330" N and 100°21'207" E). Latitude and longitude was determined by using GPS-12. After collection of samples, they were preserved in 5% formalin solution and transported to the laboratory.

Identification and measurements: Triplicate 10 g sub-sample was taken from the each station. Each individual of *A. japonicus* were observed and identified using digital microscope Keyence (VHX-500) and the book of Omori (1975). They were also separated into male and female by the presence of clasping spine on the lower antennular flagella as well as by the presence of petasma for male and the structure of genital area for female (Omori, 1975). For the study of length-weight and length-length relationship, a total 100 sampels (50 males and 50 females) of *A. japonicus* were measured each month and analyzed. The total length (TL), standard length (SL), carapace length (CL), abdomen length (AL) and telson length (TLL) of both sexes were measured in millimeter (mm) while total weight (TW) in milligram (mg) for the estimation of population structure.

Length-weight relationships: Length-weight relationships were estimated by the equation (Le Cren, 1951): $W = aL^b$, where, W = weight, L = total length, a = constant, b = exponent. The equation was transformed into the logarithmatic form as Log W = Log a + b Log L. The values of a and b were determined empirically. The observed average weight was plotted against the observed average length to examine the nature of parabola. On converting the values to logarithms, the exponential relationship was examined. The regression of log-weight and log-length was calculated by the method of 'Least-Squares' by grouping the sample data into several length groups of 1 mm.

Length-length relationships: A total of 400 individuals of *A. japonicus* were measured for the study of carapace length and total length relationships. For establishing the total length and carapace length relationship, the least square method was followed, y = a + bx using SPSS software. The 95% confidence limits of the parameter b and the statistical significance level of r^2 were estimated for the relationships.

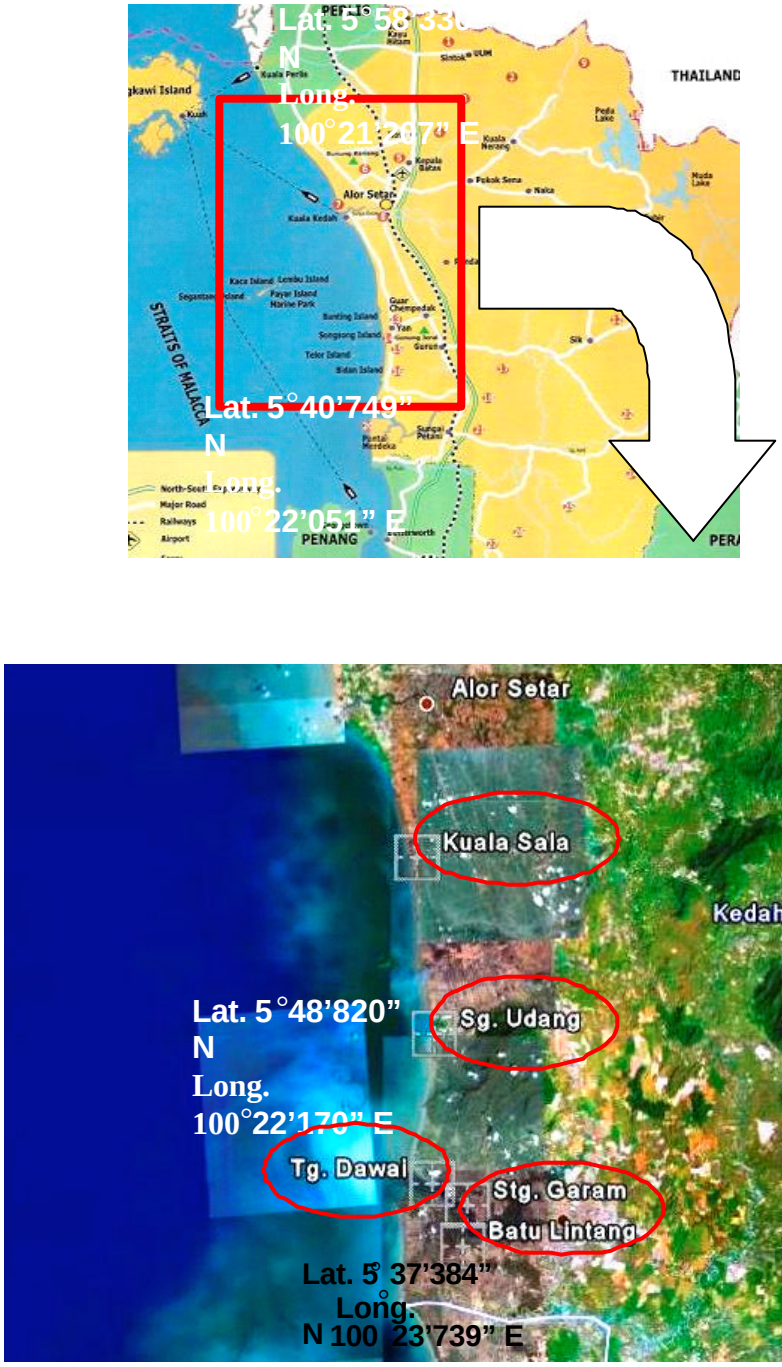

Fig. 1: Geographical location of the study sites in Kedah, west coast of peninsular Malaysia (Sg., Sungai; Tg, Tanjung; Bt, Batu)

Statistical analysis: Morphometric data were analyzed using one-way analysis of variance (ANOVA) and the PRIMER software for cluster analysis.

RESULTS

Length-weight relationships: The length-weight relationship parameters are given in Table 1. The relationship between length and weight of *A. japonicus* showed high significance ($p<0.05$) for all four stations (Table 2) and for all groups (male, female and both sex) except for male Sungai Udang and female Kuala Sala which showed lower regression co-efficient ($p>0.05$).

Length-length relationships: The carapace lengths were plotted against the total lengths. The length-length relationship parameters estimated from the study are presented in Table 3, with the all coefficient of determination (R^2) values being >0.30 for males and > 0.40 for females. The relationship between carapace and total length of this shrimp shows a highly positive correlation for females from all stations except Batu Lintang ($R^2 = 0.4137$). For male *A. japonicus*, Tg. Dawai showed less positive correlation ($R^2 = 0.3473$) whereby other three stations showed strong correlation between carapace length and total length.

Size frequency distribution

Sungai Udang: The mean total length of the female *A. japonicus* was 15.79±1.74) mm while in male was 12.54±0.67 mm. The variance for females and males was 3.04 and 0.45 mm while the

Table 1: Length weight relationship equations of *Acetes japonicus* from the coastal waters of Kedah

Stations	Sex	Equations
	F	$W = 0.0058L^{3.106}$ or Log W = 3.106 Log L-2.2337, $R^2 = 0.9366$ ($p<0.05$)
Sungai udang	M	$W = 0.1783L^{2.7893}$ or Log W = 2.7893 Log L-0.7489, $R^2 = 0.4868$ ($p>0.05$)
	B	$W = 0.0148L^{2.7697}$ or Log W = 2.7697 Log L-1.8285, $R^2 = 0.9348$ ($p<0.05$)
	F	$W = 0.0235L^{2.6186}$ or Log W = 2.6186 Log L-1.6286, $R^2 = 0.7707$ ($p<0.05$)
Batu lintang	M	$W = 0.0415L^{2.4009}$ or Log W = 2.4009 Log L-1.3823, $R^2 = 0.7122$ ($p<0.05$)
	B	$W = 0.0243L^{2.6059}$ or Log W = 2.6059 Log L-1.6143, $R^2 = 0.9221$ ($p<0.05$)
	F	$W = 0.0426L^{2.4412}$ or Log W = 2.4412 Log L-1.3702, $R^2 = 0.8158$ ($p<0.05$)
Tanjung dawai	M	$W = 0.0017L^{3.6035}$ or Log W = 3.6035 Log L-2.7775, $R^2 = 0.7635$ ($p<0.05$)
	B	$W = 0.0061L^{3.1199}$ or Log W = 3.1199 Log L-2.2135, $R^2 = 0.9064$ ($p<0.05$)
	F	$W = 0.4385L^{2.6408}$ or Log W =2.6408 Log L-0.358, $R^2 = 0.5193$ ($p>0.05$)
Kuala sala	M	$W = 0.464L^{2.4548}$ or Log W = 2.4548 Log L-0.3334, $R^2 = 0.8481$ ($p<0.05$)
	B	$W = 0.0446L^{2.4536}$ or Log W = 2.4536 Log L-1.3511, $R^2 = 0.7312$ ($p<0.05$)

Table 2: Length-weight relationship parameters of. *A. japonicus* from the coastal waters of Kedah

Station	Sex	Samples (N)	a	b (SE)	R^2	Growth type
Sg.	F	50	0.0058	3.1060 (0.04)	0.9366	Isometric
Udang	M	50	0.1783	2.7893 (0.04)	0.4868	(-) Allometric
	B	100	0.0148	2.7697 (0.05)	0.9348	(-) Allometric
Batu	F	50	0.0235	2.6186 (0.04)	0.7707	(-) Allometric
Lintang	M	50	0.0415	2.4009 (0.04)	0.7122	(-) Allometric
	B	100	0.0243	2.6059 (0.04)	0.9221	(-) Allomeric
Tg.	F	50	0.0426	2.4412 (0.05)	0.8158	(-) Allometric
Dawai	M	50	0.0017	3.6035 (0.05)	0.7635	(+) Allometric
	B	100	0.0061	3.1199 (0.05)	0.9064	Isometric
Kuala	F	50	0.4385	2.6408 (0.09)	0.5193	(-) Allometric
Sala	M	50	0.4640	2.4548 (0.03)	0.8481	(-) Allometric
	B	100	0.0446	2.4536 (0.10)	0.7312	(-) Allometric

N: Sample size; a (constant) and b (exponent), parameters of the length-weight relationship; SE: Standard error of slope b; R^2: Coefficient of determination; F: Female; M: Male; B: Both sex

Table 3: Morphometric relationship between total length and carapace length of *A. japonicus*

Station	Sex	Samples (N)	Length-length equation	R^2
Sg. Udang	F	50	CL = 3.5948TL±2.3039	0.8653
	M	50	CL = 2.6006TL±5.2166	0.5500
Batu Lintang	F	50	CL = 1.5329TL±10.904	0.4137
	M	50	CL = 1.6507TL±8.6454	0.6149
Tg. Dawai	F	50	CL = 2.1972TL±7.8438	0.7036
	M	50	CL = 1.2029TL±10.148	0.3473
Kuala Sala	F	50	CL = 3.5698TL±2.4756	0.8908
	M	50	CL = 2.4920TL±4.9698	0.7910

Table 4: Basic population characteristics for the total length of females and males *A. japonicus*

Station	Sex	Samples (N)	Mean (mm)	SD (mm)	SE (mm)	Variance (mm)	Range (mm)
Sg. Udang	F	50	15.79	1.74	0.24	3.04	11.81-19.00
	M	50	12.54	0.67	0.09	0.45	11.11-14.00
Batu Lintang	F	50	17.07	1.14	0.16	1.30	15.00-20.00
	M	50	13.78	0.85	0.12	0.72	12.40-16.00
Tg. Dawai	F	50	16.91	1.61	0.22	2.60	13.66-21.00
	M	50	13.93	0.77	0.10	0.59	12.50-15.50
Kuala Sala	F	50	14.43	1.96	0.27	3.84	10.68-18.50
	M	50	11.82	1.14	0.16	1.32	9.51-14.00

F: Female; M: Male; SD: Standard deviation; SE: Standard error

Table 5: Mean±SD, ranges (in parentheses) of morphometric characters for females

	Stations				
MC (mm)	Sg. Udang	Bt. Lintang	Tg. Dawai	Kuala Sala	F-value
TL	15.79±1.74	17.07±1.14	16.91±1.61	14.43±1.96	
	(11.81-19.00)	(15.00-20.00)	(13.66-21.00)	(10.68-18.50)	27.54*
SL	13.99±1.57	14.93±1.08	14.97±1.47	12.78±1.81	
	(10.39-17.00)	(12.29-17.40)	(12.14-18.50)	(9.41-16.50)	23.16*
CL	3.75±0.45	4.02 ± 0.47	4.13±0.61	3.35±0.51	
	(2.83-4.70)	(3.25-5.00)	(3.00-5.50)	(2.42-4.50)	22.29*
AL	10.12±1.05	10.90±0.76	10.76±0.95	9.28±1.23	
	(7.66-12.00)	(9.40-13.05)	(8.90-12.80)	(6.93-11.70)	26.67*
TLL	1.78±0.22	1.91 ± 0.12	1.92±0.15	1.63±0.25	
	(1.36-2.00)	(1.60-2.12)	(1.60-2.24)	(1.20-2.00)	22.96*

* Significant at the 5% level ($p<0.05$); MC: Morphometric character; TL: Total length; SL; Standard length; CL: Carapace length; AL: Abdomen length; TLL: Telson length; number of specimens for each location is 50

standard error was 0.24 mm (females) and 0.09 mm (male). The minimum length was 11.11 mm for males and 11.81 mm for females and the maximum length was 14.00 mm and 19.00 mm for males and females respectively (Table 4). The females was on average 3.25 mm longer than males and difference was statistically significant (t-test, $p<0.05$).

Batu lintang: The mean length of the female *A. japonicus* was 17.07±1.14) mm while in male was 13.78±0.85) mm. The variance was 1.30 mm for females and 0.72 mm for males while the standard error was 0.16 mm and 0.12 mm for females and males respectively. The minimum length was 12.40 mm for males and 15.00 mm for females while maximum length was 16.00 mm (females) and

20.00 mm (males) (Table 4). There was a statistically significant difference between males and females (t-test, $p<0.05$) which females was longer 3.29 mm than males.

Tanjung dawai: The mean length was 16.91±1.61 mm in females while in males was 13.93±0.77 mm. The variance was 2.60 mm and 0.59 mm while the standard error was 0.22 and 0.10 mm for females and males respectively. For minimum and maximum length, 13.66 and 21.00 mm was for females. The smallest male individual measured was 12.50 mm while, the largest was 15.50 mm (Table 4). The t-test is highly significant ($p<0.05$) which indicates that the difference between means is statistically significant. Average length of females was longer 2.98 mm than males.

Kuala sala: The mean length of the females *A. japonicus* was 14.43±1.96 mm while in males was 11.82±1.14 mm. The variance was 3.84 mm (female) and 1.32 mm (male). Standard error for females and males was 0.27 and 0.16 mm. The total length range for males was 9.51-14.00 mm and for females was 10.68-18.50 mm (Table 4). According to the statistically significant difference between male and female (t-test, $p<0.05$), average length of males was 2.61 mm shorter than females.

Morphometric variation: The total length of *A. japonicus* ranged from 15.00 to 20.00 mm. The population of Batu Lintang were the highest in size, with the mean value of 17.07±1.14 mm. The

Table 6: Mean (± SD), ranges (in parentheses) of morphometric characters for males

	Stations				
MC (mm)	Sg. Udang	Bt. Lintang	Tg. Dawai	Kuala Sala	F-value
TL	12.54±0.67	13.78±0.85	13.93±0.77	11.82±1.14	
	(11.11-14.00)	(12.40-16.00)	(12.50-15.50)	(9.51-14.00)	66.78*
SL	11.20±0.73	12.15±0.74	12.25±0.67	10.52±1.07	
	(9.90-13.00)	(10.99-14.00)	(10.67-13.50)	(8.40-12.50)	49.82*
CL	2.81±0.19	3.11±0.40	3.15±0.37	2.74±0.40	
	(2.32-3.00)	(2.30-4.00)	(2.47-4.00)	(2.07-3.50)	16.36*
AL	8.34±0.51	8.95±0.50	9.06±0.56	7.77±0.71	
	(7.33-9.00)	(8.00-10.00)	(7.95-10.50)	(6.34-9.00)	52.81*
TLL	1.32 ±0.20	1.61±0.19	1.64±0.21	1.30±0.17	
	(1.00-1.58)	(1.31-2.00)	(1.20-2.00)	(1.00-1.53)	44.13*

*Significant at the 5% level ($p<0.05$); MC: Morphometric character; TL: Total length; SL: Standard length; CL: Carapace length; AL: Abdomen length; TLL: Telson length; number of specimens for each location is 50

Table 7: Comparison of mean total length with the findings from previous study

		Mean±SD (mm)		
Location	Species	F	M	Reference
Sg. Udang	*A. japonicus*	15.79 ±1.74	12.54±0.67	Present study
Bt. Lintang		17.07±1.14	13.78±0.85	
Tg. Dawai		16.91±1.61	13.93±0.77	
Kuala Sala		14.43±1.96	11.82±1.14	
Bangladesh	*T. ilisha*	34.23±5.15	29.30 ± 3.45	Amin *et al*. (2005)
Malaysia	*A. intermedius*	26.42 ±2.22	24.59±1.84	Amin *et al*. (2007)

Mean±SD of *Tenualosa ilisha* in centimeter (cm) for males and females

length ranges of Batu Lintang population was 15.00-20.00 mm (Table 5). While the smallest individual of the *Acetes* was found in Kuala Sala population with mean value of 14.43±1.96) mm that ranged from 10.68 to 18.50 mm. ANOVA analysis showed that the mean difference of total length (TL), standard length (SL), carapace length (CL), abdomen length (AL) and telson length (TLL) amongst all four population were highly significant ($p<0.05$). There was no significant difference observed between Tg. Dawai and Batu Lintang for total length, telson length and carapace length ($p>0.05$).

The total length ranged from 9.51 to 16.00 mm. The biggest *Acetes* was found in Tg. Dawai population, with the mean of 13.93±0.77 mm (Table 6). While the smallest individual of *Acetes* was found in Kuala Sala population with mean value 11.82±1.14 mm. ANOVA analysis showed that the mean difference of total length (TL), standard length (SL), carapace length (CL), abdomen length (AL) and telson length (TLL) amongst all four population were highly significant ($p<0.05$). The mean difference was not significant between Tg. Dawai and Batu Lintang for all characteristics ($p>0.05$). The mean of CL and TLL between Sg. Udang and Kuala Sala did not show significant difference as well.

Dendogram in Fig. 2 on the basis of morphometric characteristics of females of *A. japonicus* showed three major clusters from four stations. Bt. Lintang and Tg. Dawai showed highest

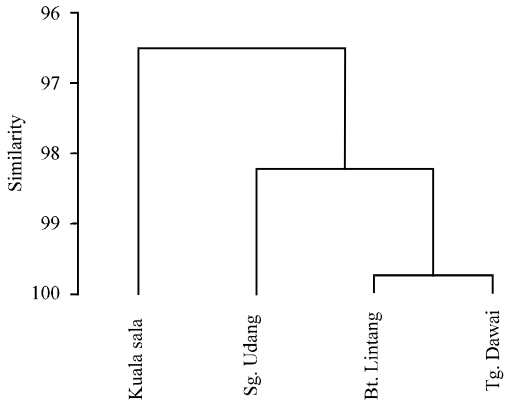

Fig. 2: Dendogram of the similarity matrix among four different stations for females *A. japonicus*

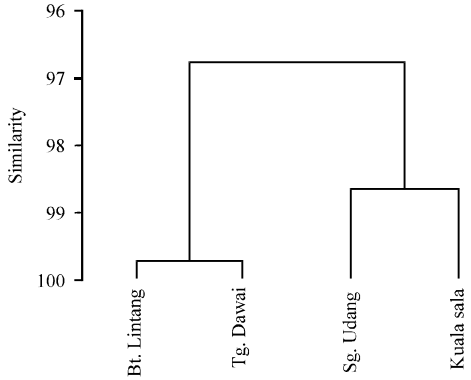

Fig. 3: Dendogram of the similarity matrix among four different stations for male *A. japonicus*

similarity(99.73%) while the similarity between Kuala Sala and Tg. Dawai were the lowest (95.91%). Dendogram in Fig. 3 showed two major clusters of the males of *A. japonicus* population in Kedah coastal water based on morphometric characteristics. The highest similarity (99.71%) were observed between Bt. Lintang and Tg. Dawai and lowest similarity (95.953%) were between Tg. Dawai and Kuala Sala.

DISCUSSION

The equations showed that sample of shrimps increased in weight with a power of approximately the cubic of the body length. In the present study, the length-weight relationships were analyzed separately for males and females from all four stations. It is observed that males and females required different equation for length-weight relationship since the value of the slope ('b') varied widely in males and females (Dineshbabu and Manissery, 2007). Ohtomi and Irieda (1997) found that studies on *S. melantho* from Kagoshima Bay of Japan showed the significant difference in slopes and elevation in the regression plot for length-weight relationship for males and females. Value of R^2 that approached to 1 indicate that higher and significant relationship between length and weight.

From the results for females, the R^2 values were 0.94 (Sg. Udang), 0.77 (Batu Lintang) and 0.82 (Tg. Dawai) which showed higher relationship but Kuala Sala (0.52) did not show significant relationship between length and weight ($p>0.05$). Only females of Sg. Udang displayed isometric growth type while other stations were (-) allometric growth type. For males, the values of R^2 were 0.71 for Batu Lintang, 0.76 for Tg. Dawai and 0.85 for Kuala Sala indicating very high degree of relationship among the characters compared. All the values were statistically significant at 95% significance level (Table 2).

Tg. Dawai population displayed (+) allometric growth while other populations showed (-) allometric growth. Based on the study by Le Cren (1951), the values of the regression co-efficient 'b' commonly lies between the expected value of 2.5-3.5 reported for most aquatic organisms. However, according to Ricker (1975), 'b' values outside the range of 2.5-3.5 are generally to be erroneous. While, Hile (1936) and Martin (1949) found that the exponent 'b' usually lies between 2.5 and 4.0. From the results, all the values lies between expected value, except male Sg. Udang (1.7893), male Bt. Lintang (2.4009) and male and female Kuala Sala (1.6408 and 1.4548 respectively). If the exponent 'b' estimated was closed to 3, which indicated that the growth was more or less isometric but when the growth is isometric, the 'b' values will be exactly '3' (Ricker, 1975). According to Sinha (1972), the exponential value b is supposed to be under the influence of numerous factors i.e., seasonal fluctuations, physiological condition at the time of collection, sex, gonadal development and nutritive conditions of the environment. While based on previous study by Bagenal and Tesch (1978), the values of 'b' differs between same species due to sex. This is because size of female *A. japonicus* was bigger and the weight was heavier than male. Other than that, values of 'b' differs under influence of maturity, seasons and even time of day because of changes in stomach fullness.

The relationship between total length and carapace length was recorded to determine the length-length relationship of the *A. japonicus*. Besides, the significant and non-significant relationship between the characteres compared can be determined as well by the equation and R^2 values. The relationship was found to be straight line by the least square method when plotting the carapace length against total length. For female, the regression coefficient (R^2) values were 0.87 (Sg. Udang), 0.70 (Tg. Dawai) and 0.89 (Kuala Sala) which indicated that higher and significant

relationship ($p<0.05$) between the characters have been compared except Batu Lintang (0.41). This suggesting that the total length increased with the increase in carapace length. While for males, the regression coefficient (R^2) values were 0.55 (Sg. Udang), 0.61 (Batu Lintang), 0.34 (Tg. Dawai) and 0.79 (Kuala Sala) (Table 3). Tg. Dawai and Sg. Udang showed less co-efficient of regression whereas stronger relationship between total length and carapace length were Batu Lintang and Kuala Sala. According to Amin *et al.* (2007), the study for length-frequency structure of *A. intermedius* showed the mean length for females was significantly higher than males (Table 7). Amin *et al.* (2005) found that from the study of size frequency distribution of Hilsa fish (*Tenualosa ilisha*) in Bangladesh water, the length and weight of the females fish on average higher than males. In present study, the size and frequency distribution analysis showed that, females *A. japonicus* from Kedah waters were heavier weight, longer carapace and the sizes were much bigger than the males. It was strongly proven that this finding was similar to the previous study in term of size frequency distribution (Table 7).

The percentage of similarity between females Batu Lintang and Tanjung Dawai was the highest which was 99.73%. This similarity was due to the location of Batu Lintang was near to Tg. Dawai compared to other stations. Sg. Udang showed significant difference between other three stations which the characteristics less similar. This also applied for Kuala Sala population. Due to location as the factor that might influenced similar characteristics, Kuala Sala and Tg. Dawai showed less percentage of similarity which the value was 95.91% because Kuala Sala located far from Tg. Dawai than Sg. Udang and Batu Lintang. The nearest distance will increased the percentage of similarity in morphometric characteristics between two different populations. Besides food, differences in abiotic factors such as physico-chemical characteristics of water from four different stations may also explain the morphological variation in *A. Japonicus*, environmental factors perhaps might have contributed to the results obtained as different stations or locations were dissimilar in environmental surroundings from one another. Phenotypic variation in morphological characters may not only be genetic but may be environmentally induced (Lindsey, 1962).

CONCLUSION

The length-weight relationship showed that for females, Sg. Udang displayed isometric growth while other stations were (-) allometric growth. For males, all stations showed (-) allometric growth except Tg. Dawai which displayed (+) allometric growth. The length – length relationship for females, showed higher and significant relationship ($p < 0.05$) between the characters have been compared for all stations except Batu Lintang.

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