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Morphometric Variation Among the Populations of Planktonic Shrimp, *Acetes japonicus* in the West Coast of Peninsular Malaysia

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ABSTRACT

Planktonic shrimp *Acetes japonicus* is found in the west of Peninsular Malaysia around the year. The study was conducted to observe the morphometric variation among the population of *Acetes japonicus* from four different sites along the coastal waters of Malacca, Penang and Perlis. Morphometric data of this species was analyzed using ANOVA and PRIMER software to investigate the degree of similarity among the populations of *A. japonicus* collected from four different sites (Malacca, Penang and two sides in Perlis) in the west coast of Peninsular Malaysia. The ANOVA showed that the mean difference of total length, standard length, carapace length and abdomen length amongst the four populations were highly significant ($p < 0.05$). No significant difference was observed amongst the telson length of four populations ($p > 0.05$). Dendrogram based on both sexes of morphometric characters showed three clusters amongst the populations. Sg. Berembang and Pantai Bersih populations were clustered in one group, Sg. Baharu population was in another group and both groups were well separated from the Klebang Besar population. The highest morphometric resemblance is observed between Sg. Berembang and Pantai Bersih populations which fall under the same group with a similarity of 99.67%. Analysis of variance showed that shrimp samples from the four sites differed significantly ($p < 0.05$) based on morphometric characters.

Key words: *Acetes japonicus*, morphometric variation, length-weight relationship, Peninsular Malaysia

INTRODUCTION

The shrimps of the genus *Acetes* from the family of Sergestidae, are a minor planktonic crustacean group represented by a small number of species but are one of the economically important organisms in Asian and East African waters (Omori, 1975). Basically, the representatives of this family are marine or marine and estuarine. *Acetes* inhabit the estuaries and coastal waters of the tropical, subtropical and temperate regions (Omori, 1975) in generally less than 50 m depth. They can withstand the great change of salinity. *Acetes* aggregate conspicuously near the shore during certain part of the year.

In total, five species of *Acetes* (*A. indicus*, *A. japonicus*, *A. intermedius*, *A. vulgaris* and *A. serrulatus*) were recorded from the different coastal region of Malaysia (Amin *et al.*, 2010). *Acetes indicus* was mainly reported from the coastal waters of Malacca and Perak. The widely distributed

shrimp of *A. japonicus* is found from the coastal waters of Malacca, Perak, Penang, Kedah and Perlis. *A. intermedius* was recorded for the first time (Arshad *et al.*, 2007) from the coastal waters of Klebang Besar in Malacca. There was no record of this species before in Malacca waters. In addition, *A. vulgaris* and *A. serrulatus* were found in the coastal waters of Johor Bahru. *A. japonicus* are widely distributed around the world. It is reported from Japan, India and Vietnam (Omori, 1975) and from Bangladesh (Zafar, 2000).

Acetes range approximately 10-40 mm in body length (Omori, 1975). The females are somewhat larger than the males (Arshad *et al.*, 2007). The body is transparent or semi-transparent with black cornea and pairs of red pigment spots which are considered to be photogenic by Okada (1928), on the basipod and endopod of the uropods. The life span of *Acetes* is less than 3-10 months and the adult die soon after spawning (Omori, 1975).

There is a lack of information on the morphometric variation among the populations of *A. japonicus*. However, detail studies on population biology on this species have been reported by Amin and Arshad (2010). Hence, the present study was to estimate the morphometric variation in the populations of *A. japonicus* from the west coast of Peninsular Malaysia.

MATERIALS AND METHODS

Study sites and sampling: Samples of *Acetes* specimens were collected from four different areas in west coast of Peninsular Malaysia which were Sg. Berembang, Perlis (6°21'00.04"N 100°08'59.84"E), Sg. Baharu, Perlis (6°20'02.58"N 100°09'59.24"E), Pantai Bersih, Penang (5°25'36.34"N 100°22'30.13"E), Klebang Besar, Malacca (2°13'01.94"N 102°11'45.78"E) during March 2007 (Fig. 1).

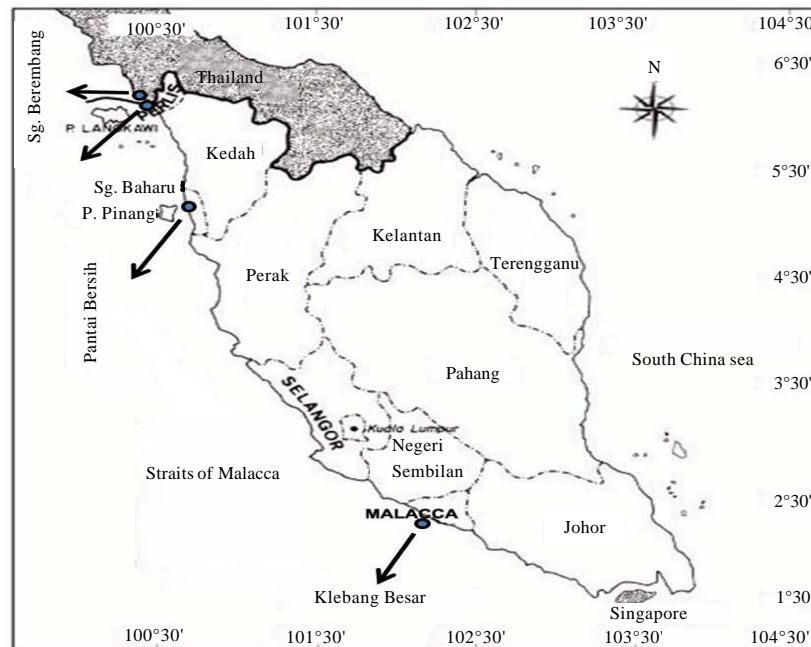


Fig. 1: Geographical location of the sampling stations (dots) in the west coast of Peninsular Malaysia

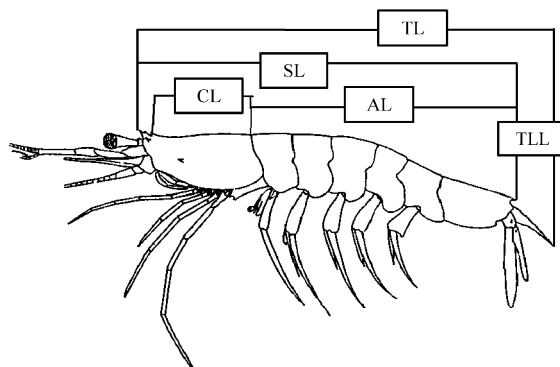


Fig. 2: Diagrammatic representation of morphometric characteristics, total length (TL), standard length (SL) carapace length (CL), abdomen length (AL) and Telson length (TLL) used for *A. japonicus*

Species identification: Ten grams sub-samples from the main sample were taken to approximately 3 replicates. Specimens were identified using a Nikon dissecting microscope in the laboratory. *A. japonicus* specimen was identified using the reference of Omori (1975). The sex determination was based on external characters. The species of *A. japonicus* were separated into male and female on the presence of clasping spine or petasma. Under digital microscope (Keyence VHX-500), five morphometrical measurements were taken for each individual (Fig. 2). The wet weight of specimen was recorded using electronic balance. Each measurement was done to the nearest 0.01 mm while individual total weight was recorded to the nearest 0.01 mg. Morphometric data were analysed using one-way ANOVA and PRIMER 5 software for cluster analysis.

Length-frequency analysis: Total length of *A. japonicus* was considered for this analysis. In total 100 specimens of *A. japonicus* (50 male and 50 female) from Sg. Berembang, Sg. Baharu, Pantai Bersih and Klebang Besar were measured for its total length. Then length-frequency was analyzed using the MINITAB 14 and SPSS software.

Length-weight relationship: The relationship between total length and body weight was expressed by the equation (Le Cren, 1951) $W = aL^b$ where W is total weight (mg) and L is total length (mm), 'a' is intercept (condition factor) and 'b' is the slope (growth coefficient). The equation was transformed into a logarithmic form; $\log W = \log a + b \log L$ and from that, parameters a and b were estimated by least squares linear regression. The coefficient of determination (R^2) was used as an indicator of the quality of linear regression (Scherrer, 1984). Additionally, 95% confidence limits of the parameter b and the statistical significance level of R^2 were estimated.

Length-length relationship: For establishing the length-length relationship, total length and carapace length were considered in the least squares method as $y = a + bx$. The 95% confidence limits of the parameter b and the statistical significance level of R^2 were estimated for the relationship.

RESULTS

Morphometric variation: The Mean \pm Standard Deviation (SD) values and ranges of morphometric characters for male *A. japonicus* are presented in the corresponding Table 1. The

Table 1: Morphometric characters of males *A. japonicus* collected from four different locations of Peninsular Malaysia

Morphometric character (mm)	Station								F-value
	Sg. Berembang (Perlis)		Sg. Baharu (Perlis)		Pantai Bersih (Penang)		Klebang Besar (Malacca)		
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	
Total length	11.82±1.42	9.71-15.25	12.10±1.23	9.55-14.5	11.65±1.04	9.24-14.0	13.44±1.40	10.25-15.81	20.09*
Standard length	10.41±1.23	8.58-13.25	10.77±1.08	8.51-13.0	10.30±0.91	8.17-12.0	11.92±1.31	9.00-14.10	21.08*
Carapace length	2.60±0.30	2.15-3.500	2.67±0.30	2.19-3.75	2.53±0.24	2.00-3.00	2.95±0.26	2.50-3.710	22.00*
Abdomen length	7.57±0.92	6.00-9.750	7.90±0.83	5.88-9.50	7.57±0.63	5.95-8.75	8.78±1.07	6.50-10.71	21.46*
Telson length	1.43±0.27	0.86-2.000	1.35±0.21	1.01-1.75	1.38±0.19	1.06-2.00	1.53±0.15	1.25-1.850	7.37*

*Significant at the 5% level at $p < 0.05$, No. of specimens (*A. japonicus*) examined in each location is 50

Table 2: Morphometric characters of females *A. japonicus* collected from four different locations of Peninsular Malaysia

Morphometric character (mm)	Station								F-value
	Sg. Berembang (Perlis)		Sg. Baharu (Perlis)		Pantai Bersih (Penang)		Klebang Besar (Malacca)		
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	
Total length	14.55±2.57	9.17-22.00	14.87±2.17	9.19-21.0	14.44±1.92	11.50-20.25	15.74±1.94	11.54-20.00	3.65*
Standard length	12.94±2.25	8.07-19.25	13.25±1.91	8.20-18.5	12.81±1.71	10.00-18.00	14.02±1.75	10.24-17.50	4.00*
Carapace length	3.41±0.62	2.10-5.250	3.41±0.52	2.11-5.00	3.29±0.46	2.50-4.750	3.59±0.45	2.50-4.750	2.71*
Abdomen length	9.32±2.03	5.67-18.00	9.51±1.41	5.84-13.0	9.25±1.26	7.00-12.50	10.17±1.29	7.50-12.75	3.79*
Telson length	1.67±0.36	1.00-2.750	1.68±0.33	1.03-2.50	1.65±0.26	1.25-2.500	1.76±0.27	1.25-2.500	1.27 ^{NS}

*Significant at the 5% level at $p < 0.05$, NS: Not significant at the 5% level at $p > 0.05$, Number of specimens (*A. japonicus*) examined in each location is 50

total length of the 200 specimens of male *A. japonicus* ranged from 9.24-15.81 mm with a mean of 12.25±1.46 mm and the standard length ranged from 8.17-14.10 mm with a mean of 10.85±1.31 mm. The larger shrimp was found in the Klebang Besar population whilst the smallest individual was from Pantai Bersih population. Analysis of variance showed that shrimp samples from the four sites differed significantly ($p < 0.05$) based on morphometric characters. It is revealed that the population from Klebang Besar, Malacca has the largest mean size in all morphometric characters than other stations.

The Mean±SD values and ranges of morphometric characters for female *A. japonicus* are presented in Table 2. In the female population, the total length of the 200 specimens of *A. japonicus* ranged from 9.17-22.0 mm with a mean of 14.9±2.21 mm and the standard length ranged from 8.07-19.25 mm with a mean of 13.25±1.96 mm. The biggest and also the smallest shrimp individuals were found in the Sg. Berembang. The ANOVA showed that the mean difference of TL, SL, CL and AL amongst the four populations were highly significant ($p < 0.05$). No significant different was observed amongst the telson length of four populations ($p > 0.05$). As observed in male population, the female sample from Klebang Besar has the largest mean length in all morphometric characters observed.

Dendrogram based on male morphometric characters showed three clusters amongst the populations (Fig. 3). Sg. Berembang and Pantai Bersih populations were clustered in one group, Sg. Baharu was in another group and both groups were well separated from the Klebang Besar population. The highest morphometric resemblance is observed between Sg. Berembang and Pantai Bersih populations which fall under the same group with 99.64% of similarity (Table 3).

Table 3: Similarity matrix (%) of male *A. japonicus* population among four stations in the west coast of Peninsular Malaysia

Stations	Sg. Berembang	Sg. Baharu	Pantai Bersih	Klebang Besar
Sg. Berembang				
Sg. Baharu	99.13			
Pantai Bersih	99.64	98.97		
Klebang Besar	96.79	97.35	96.42	-

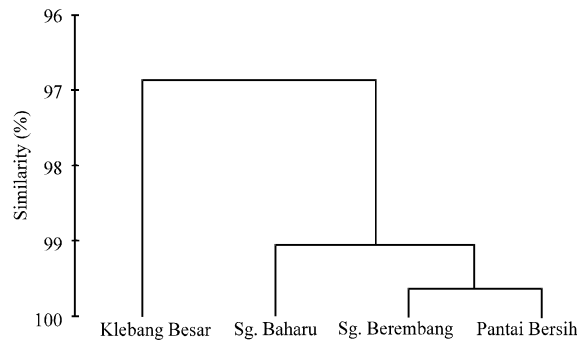


Fig. 3: Dendrogram of four populations of male *A. japonicus* based on morphometric characters collected from the west coast of Peninsular Malaysia

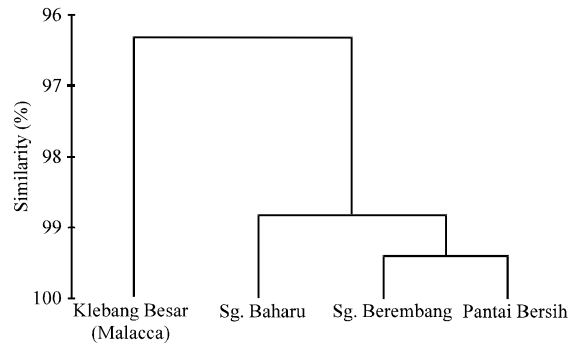


Fig. 4: Dendrogram of four populations of female *A. japonicus* based on morphometric characters collected from the west coast of Peninsular Malaysia

Dendrogram based on female morphometric characters showed three clusters amongst the populations (Fig. 4). Sg. Berembang and Pantai Bersih populations were clustered in one group, Sg. Baharu population was in another group and both groups were well separated from the Klebang Besar population.

This pattern seems to be the same as observed in male population. The highest morphometric resemblance was observed between Sg. Berembang and Pantai Bersih populations which fall under the same group as in male population but with a similarity of 99.7% (Table 4). The lowest similarity was observed between the population of Klebang Besar and Pantai Bersih (97.83%).

Length-frequency distribution: Figure 5 and 6 shows the size frequency distribution of two different groups (males and females) of *A. japonicus* in four selected sites located on the west coast of Peninsular Malaysia. The total lengths (mm) were plotted against the frequency. Apparently,

the histograms show that the size distribution of the two groups of *A. japonicus* was normally distributed (bell-shaped). The mean total lengths for Sg. Berembang populations were 11.82 ± 1.42 and 14.55 ± 2.57 mm for male and female, respectively. In males the minimum and maximum total lengths were 9.71 and 15.25 mm and in females, they were 9.17 and 22 mm, respectively (Table 5). The female was on average 2.73 larger than male. The mean total lengths

Table 4: Similarity matrix (%) of female *A. japonicus* population among stations in the west coast of Peninsular Malaysia

Stations	Sg. Berembang	Sg. Baharu	Pantai Bersih	Klebang Besar
Sg. Berembang				
Sg. Baharu	99.56			
Pantai Bersih	99.70	99.27		
Klebang Besar	98.13	98.56	97.83	

Table 5: Descriptive statistics for the total length (TL) of male and female *A. japonicus* collected from the west coast of Peninsular Malaysia

Station	N	Sex	Length range (mm)	Mean total length (mm)	SD (mm)	Variance (mm)
Sg. Berembang	50	Male	9.71-15.25	11.82	1.42	2.02
	50	Female	9.17-22.00	14.55	2.57	6.59
Sg. Baharu	50	Male	9.55-14.50	12.10	1.23	1.51
	50	Female	9.19-21.00	14.87	2.17	4.72
Pantai Bersih	50	Male	9.24-14.00	11.65	1.04	1.09
	50	Female	11.50-20.25	14.44	1.92	3.68
Klebang Besar	50	Male	10.25-15.81	13.44	1.40	1.96
	50	Female	11.54-20.00	15.73	1.94	3.76

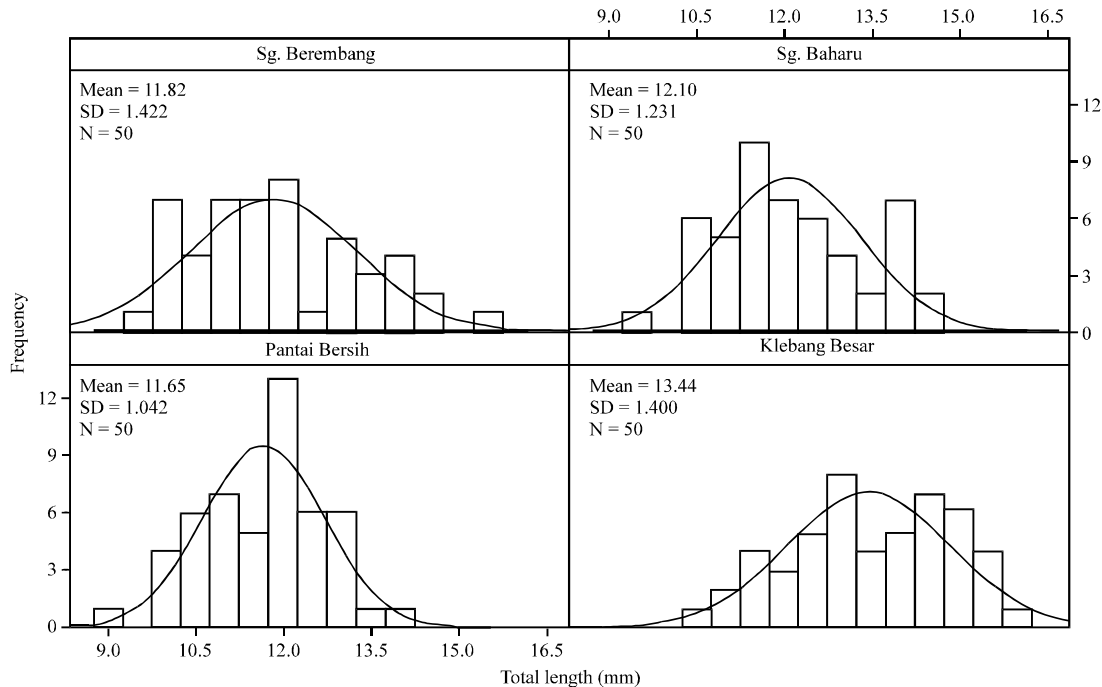


Fig. 5: Length-frequency distribution of both sexes *A. japonicus* collected from different locations of west coast of Peninsular Malaysia

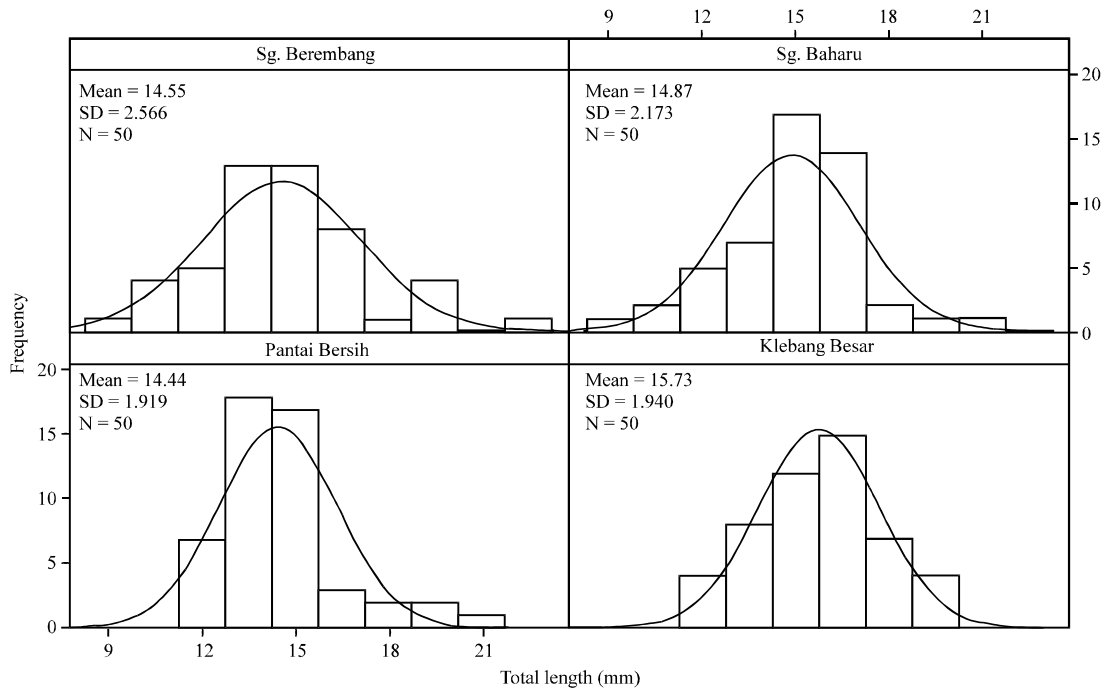


Fig. 6: Length-frequency distribution of female *A. japonicus* collected from four locations of west coast of Peninsular Malaysia

for Sg. Baharu populations were 12.10 ± 1.23 and 14.87 ± 2.17 mm for male and female, respectively. In males, the minimum and maximum total lengths were 9.55 and 14.50 mm and in females, they were 9.19 and 21.00 mm, respectively (Table 5). The female was on average 2.77 larger than male. The mean total lengths for Pantai Bersih populations were 11.65 ± 1.04 and 14.44 ± 1.92 mm for male and female, respectively. In males, the minimum and maximum total lengths were 9.24 and 14.00 mm and in females, they were 11.50 and 20.25 mm, respectively (Table 5). The female was on average 2.79 larger than male. The mean total lengths for Klebang Besar were 13.44 ± 1.40 and 15.73 ± 1.94 mm for male and female, respectively. In males, the minimum and maximum total lengths were 10.25 and 15.81 mm and in females, they were 11.40 and 20.00 mm, respectively (Table 5). The female was on average 2.29 larger than male.

Sex ratio: A total number of 941 specimens of *A. japonicus* were examined from four sites with 327 (34.8%) males and 614 (65.2%) females. The overall sex ratio for four observed locations was found to be 1:1.88 (males: females). The specimens from Sg. Berembang and Pantai Bersih populations have a higher ratio of males to females with 1:2.37 and 1:2.68 compared to Sg. Baharu and Klebang Besar in which the ratio of males to females was found to be approximately close to 1:1.

Length-weight relationship: The length-weight relationship for male, female and combined sexes of *A. japonicus* from Sg. Berembang and Sg. Baharu in Perlis, Pantai Bersih in Penang and Klebang Besar in Malacca showed parabolic curves (arithmetic scale) and linear lines (logarithmic scale) which were acquired by plotting the values of total length (mm) against their total weight (mm). The regression between Total Length (TL) and Total Weight (TW) of these groups showed

positive relationship. The parameters of total length-total weight relationships for different groups (males, females and total) are presented in Table 6. The calculated equations for the length-weight relationships of male, female and combined sexes of *A. japonicus* from four locations were:

Sg. Berembang (Perlis)

Male	$TW = 0.0275TL^{2.5253}$	or $\log TW = 2.5253TL - 1.5602$ ($R^2 = 0.6881$)
Female	$TW = 0.0088TL^{3.0163}$	or $\log TW = 3.0163TL - 2.0562$ ($R^2 = 0.9522$)
Total	$TW = 0.0085TL^{3.0158}$	or $\log TW = 3.0158TL - 2.0702$ ($R^2 = 0.9081$)

Sg. Baharu (Perlis)

Male	$TW = 0.0023TL^{3.5207}$	or $\log TW = 3.5207TL - 2.6453$ ($R^2 = 0.9103$)
Female	$TW = 0.0076TL^{3.0599}$	or $\log TW = 3.0599TL - 2.1194$ ($R^2 = 0.9465$)
Total	$TW = 0.0043TL^{3.2699}$	or $\log TW = 3.2699TL - 2.3694$ ($R^2 = 0.9556$)

Pantai Bersih (Penang)

Male	$TW = 0.0098TL^{2.9669}$	or $\log TW = 2.9669TL - 2.0102$ ($R^2 = 0.8708$)
Female	$TW = 0.0041TL^{3.3045}$	or $\log TW = 3.3045TL - 2.3861$ ($R^2 = 0.9282$)
Total	$TW = 0.0061TL^{3.1576}$	or $\log TW = 3.1576TL - 2.2148$ ($R^2 = 0.9494$)

Klebang Besar (Malacca)

Male	$TW = 0.0039TL^{3.2874}$	or $\log TW = 3.2874TL - 2.4103$ ($R^2 = 0.934$)
Female	$TW = 0.0188TL^{2.8121}$	or $\log TW = 2.8121TL - 1.7258$ ($R^2 = 0.6571$)
Total	$TW = 0.0017TL^{3.6394}$	or $\log TW = 3.6394TL - 2.7599$ ($R^2 = 0.8264$)

Length-length relationship: The carapace lengths were plotted against the total lengths. The regression of Total Length (TL) against Carapace Length (CL) for male, females and combined sexes showed positive relationship. Length-length relationship parameters were estimated from the study is presented in Table 7.

Table 6: Parameters of length-weight relationship of *A. japonicus* in the west coast of Peninsular Malaysia Sg. Berembang, Perlis

Sex	N	a	b	SE	95% CI of b	R ²	Growth type
Sg. Berembang							
Male	50	0.0275	2.525	0.245	2.032-3.019	0.69	Allometric (-)
Female	50	0.0088	3.016	0.098	2.820-3.213	0.95	Isometric
Total	100	0.0085	3.016	0.097	2.824-3.208	0.91	Isometric
Sg. Baharu, Perlis							
Male	50	0.0023	3.521	0.159	3.200-3.841	0.91	Allometric (+)
Female	50	0.0076	3.060	0.105	2.849-3.271	0.95	Isometric
Total	100	0.0043	3.270	0.071	3.129-3.411	0.96	Allometric (+)
Pantai Bersih, Penang							
Male	50	0.0098	2.967	0.165	2.635-3.299	0.87	Isometric
Female	50	0.0041	3.305	0.133	3.038-3.571	0.93	Allometric (+)
Total	100	0.0061	3.158	0.074	3.012-3.304	0.95	Isometric
Klebang Besar, Malacca							
Male	50	0.0039	3.287	0.126	3.034-3.541	0.93	Allometric (+)
Female	50	0.0188	2.812	0.293	2.223-3.402	0.66	Allometric (-)
Total	100	0.0017	3.639	0.168	3.305-3.974	0.83	Allometric (+)

a and b: Parameters of the length-weight relationship

Table 7: Relationships between total length and carapace length of *A. japonicus* in the west coast of Peninsular Malaysia

Sex	Length-length equation	N	R ²
Sg. Berembang, Perlis			
Male	TL = 4.4530CL+0.2426	50	0.89
Female	TL = 4.0113CL+0.8726	50	0.94
Sg. Baharu, Perlis			
Male	TL = 3.2031CL+3.5454	50	0.61
Female	TL = 3.6409CL+2.4668	50	0.77
Pantai Bersih, Penang			
Male	TL = 3.8017CL+2.0374	50	0.79
Female	TL = 4.0741CL+1.0223	50	0.96
Klebang Besar, Malacca			
Male	TL = 4.3891CL+0.4896	50	0.68
Female	TL = 4.0201CL+1.3180	50	0.88

DISCUSSION

There is no previous report on morphometric variation of *A. japonicus* from any part of the world. The species is previously reported from Indo-West Pacific west coast of India to Korea, Japan, China and Indonesia (Omori, 1975) and currently in the west coast of Peninsular Malaysia mainly in Sg. Berembang and Sg. Baharu (Perlis). Morphometric characteristics such as petasma with numerous hooks, apex of telson is rounded which is fully agreed with Omori (1975).

The result of ANOVA showed that the five morphometric characters of *A. japonicus* observed were significantly difference ($p < 0.05$) among four selected sites Telson length of female population which is not significantly different, $p = 0.284$ ($p > 0.05$) amongst the populations. This indicates that the telson length of female *A. japonicus* among the four locations is not varied in any extent.

The size of *A. japonicus* varies from one population to another. The highest size observed in Malacca ranging from 10.25-15.81 with a mean of 13.44 mm in total length while the population of Pantai Bersih mostly comprised the smallest sized individuals, ranging from 9.24-14.00 mm with a mean of 11.65 mm. On average, the same pattern was observed in the female populations of Klebang Besar (range: 11.54-20.00 mm, mean total length 15.74 mm) which comprised the larger individuals and Pantai Bersih (range: 11.50-20.25 mm, mean total length: 14.44 mm) which comprised the smallest sized individuals in terms of the total lengths. Various factors may be accountable for the differences such as food availability, environmental conditions, stage of maturity and seasonal changes, such as dry and rainy seasons (Sinha, 1972).

On the basis of morphometric characteristics, the cluster analysis showed that the population of male and female of *A. japonicus* were divided into three clusters respectively at different percentage of similarity which is 99.13 and 99.56%. Sg. Berembang and Pantai Bersih populations were clustered in one group while Sg. Baharu population in another group and both groups were well separated from the Klebang Besar population. This clustering suggests closer morphological similarity between Sg. Berembang and Pantai Bersih. The morphologically differences observed between these three clusters could be due to environmental differences among the locations.

The growth coefficient *b* of length-weight relationship in all four observed sites shows considerably variation ranging from 2.525-3.639. Hile (1936) and Martin (1949) showed that the exponent 'b' usually lies between 2.5 and 4.0. The relation is said to be isometric when it is closest to 3, reported for most aquatic organisms (Carlander, 1977; Le Cren, 1951). Regression analysis showed that there is significant variation in the growth pattern between sexes from four sites. In

present case, the estimated b for males from Sg. Baharu (3.521) and Klebang Besar (3.287) and females from Pantai Bersih (3.305) is higher than isometric values (3). This indicates that the positive allometric nature of growth is observed in these populations. In the case of males from Pantai Bersih (2.967) and females from Sg. Berembang (3.016) and Sg. Baharu (3.060), the estimated b is closed to isometric value and not significantly differ from 3 at 95% level. So, the growth of *A. japonicus* in these populations is isometric. The estimated b for population of male from Sg. Berembang (2.525) and females from Klebang Besar (2.812) were lower than isometric values (3) mentioned by Carlander (1977) which are considered as negatively allometric growth.

During the present investigation on the morphometry of *A. japonicus* from four sites, the coefficient of determination (R^2) for total length against carapace length ranged from 0.61-0.96 indicating high degree of relationship of both sexes. The length-length relationship showed positive relationship presented by the straight line. Female population from Pantai Bersih showed the highest degree of relation between total length and carapace length ($R^2 = 0.96$) compared to other populations.

The variation monitored in b values from regression analysis may be due to sex, maturity, time of the day or seasonal changes. Furthermore, availability of food, competition and water quality might be the attributing factors. This difference not only occurs between species but also occasionally observed between the stocks of the same species (Bagenal and Tesch, 1978).

The size structure of the population in the sampling areas consists of a relatively higher percentage of females than males. Females attained a greater size indicating a size dimorphism. In general sex ratio is known to be close to 1:1 (females:males) in nature (Fisher, 1958). This is only shown by *A. japonicus* population in Sg. Baharu and Klebang Besar with the ratio of male to female approximately 1:1. However, for *A. japonicus* population from Sg. Berembang and Pantai Bersih, females predominate in the population. Similar results were observed in several *Acetes* species (Chaitiamvong, 1980; Oh and Jeong, 2003; Henry, 1977; Lei, 1988; Zhang, 1992). Skewed sex ratio may be caused by different mortality between sexes and different behavioural characteristics such as migration (Kim, 2005).

CONCLUSION

It could be concluded that mean length of *A. japonicus* of female was significantly ($p < 0.05$) higher than male in all four sites. Individuals of *A. japonicus* from Klebang Besar seem to be larger than others while Pantai Bersih that mostly comprised of the smallest size individuals. Sex ratio of *A. japonicus* in Sg. Berembang and Pantai Bersih samples showed larger proportion of females than males. Both cluster analysis and similarity matrix revealed that there are three groups amongst the populations of *A. japonicus* in the west coast of Peninsular Malaysia.

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