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New Distribution Records of Sergestid Shrimp, *Acetes intermedius* (Decapoda: Sergestidae) from Peninsular Malaysia with Notes on its Population Characteristics

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Abstract: Present research records for the first time, the occurrence of the sergestid shrimp *Acetes intermedius* in Peninsular Malaysia. A taxonomic account of this shrimp is provided. Notes on its habitat and population characteristics were examined based on 995 specimens collected from the Klebang Besar, coastal waters of Malacca, Peninsular Malaysia during February 2005 to January 2006. Size-frequency distribution revealed that the mean size of females consistently exceeded that of males throughout the year (TL range: 15-27.50 and 13.50-33 mm for males and females, respectively). The overall yearly and the monthly sex ratio were in favor of females. Asymptotic length ($L\infty$) and growth co-efficient (K) was estimated as 34.65 mm and 1.50 $year^{-1}$. The exponent b (2.979) of the length-weight relationship for males was found near to the isometric value (b = 3.0) and positive allometric growth was observed in females and combined sexes (b = 3.227 for females and b = 3.249 combined sexes). The asymptotic weight was calculated as 211.21 mg. The overall average growth rate of *A. intermedius* showed 2.10 (± 0.88) mm/month in the coastal waters of Malacca.

Key words: New records, *A. intermedius*, Peninsular Malaysia

INTRODUCTION

The sergestid shrimp *Acetes* is locally familiar as udang garagau in the coastal region of Malacca supports a considerable subsistence fishery (Tham, 1950), which is mainly based on two species *A. indicus* and *A. joponicus* (Omori, 1975), although other two species *A. erythraeus* and *A. sibogae* also occur (Pathansali, 1966; Johnson, 1976) in the Malay Peninsula.

The species *Acetes intermedius* is one of the most important commercial shrimp resources and is also an important component of the marine ecosystem in the coastal waters of south-western Taiwan (Chiou *et al*., 2000). Annual catch of this species was greater than 2700 tones in south-western Taiwan and was valued at more than US$ 2027680 in 2000 (Chiou, 2002). *A. intermedius* migrates from estuaries to offshore waters and performs a diel vertical migration in the coastal waters of Southwestern Taiwan during the period from June to October (Chiou *et al*., 2000).

Species of the genus *Acetes* live in the estuaries and coastal waters of the tropical and subtropical regions. *Acetes* range from 10-40 mm in total length and are widely distributed in the world (Omori, 1975; Holthuis, 1980). They are major economically important shrimps in Asia and east Africa waters. During certain parts of the year, they form conspicuous aggregations near the shore and are fished mainly with push net and fixed bag net that is set near the shore against the flow of the tide. The fishing is generally done during the day time. In many Asian countries, only a small proportion of the catch is marketed as fresh shrimps; the greater proportion is dried, salted or fermented in various forms of food. Shrimp paste and sauce are manufactured extensively throughout Southeast Asia and are esteemed in their taste and nourishment (Omori, 1977; Xiao and Greenwood, 1993).

There are several earlier accounts on the *Acetes* fishery from Malay Peninsula (Tham, 1950; Pathansali, 1966; Omori, 1975; Johnson, 1976; Ahamad, 1993). All are very brief except those of Omori (1975) and Ahamad (1993). During a detailed study of the systematic of the genus *Acetes* H. Milene-Edwards, specimens of *A. intermedius* were observed in the west coast of Peninsular Malaysia. In this study, the occurrence of *A. intermedius* in the coastal waters of Malacca, Peninsular Malaysia is recorded by the first time as far as authors aware. The morphology of the specimens is compared to that of the specimens described by Omori (1975). The species is referable to as *A. intermedius*. The present report provides description with its some biological aspects like population structure, growth, sex ratio and length-weight relationship in the nature.

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MATERIALS AND METHODS

Sample collection and identification: Monthly samples of *Acetes* specimens were collected from the Klebang Besar, (N 102° 13.009′ and E 102° 11.921′) in the coastal waters of Malacca, Peninsular Malaysia (Fig. 1) between February 2005 and January 2006. The push net (mesh size 3.2 cm at anterior section, 0.75 cm at middle and 0.5 cm at cod end) was used to catch the *Acetes*. Specimens were preserved with 10% formalin immediately after collection and transported to the laboratory for further analysis. In the laboratory, *A. intermedius* was identified using a Nikon dissecting microscope. Sex of adult *A. intermedius* was determined by the presence or absence of petasma on the first pleopod and clasping spine on the lower antennular flagellum (Omori, 1975). Hansen (1919), Omori (1975) and Zafar (2000) were followed during identification of *A. intermedius*. The specimens are deposited at the Laboratory of Marine Science and Aquaculture, Institute of Bioscience, Universiti Putra Malaysia.

Water parameters: Physicals variables measured at the site shown in Fig. 1. Water temperature (°C) and salinity (ppt) were measured with a SCT meter (YSI model 33) for one year from February 2005 to January 2006.

Length-weight relationship: Total length of *A. intermedius* from tip of the rostrum to the end of telson was measured to the nearest millimeter and total weight was taken by an electronic balance of 0.1 mg accuracy. To establish the length-weight relationship, the commonly used relationship $W = aL^b$ was applied (Ricker, 1975; Quinn II and Deriso, 1999), where, W is the weight (mg), L is the total length (mm), a is intercept (condition factor) and b is the slope (growth coefficient, i.e., shrimp relative growth rate). The parameters a and b were estimated by least squares linear regression on log-log transformed data:

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

The coefficient of determination (R^2) was used as an indicator of the quality of linear regressing (Scherrer, 1984). In addition, 95% confidence limits of the parameter b and the statistical significance level of R^2 was estimated. Allometry was tested (H_o: b = 3) by Student's t-test (Zar, 1996).

Length-frequency analysis: To estimate the population structure, the length-frequency data of *A. intermedius* were analyzed by using the MINTAB Version 14 and SPSS Version 11.5. The differences in the size-frequency distributions of population between sexes were determined by the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf, 1995). Student's t-test was used for comparison of the mean total length of males and females (Zar, 1996).

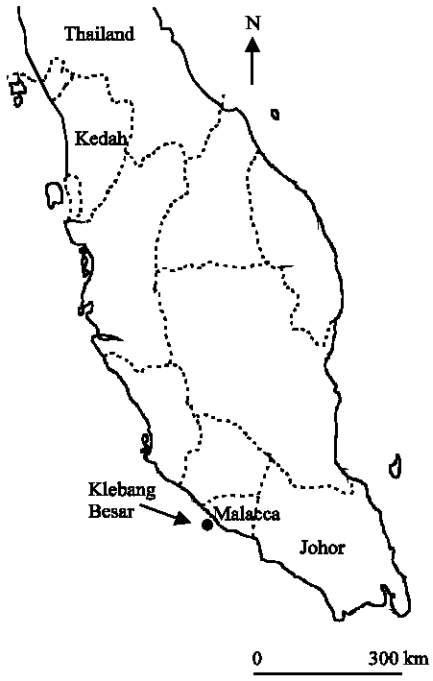

Fig. 1: Geographical location of the sampling station (●) in the coast of Malacca

Sex ratio: Monthly sex ratio (females/total) and sex ratio by size class (TL) were calculated and results were tested using the chi-square analysis (χ^2-test).

Growth parameters: Asymptotic length ($L\infty$) and growth co-efficient (K) of the von Bertalanffy Growth Function (VBGF) were estimated by means of ELEFAN-1 (Pauly and David, 1981) incorporated in FiSAT computer package (Gayalino *et al*., 1996). K scan routine was conducted to assess a reliable estimate of the K-value. The estimated of L_∞ and K was used to calculate the growth performance index (φ') (Pauly and Munro, 1984) of *A. intermedius* using the equation:

$$\varphi' = 2 \log_{10} L\infty + \log_{10} K$$

Age and growth: The inverse von Bertalanffy growth equation (Sparre and Venema, 1992) was used to find the lengths of the *A. intermedius* at various ages. Then VBGF was fitted to estimate of length-at-age curve using non-linear squares estimation procedures (Pauly *et al*., 1992).

The VBGF is defined by the equation:

$$L_t = L_\infty [1 - e^{-K(t-t_0)}]$$

where:

L_t = Mean length at age t.
L_∞ = Asymptotic length.
K = Growth co-efficient.
t = Age of the *A. intermedius*.
t_0 = The hypothetical age at which the length is zero (Dulcic and Kraljevic, 1995).

RESULTS

Taxonomic account:
Family: Segestidae
Sub-family: Sergestinae
Genus: *Acetes* Milne Edwards
Species: *Acetes intermedius* Omori, 1975 (Fig. 2).
Acetes intermedius Omori, 1975: 40, Fig. 16-17.

Material examined: Klebang Besar, near Malacca, west coast of Peninsular Malaysia, 995 specimens both sex, males, TL 15-27.50 mm, females, TL 13.50-33 mm.

Descriptive remarks: The specimen is easily identified and agreed well with the description given by Omori (1975). In the males lower antennular flagellum is 13 or 14 segmented with one clasping spine (Fig. 2a). The petasma agreed in bearing with pars astringens and capitulum of petasma with 4 subsequently large hooks along outer margin (Fig. 2b). The coxa of the third pereiopod lacks a tooth on the distal inner margin. Appendix masculine hold 3 hooks.

In females, first segment of antennular peduncle at most as long as second and third segments combined (Fig. 2c). The lower antenular flagellum is 12-15 segmented. The basis of the third pereiopod has a small projection on the distal inner margin. There is a pair of distinct protuberances on the anterior part of the third thoracic sternite; the sternite is concave in the median part and is not produced backwards. There is a small procurved tooth between the bases of the first pereiopod in both females and males. The apex of the telson is sharply pointed and triangular (Fig. 2d). There is a red spot on the proximal part of the endopods of uropod.

Water parameters: The mean value of salinity recorded in the coastal waters of Malacca was 26.39±5.65 ppt (mean±SD). The lowest value of salinity recorded was 15.56 ppt during the month of August, while the highest value of salinity recorded was 32.35 ppt during the month of February (Fig. 3). Water temperature was relatively constant between 28.03 and 33.70 °C (mean±SD, 31.23±1.60°C)

Length-weight relationship: Total length-body weight relationships for different groups (males, females and

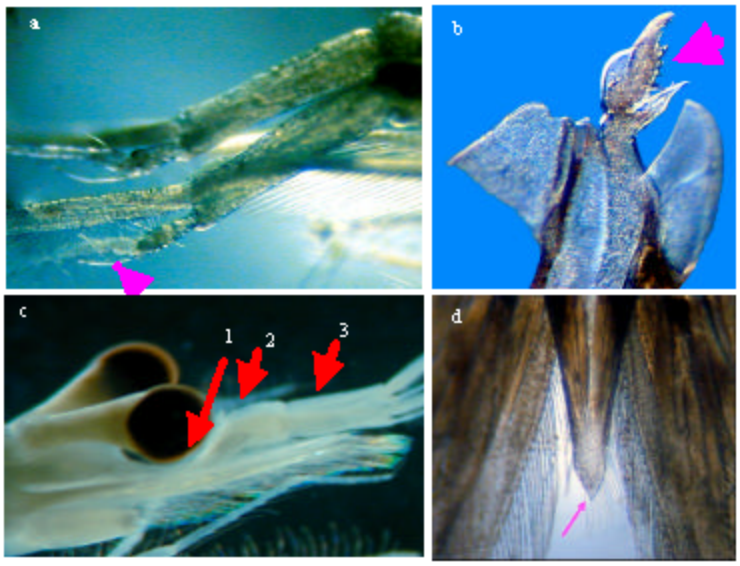

Fig. 2: *A. intermedius* Omori (a) Clasping spine (x30), (b) Petasma (x40), (c) Segments of antennular peduncle (x20) (female) (1: 1st segment, 2: 2nd segment; 3: 3rd-segment) and (d) Apex of the telson triangular (x30) (male)

Table 1: Length-weight relationship parameters of *A. intermedius* in the coastal waters of Malacca, Peninsular Malaysia

Sex	N	TL range	TW range	a	b (SE)	95% CI of b	R^2	Growth type
M	269	15.00-27.50	13.60-103.50	0.0049	2.979 (0.09)	2.798-3.159	0.80	Isometric
F	726	13.50-3300	11.80-206.20	0.0024	3.227 (0.03)	3.159-3.296	0.92	Allometric (+)
B	995	13.50-3300	11.80-206.20	0.0021	3.249 (0.03)	3.185-3.312	0.91	Allometric (+)

N: Sample size; TL: Range minimum and maximum total length (mm); TW range: Minimum and maximum total weight (mg); a and b: Parameters of the length-weight relationship; SE: Standard error of the slope b; R^2: Coefficient of determination

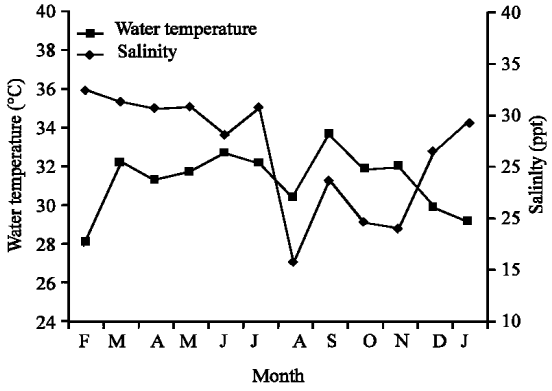

Fig. 3: Water parameters of the coastal waters of Malacca, Peninsular Malaysia

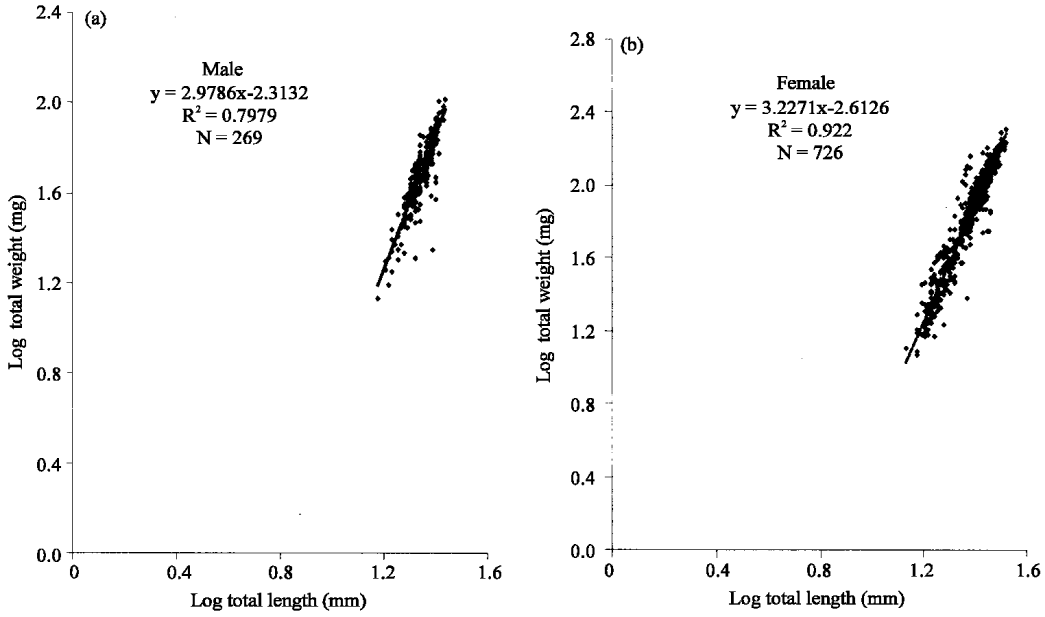

Fig. 4: Relationship between log total length (mm) and log total weight (mg) in males (a) and females (b) of *A. intermedius*

combined sexes) are shown in Table 1. The regression of TL (total length) and TW (total weight) and CL (carapace length) against TL for males and females showed positive relationship, respectively (Fig. 4 and 5). The length-weight and length-length equations were calculated as:

Log TW = 2.9786 Log TL -2.3132,
R^2 = 0.80 for male *A. intermedius*
Log TW = 3.2274 Log TL -2.6131,
R^2 = 0.92 for female *A. intermedius*
Log TW = 3.2489 Log TL -2.6518,
R^2 = 0.91 for combined sexes of *A. intermedius*
TL = 5.0613 CL + 0.7155,
R^2 = 0.8343 for male *A. intermedius*
TL = 3.9326 CL + 4.6815,
R^2 = 0.8807 for female *A. intermedius*

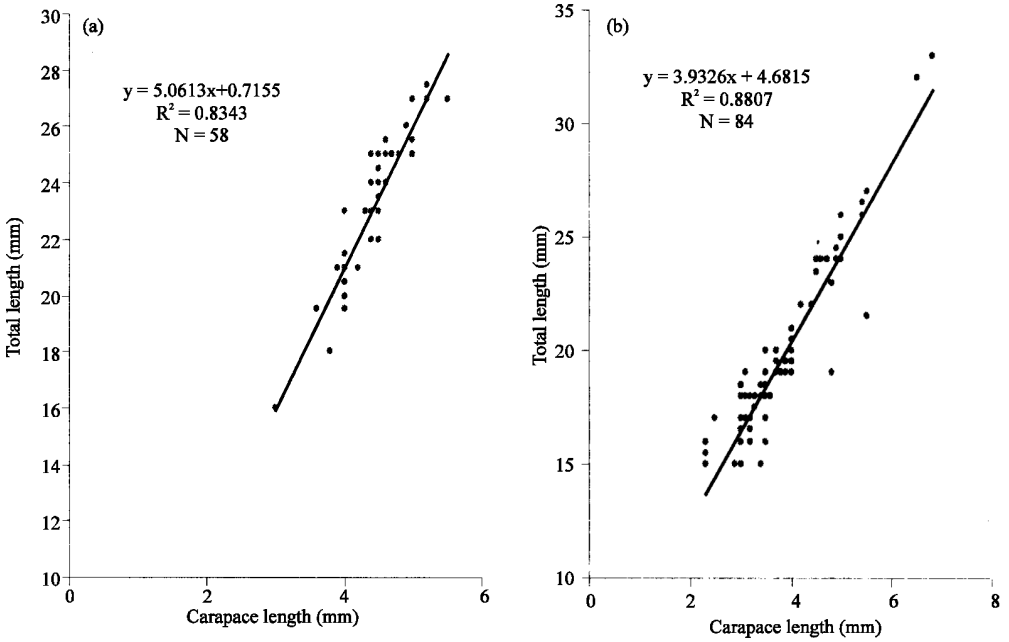

Fig. 5: Relationship between carapace length (mm) and total length (mm) in males (a) and females (b) of *A. intermedius*

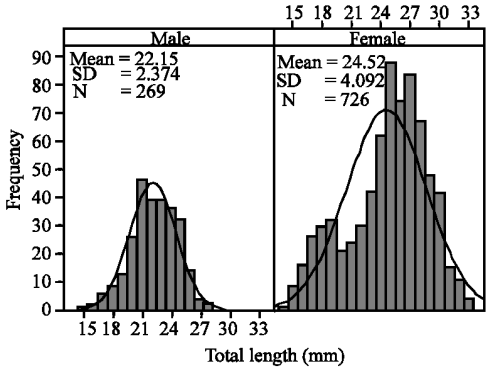

Fig. 6: Annual length-frequency histogram of males and females of *A. intermedius* collected from the coastal waters of Malacca

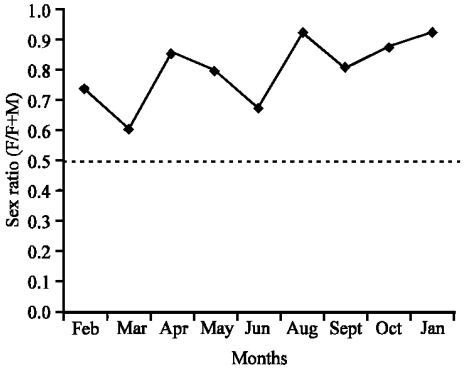

Fig. 7: Temporal variation of sex ration of *A. intermedius*. The dotted line indicates a ratio of 1:1 (female: male)

Population structure: Total number of individuals collected for this study was 269 (27.04%) for male and 726 (72.96%) for female, respectively. According to the size-frequency distribution, there was significant difference between males and females (Kolmogorov-Smirnov test: dmax = 0.403, $p<0.001$) (Fig. 6). The mean total lengths were 22.151 (±2.373) mm and 24.517 (±4.091) for male and female, respectively. In males, the minimum and maximum total lengths were 15 mm and 27.50 and in females, they were 13.50 and 33 mm, respectively. The mean total length of female was 2.40 mm larger than that of the male and it was significantly different (t-test, $p<0.001$).

Sex ratio: The overall yearly sex ratio was found to be 1:2.67 (males: females). In all samples, there was a predominance of females in every month (Fig. 7). Chi-square test revealed that the total number of females was significantly greater than of males in the samples throughout the sampling period ($\chi^2 = 39.24$, df = 8, $p<0.001$). The sex ratio by size class (CL) showed a clear predominance of female's number in the lower sizes (<19 mm) and also in the larger size classes (> 22 mm) (Fig. 8). Males dominated the intermediate size classes (19-21 mm).

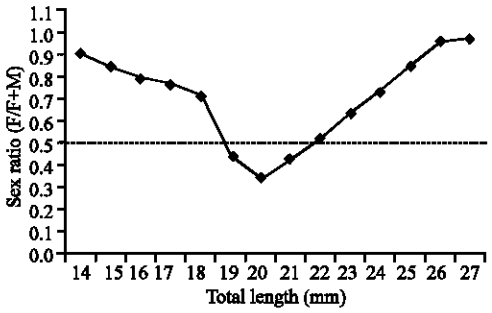

Fig. 8: Variation of sex ration in relation to size (TL) of *A. intermedius*. The dotted line indicates a ratio of 1:1 (female: male)

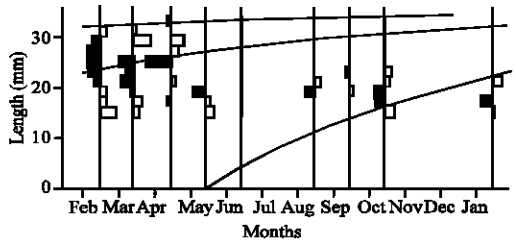

Fig. 9: von Bertalanffy growth curves ($L\infty$ = 34.65 mm and K = 1.50 year^{-1}) for *A. intermedius* superimposed on the restructured length-frequency histograms. The black and white bars are positive and negative deviation from the weighted moving average of three length classes and they represent pseudo-cohorts

Growth parameters: The observed extreme length and the predicted extreme length were found to be 33 and 35.62 mm, respectively. The range at 95% confidence interval for total length was 30.39-40.84 mm. This initial extreme length value was used into ELEFAN-I, incorporated in FiSAT package (Gayanilo *et al*., 1996) producing the optimum growth curve. The best value of VBGF growth constant (K) was estimated as 1.5 year^{-1} by ELEFAN-I. The response surface (Rn) was calculated by ELEFAN-I as 0.479 which selected the best combination of growth parameters are: L_∞ = 34.65 mm and K = 1.50 year^{-1}. The optimized growth curve was superimposed on the restructured length-frequency histograms (Fig. 9). The calculated growth performance index (φ') of *A. intermedius* was 3.255.

Age and growth: It has assumed in the ELEFAN-I analysis that the value of the third parameter of the von Bertalanffy growth function t_0 be zero (Pauly and David, 1981). Therefore, the sizes attained by *A. intermedius* were 7.66, 13.63, 18.28, 21.90, 24.72 and 26.92 mm at the end of 2, 4, 6, 8, 10 and 12 months of age, respectively. The absolute increase is presented in Fig. 10. The calculated average growth rate of *A. intermediuss* for the first six months was 2.86 (± 0.58) mm/month and in the following six months it was 1.35 (±0.27)/month.

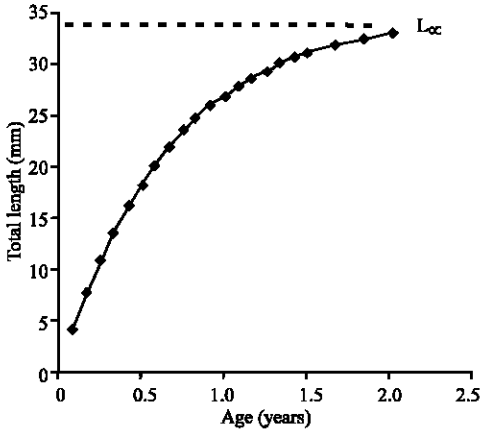

Fig. 10: Plot of age and growth of *A. intermedius* based on computed growth parameters ($L\infty$ = 34.65 mm and K = 1.5 year^{-1})

DISCUSSION

The species *A. intermedius* is previously reported from Bangladesh (Zafar, 2000); Taiwan, Philippines and south coast of Java, Indonesia (Omori, 1975) and now in the coast of the Straits of Malacca, Peninsular Malaysia. It is one of the most important commercial shrimp resources and is also an important component of the marine ecosystem in the coastal waters of south-west Taiwan (Chiou *et al*., 2000). The comparison with morphological characters obtained in other studies show differences in *A. intermedius* from different areas in the world (Table 2). The morphometric characteristics like petasma with pars astringens with 4 subsequent large hooks, apex of telson is sharply pointed and triangular which is fully agreed with Omori (1975). The present specimens afford the first subsequent record of the species *A. intermedius* and extend considerably the range of distribution, being the first to be known from the cost of Peninsular Malaysia.

The growth coefficient b of length-weight relationship generally lies between 2.5 and 3.5 and the relation is said to be isometric when it is equal to 3, reported for most aquatic organisms (Carlander, 1977; Le Cren, 1951). Table 3 shows previously published values of the coefficients a and b for the genus *Acetes*. The values of b show considerable variation, ranging from

Table 2: Morphological characters of three *Acetes* species from other locations

	A. intermedius		*A. indicus*		*A. japonicus*	
Characters	Male	Female	Male	Female	Male	Female
Body length range in (mm)	17.0-24.0	20.0-24.0	15.5-25.0	16.5-31.0	11.0-23.5	12.0-29.0
No. of clasping spines on lower antennular flagellum	1	-	1	-	2	-
Details of petasma	Pars astringens present	-	Pars astringens absent	-	Pars astringens absent	-
Procurved tooth between first pleopod	Present	Present	Present	Present	Absent	Absent
Details of apex of telson	Triangular	Triangular	Triangular	Triangular	Round/truncate	Triangular
Anterior margin of genital coxa	Round	-	Pointed	-	Round	-

Source: Omori (1975)

Table 3: Parameters of length-weight relationship (a and b) for the genus *Acetes* from various locations

Location	Species	a	b	R^2	Growth type	Source
Bangladesh	*A. indicus*	0.0047	3.108	0.98	Isometric	Zafar *et al.* (1997)
Bangladesh	*A. chinensis*	0.0107	2.908	0.98	Negative allometric	Zafar *et al.* (1998a)
Bangladesh	*A. erythræus*	0.0051	3.106	0.99	Isometric	Zafar *et al.* (1998b)
China	*A. joponicus*	0.1302	2.155	-	Negative allometric	Lei (1988)
Japan	*A. japonicus*	0.1566	2.231	0.96	Negative allometric	Uye (1982)
Japan	*A. sibogae*	0.0085	2.985	0.98	Isometric	Ikeda and Raymont (1989)

2.155 (Lei, 1988) to 3.108 (Zafar *et al.*, 1997). In present case, the estimated b is 3.227 for females and it lies between the values mentioned by Carlander (1977) and Ecoutin *et al.* (2005), which is significantly higher than isometric value (3) at 5% level. This indicates that the positive allometric nature of growth for female's *A. intermedius*. In case of males, the estimated b is 2.979 and it is not significantly lower from isometric value at 5% level. The relationship between total lengths against total weight suggested that as total length increases weight is heavier in females than in males. Regression analysis on the log-transformed data showed a strong relationship of both sexes ($R^2 = 0.797$ for males and $R^2 = 0.92$ for females) and significant ($p<0.05$).

The size structure of the population in the sampling area 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: male) in nature (Fisher, 1958), but in *A. intermedius* population of the coastal waters of Malacca, it was in favor of females in most of the months of the years. Similar results were observed in several *Acetes* species (Chaitiamvong, 1980; Jeong *et al.*, 2003; Henry, 1977; Lei, 1988; Zhang, 1992). Skewed sex ratio can be caused by different mortality between sexes and different behavioral characteristics such as migration (Kim, 2005).

The overall average growth rate of *A. intermedius* showed 2.10 (±0.88) mm month^{-1}, which enable it to attain a total length of around 26.92 mm in 12 months. Similar studies have been reported by Al- Barwani *et al.* (2007), Amin *et al.* (2001), Amin and Zafar (2004) and Blaber *et al.* (1998) through length converted age method which also been followed in this study.

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