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Population Dynamics of Sergestid Shrimps *Acetes japonicus* in the Estuary of Tanjung Dawai, Kedah, Malaysia

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ABSTRACT

Population parameters of male and female *A. japonicus* were studied using the monthly length frequency data to evaluate the mortality rates and its exploitation level. The sex ratio (male: Female) was found at 1: 0.94. Asymptotic length ($L\infty$) was 25.20 mm and 28.88 mm for male and female, respectively. Growth co-efficient (K) for males and females was estimated at 1.80 and 1.30 $year^{-1}$, respectively. Total mortality (Z) was calculated at 5.98 and 4.44 $year^{-1}$ for male and female of *A. japonicus* respectively. Natural mortality (M) was 2.82 and 2.19 $year^{-1}$ for the male and female shrimps. The fishing mortality (F) was 3.16 $year^{-1}$ for male and 2.25 $year^{-1}$ for female. Exploitation level (E) for male and female of *A. japonicus* was calculated at 0.53 and 0.51. The exploitation level was slightly over (E>0.50) the optimum level of exploitation (p = 0.50). The stock of *A. japonicus* was found to be slightly over exploited in Tanjung Dawai estuarine waters.

Key words: Population parameters, *Acetes japonicus*, Peninsular Malaysia

INTRODUCTION

The shrimp of family Sergestidae includes many small-sized commercially important shallow water marine majorities of tropical and sub-tropical regions (Pathansali, 1966). Knowledge on the shrimp's biology and population characters are important if proper management of those fragile resources is to be effective. Age for crustacean is difficult to estimate because exoskeletons are lost during ecdysis.

Analysis of length-frequency has been used for many years to estimate growth number of year classes in a population of *Acetes* (Amin *et al*., 2008, 2010a, b; Zafar *et al*., 2001, 1998). Length-weight relationships are useful for a wide number of studies, such as estimating growth rates, age structure and other aspects of fish or shrimp population dynamics. In addition, length-weight relationships are useful for between region comparisons of life histories of a certain species (Tsoumani *et al*., 2006).

In the Peninsular Malaysia, the species shows a considerably wide geographical distribution even along the Straits of Malacca (Amin *et al*., 2009). Pathansali (1966) stated the high abundance of *A. japonicus* in Glugor and Batu Maung of Penang Island in most months of the year. But there is no report yet available on the population dynamics of *A. japonicus* in the coastal waters of Kedah. Information on mortality rates and exploitation level are necessary for open water coastal

fishery management. Therefore, the present study on the population parameter such as growth, mortality and exploitation of *A. japonicus* were undertaken to address this shortage of information. Apart from the Straits of Malacca, *A. japonicus* is also recorded from both east and west coast of India. In Japan, the shrimp is found in the neritic waters around Kyushu and western part of Honshu but it is commercially fished in the Ariake Sea, Seto Inland Sea and Toyama Bay (Omori, 1975). The occurrence of the species in the easternmost region is through the record at the mouth of Shinano River, the Sea of Japan (Omori, 1975), while *A. japonicus* are found as far north as Kuwait Bay (Khor al Sabiya) in Gulf of Arabia (Grabe and Lees, 1992; Euzen, 1987; Miquel, 1984; Enomoto, 1971) and in South Africa (Barnard, 1955).

The main objectives of this study is to estimate the population parameters such as asymptotic length (L_∞) growth coefficient (K), natural mortality (M) and fishing mortality (F) of *A. japonicus*. The results would be used to estimate the recruitment pattern of *A. japonicus* and also to estimate the present status of exploitation levels (E) in the study area.

MATERIALS AND METHODS

Study area and sampling: Monthly samples of *Acetes* catches were collected between June 2008 and May 2009 from the local fisherman of Tanjung Dawai, Kedah (N5° 40' 48" and E 100° 22' 5") (Fig. 1). The fisherman used Set Bag Net (SBN) for catching the sergestid shrimps. Fresh catches were taken from fisherman immediately after hauling and preserved in 10% formalin for laboratory analysis.

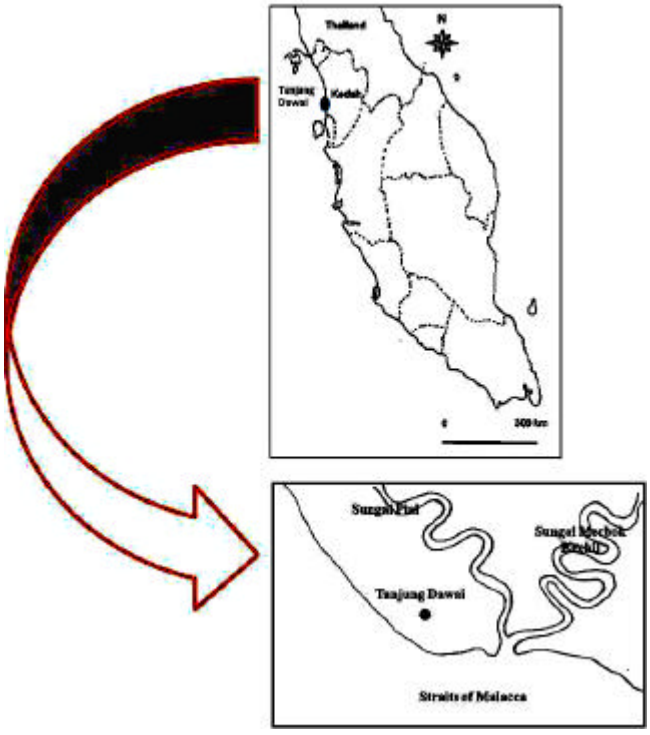

Fig. 1: Geographical location of the study site in the Tanjung Dawai (•), Kedah, Peninsular Malaysia

Laboratory measurement: Total Length (TL) of 2060 individuals (males 1057 and females 1003) from the tip of the rostrum to the tip of the telson were measured to the nearest 0.1 mm and total weight was measured using an electronic balance having an accuracy of 0.001 g. Then the length-frequency data were prepared with 2 mm interval.

Data analysis: Length-weight relationship was estimated by using the relationship of $W = aL^b$ applied by Ricker (1975), where, W is the total weight (mg), L is the total length (mm), a is condition factor and b is the slope (growth coefficient). The parameters a and b was estimated by least squares linear regression on log-log transformed data:

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

Additionally, 95% of confidence limits of the parameter b and the statistical significance level of r^2 was estimated (Scherrer, 1984). Monthly length-frequency data of *A. japonicus* were analyzed using the FiSAT software (Gayanilo *et al*., 1996). The parameters of the Von Bertalanffy Growth Function (VBGF), asymptotic length (L_∞) and growth co-efficient (K) were estimated using ELEFAN-I routing (Pauly and David, 1981). The L_∞ and K was used to calculate the growth performance index (φ') (Pauly and Munro, 1984) of *A. japonicus* using the following equation:

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

Total mortality (Z) was estimated by using the length converted catch curve (Pauly, 1984). Natural mortality (M) was estimated using empirical relationship of Pauly (1980):

$$\text{Log}_{10} M = -0.0066 - 0.279 \text{ Log}_{10} L_\infty + 0.6543. \text{ Log}_{10} K + 0.4634 \text{ Log}_{10} T$$

where, M is the natural mortality, $L\infty$ the asymptotic length, K the growth co-efficient of the VBGF and T the mean annual habitat water temperature °C.

Once Z and M were obtained, fishing mortality (F) was found using the relationship:

$$F = Z - M$$

where, Z is the total mortality, F fishing mortality and M, the natural mortality. The exploitation level (E) was obtained by the relationship of Gulland (1971):

$$E = F/Z = F/(F+M)$$

The recruitment pattern of the stock was determined by backward projection on the length axis of the set of available length frequency data as described in FiSAT.

RESULTS

Length-weight relationships: The length-weight relationship equations for the males, females and combined sexes were established as:

- Log TW = 0.0152 Log TL-2.53, $r^2 = 0.82$ for male
- Log TW =0.0153 Log TL-2.55, $r^2 = 0.84$ for female
- Log TW =0.011 Log TL-2.66, $r^2 = 0.89$ for combined sexes

Total lengths and total weights of *A. japonicus* were in the range of 11.00-24.00 mm and from 5.60 to 49.20 g for males, from 15.00-28.50 mm and from 8.80 to 71.40 g for females and from 11.00 to 28.50 mm and 5.60 to 71.40 g for both sexes accordingly. The parameters of length weight regressions for males, female and all individuals are given in Table 1. The results showed that growth was negative allometric for males, females in the estuarine waters of Tanjung Dawai. The curves of length-weight relationship of male presented in Fig. 2.

Sex ratio: In total, 2060 individuals were examined during one year study period. Among them 1057 (51.3%) were males and 1003 (48.7%) were females. The annual sex ratios of males to females were found to be 1: 0.94. Female's numbers were higher than males in July-October and March-May during the study period. On the other hand, the numbers of females were lower in June, December- January (Fig. 3) in the study area. The χ^2- test revealed that the sex ratio between males to females was not significantly different from the theoretical 1:1 sex ratio ($p>0.05$).

Size frequency distribution: The mean total length was 14.84±1.94 and 18.42±2.97 mm for male and female, respectively. In males, the maximum and minimum total lengths were 24 mm and 11 mm and in the females, they were 28.50 mm and 11 mm respectively. The mean total length of female was 2.97 mm longer than that of the male and it was significantly different ($p<0.05$). In general, males were predominance in the smaller lengths and females in larger lengths (Fig. 4a, b).

Table 1: Length-weight relationship parameters of *A. japonicus* in the coastal waters of tanjung dawai, Kedah

Sex	N	TL range	TW range	a	b	95% CI of b	R^2
M	1057	11.00-24.00	5.60-49.20	0.0152	2.53	2.464-2.608	0.82
F	1003	15.00-28.50	8.80-71.40	0.0153	2.55	2.491-2.625	0.84
B	2060	11.00-28.50	5.60-71.40	0.011	2.66	2.626-2.704	0.89

Legends: N: Sample size; TL: Range, minimum and maximum total length (mm); a and b: Parameters of the length-weight relationship; R^2: Coefficient of determination

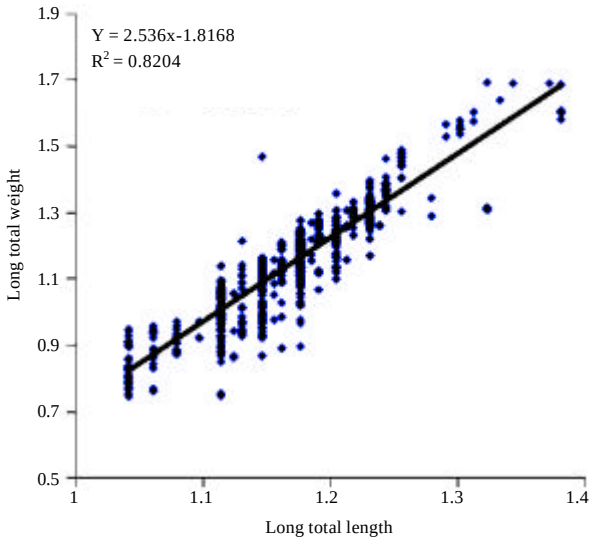

Fig. 2: Length-weight relationship of male *A. japonicus* in the coastal waters of Tanjung Dawai

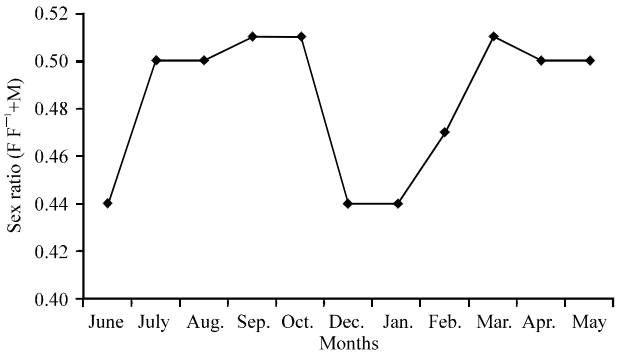

Fig. 3: Temporal variation of sex ratio of *A. japonicus* in the estuarine waters of Tanjung Dawai, Kedah

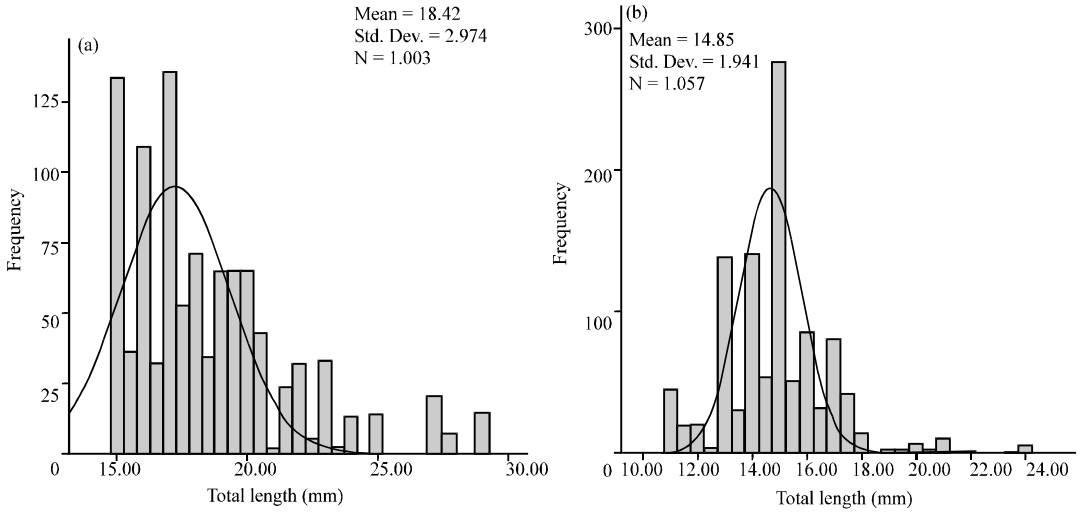

Fig. 4(a-b): Annual length frequency distribution of male and female *A. japonicus* in the coastal waters of Tanjung Dawai, Kedah; (a) Female and (b) Male

Growth parameters: The estimated population parameters of *A. japonicus* from coastal waters of Tanjung Dawai, Kedah are presented in Table 2. The growth parameter of the von Bertalanffy equation likes asymptotic length (L_∞) and growth co-efficient (K year^{-1}) were: L_∞= 25.20 mm, K = 1.80 year^{-1} for males and L_∞= 28.88 mm, K = 1.30 year^{-1} for females. It was revealed that females were longer than males. But growth co-efficient was higher in males than females. The fitted von Bertalanffy growth curves for males and females are presented in Fig. 5a and b. The growth performance index (φ') was calculated at 3.03 for females and 3.05 for males.

Recruitment pattern: The recruitment pattern of males and females *A. japonicus* are given in Fig. 6a and b. The recruitment patterns were continuous with two major peaks for both males and females. Highest peak was found between months of February and June for both males and females and the second peak was observed in September-November.

Mortality and exploitation rate: Natural mortality of males and females was 2.82 and 2.19 year^{-1}, respectively and fishing mortality was 3.16 and 2.25 year^{-1} for males and females

Table 2: Estimated population parameters of *A. japonicus* in the coastal waters of Tanjung Dawai, Kedah

Population parameters	Male	Female
Asymptotic length (L_∞) in mm	25.2	28.88
Growth co-efficient (K year^{-1})	1.8	1.3
Natural mortality (M yearr^{-1})	2.82	2.19
Fishing mortality (F year^{-1})	3.16	2.25
Total mortality (Z year^{-1})	5.98	4.44
Exploitation level (E)	0.53	0.51
Sample number (N)	1057	1003

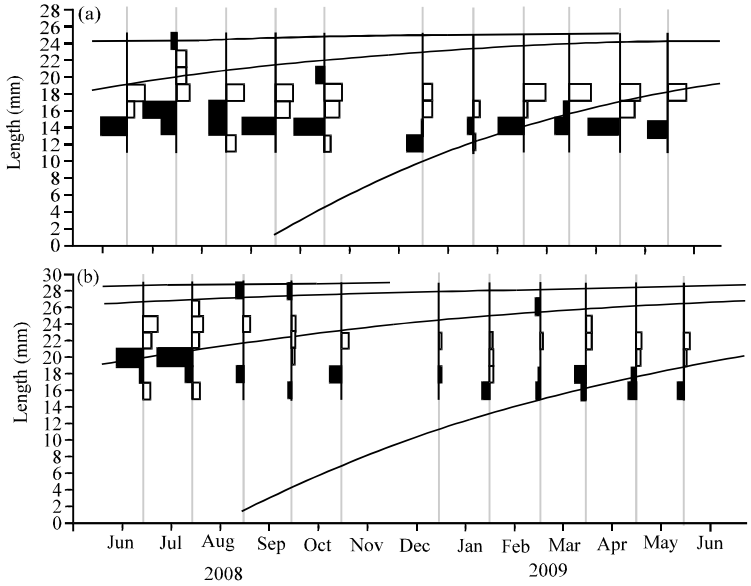

Fig. 5(a-b): von Bertalanffy growth curves of (a) Male and (b) Female *A. japonicus* from Kedah, Malaysia

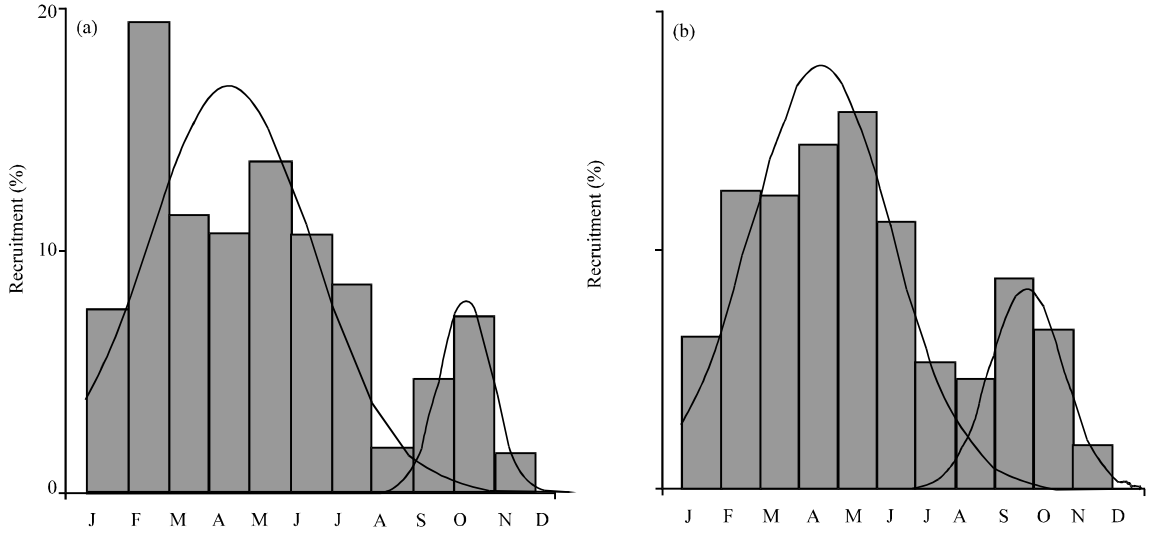

Fig. 6(a-b): Recruitment pattern of (a) Male and (b) Female *A. japonicus* from Kedah, Malaysia

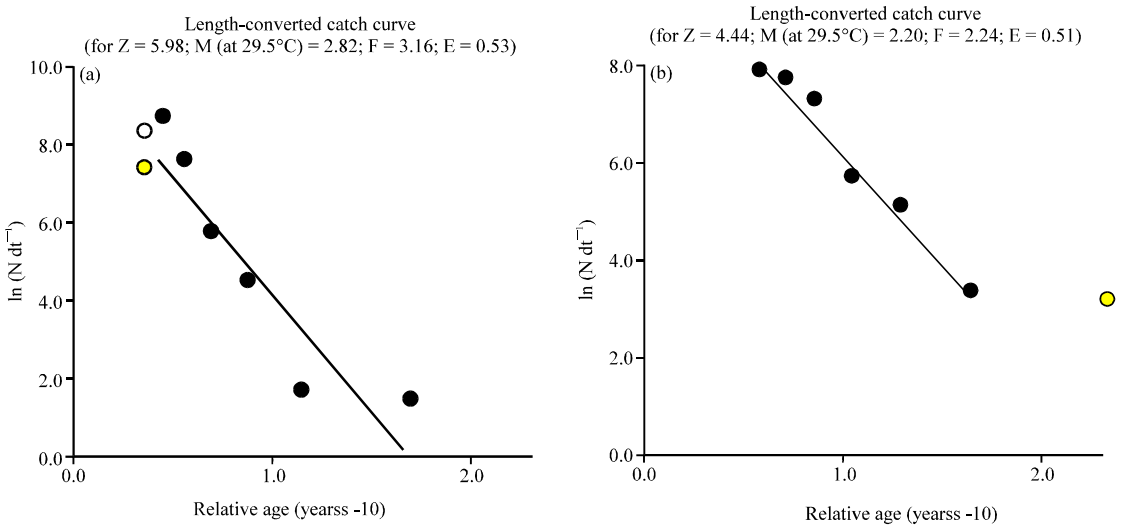

Fig. 7(a-b): Length converted catch curve of (a) Male and (b) Female *A. japonicus* from Kedah, Malaysia

(Table 2). Total mortality for males and females was 5.98 and 4.44 year^{-1}, respectively (Fig. 7a, b). Based on mortality parameters, exploitation level were calculated for males and females at 0.53 and 0.51, respectively. It was revealed that the exploitation levels for males and females were slightly higher than the optimum level (E = 0. 50).

DISCUSSION

The growth coefficient 'b' of length-weight relationship generally lies between 2.50 and 3.50 and the relation is said to be isometric when it is equal to 3 as reported for most aquatic organisms. Table 3 shows parameters of length-weight relationship (a and b) for the *A. japonicus* from various locations. The values of b show considerable variation, ranging from 2.155 (Lei, 1988) to 3.063 (Amin *et al*., 2009). In the present study, the estimated b is 2.53 for males, 2.55 for females and 2.66 for both sexes of *A. japonicus*. The growth was negative allometric for males, females in the estuarine waters of Tanjung Dawai.

Estimated L_∞ and K were 25.20 mm and 1.80 year^{-1} for males and in females they were 28.88 mm and 1.30 year^{-1}. Comparisons with population parameters from other studies (Table 4) show that differences exist for different *Acetes* from different areas. The highest value of L_∞ (29.08 mm in both sexes) for *A. japonicus* (Amin *et al*., 2009); the lowest value 25.20 mm in males is observed in the present study in Tanjung Dawai estuary. The K values ranged between 1.30 and 1.80 year^{-1}. The phi prime for this species with the present estimates of L_∞ and K were found to be excellent and varied between 3.03 and 3.05.

In the present study, two major recruitment peaks per year was observed for *A. japonicus* population. Two recruitment peaks per year were also reported by Amin *et al*. (2009) in the coastal waters of Malacca, Malaysia. Similar observations are also reported for Oh and Jeong (2003) in Korean waters and Zafar *et al*. (1998) in Bangladesh waters for *A. chinensis*. Though one recruitment peak with continuous recruitment is reported by Zafar and Amin (2002) for *A. erythraeus* from Bangladesh waters, the recruitment pattern of *A. intermedius* is continuous with one major cohort produced per year. On other findings, Oh and Jeong (2003) and Zafar *et al*. (1997) reported two recruitment peaks per year for the *A. chinensis*. Species biological characteristics and locality could possibly contributed to the difference in recruitment process.

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

Location	Species	a	b	r2	Source
Malaysia	*A. japonicus* (M)	0.0152	2.53	0.82	Present study
Malaysia	*A. japonicus* (F)	0.0153	2.55	0.84	Present study
Malaysia	*A. japonicus* (C)	0.011	2.66	0.89	Present study
Malaysia	*A. japonicus*	0.004	3.063	0.93	Amin *et al.* (2009)
China	*A. joponicus*	0.1302	2.155	-	Lei (1988)

Table 4: Growth parameters (L_∞ and K) and exploitation level of the genus *Acetes* from different locations in Malaysia

Location	Species	$L\infty$	K year^{-1}	E	°C	Source
Malaysia	*A. japonicus* (M)	25.20 TL	1.8	0.53	29.3	Present study
Malaysia	*A. japonicus* (F)	28.88 TL	1.3	0.51	29.3	Present study
Malaysia	*A. japonicus* (C)	29.08 TL	1.4	0.54	31	Amin *et al.* (2009)

Legends: M: Male, F: Female, C: Combined sexes

Exploitation rate (E) values obtained at 0.53 and 0.51 (males and females) for *A. japonicus* from Tanjung Dawai slightly showed that the resource is over exploited. This is based on the assumption that a stock is optimally exploited when fishing mortality (F) equals natural mortality (M), or E = (F/Z) = 0.5 (Gulland, 1971).

CONCLUSIONS

Higher fishing mortalities of *A. japonicus* verses the natural mortalities observed from the present study indicate the unbalance position in the stock. Exploitation level (E) of males and females are higher than the optimum level of exploitation. Two major recruitment peaks per year are observed in *A. japonicus* in the study area. It could be suggested that the stock of *A. japonicas* is at present slightly over exploited.

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REFERENCES

Amin, S.M.N., A. Arshad, B. Japar Sidik and S.S. Siraj, 2008. Growth, mortality and yield-per-recruit of sergestid shrimp, *Acetes intermedius* Omori, 1975 (Decapoda: Sergestidae) from length frequency analysis in the coastal waters of Malacca, Peninsular Malaysia. Pertanika J. Trop. Agric. Sci. 31: 95-106.

Amin, S.M.N., A. Arshad, S.S. Siraj and B.J. Sidik, 2009. Population structure, growth, mortality and yield per recruit of segestid shrimp, *Acetes japonicus* (Decapoda: Sergestidae) from the coastal waters of Malacca, Peninsular Malaysia. Indian J. Mar. Sci., 38: 57-68.

Amin, S.M.N., A. Arshad, N.H. Ismail, M.H. Idris, J.S. Bujang and S.S. Siraj, 2010a. Morphometric variation among the three species of the genus *Acetes* (Decapoda: Sergestidae) in the coastal waters of Malacca, Peninsular Malaysia. Pertanika J. Trop. Agric. Sci., 33: 341-347.

Amin, S.M.N., A. Arshad, S.S. Siraj and S.B. Japar, 2010b. Reproductive seasonality and maturation of the sergestid shrimp, *Acetes japonicus* (Decapoda: Sergestidae) in coastal waters of Malacca, Peninsular Malaysia. Afr. J. Biotechnol., 9: 7747-7752.

Barnard, K.H., 1955. Additions to the fauna-list of South African Crustacea and Pycnogonida. Ann. S. Afr. Museum, 43: 1-107.

Enomoto, Y., 1971. Oceanography and biological study of shrimps in the waters adjacent to the eastern coasts of the state of Kuwait. Bull. Tokai Reg. Fish. Res. Lab., 66: 1-74.

Euzen, O., 1987. Food habits and diet composition of some fish of Kuwait. Kuwait Bull. Mar. Sci., 9: 65-85.

Gayanilo, F.C., P. Soriano and D. Pauly, 1996. The FAO-ICLARM stock assessment tools (FiSAT) users guide. FAO Computerised Information Serries (Fisheries), No. 8. Rome, FAO, pp: 266.

Grabe, S.A. and D.C. Lees, 1992. Macrozooplankton studies in Kuwait Bay (Arabian Gulf). II. Distribution and composition of planktonic penaeidae. J. Plankton Res., 14: 1673-1686.

Gulland, J.A., 1971. The Fish Resources of the Ocean. Fishing News Book Ltd., West Byfleet, Surrey, UK., Pages: 255.

Lei, M., 1988. Studies in the biology of *Acetes japonicusi* Kishinouye in the Eastern Coastal Waters of Guangdong Province, China. 1st Edn., Ocean Press, Bejing, pp: 234-243.

Miquel, J.C., 1984. Range extension of species of *Acetes*, *Metapenaeopsis* and *Parapenaeus* (Decapoda, Penaeidea). Crustaceana, 46: 211-216.

Oh, C.W. and I.J. Jeong, 2003. Reproduction and population dynamics of *Acetes chinensis* (Decapoda: Sergestidae) on the Western coast of Korea, Yellow Sea. J. Crustacean Biol., 23: 827-835.

Omori, M., 1975. The systematics, biogeography and fishery of epipelagic shrimp shrimps of the genus *Acetes* (Crustacea, Decapoda, Sergestidae). Bull. Ocean Res. Inst. Univ. Tokyo, 7: 1-91.

Pathansali, D., 1966. *Acetes* (Sergestidae) from the Malay Peninsula. Bull. Nat. Muse. Sing., 33: 59-63.

Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 Fish stocks. J. Cons. Int. Explor. Mer., 39: 175-192.

Pauly, D. and N. David, 1981. ELEFAN-I a basic program for the objective extraction of growth parameters from Length frequency data. Meeresforschung Rep. Mar. Res., 28: 205-211.

Pauly, D., 1984. Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Studies Rev. Manila, 8: 325-325.

Pauly, D. and J.L. Munro, 1984. Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte, 2: 21-21.

Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can., 191: 1-382.

Scherrer, B., 1984. Biostatistique. G. Morin, Montreal, Paris, ISBN-13: 9782891050937, Pages: 850.

Tsoumani, M., R. Liasko, P. Moutsaki, I. Kagalou and I. Leonardos, 2006. Length-weight relationships of an invasive cyprinid fish (*Carassius gibelio*) from 12 Greek lakes in relation to their trophic states. J. Applied Ichthyol., 22: 281-284.

Zafar, M., M.G. Mustafa, S.M.N. Amin and S. Akhter, 1997. Studies on population dynamics of *Acetes indicus* from Bangladesh coast. J. Nat. Ocea. Mar. Inst, 14: 1-15.

Zafar, M., M.G. Mustafa and S.M.N. Amin, 1998. Population dynamics of *Acetes chinensis* in the Kutubdia channel of Bangladesh coastal waters. Indian J. Fish., 45: 121-127.

Zafar, M., M.S.K. Chowdhury and S.M.N. Amin, 2001. Size frequency distribution and carapace length-total length relationship of *Acetes chinensis* in the Kutubdia channel of Bangladesh coast. Bangladesh J. Fish. Res., 5: 205-208.

Zafar, M. and S.M.N. Amin, 2002. Population dynamics of *Acetes erythraeus* in the Kutubdia channel of Bangladesh coastal water. Ind. J. Fish., 49: 141-146.