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Growth, Mortality and Recruitment of Planktonic Shrimp, *Acetes intermedius* in the Coastal Waters of Bintulu, Sarawak East Malaysia

[1]Masitah Saini, [2]Aziz Arshad, [2]S.M.N. Amin and [3]Mohd Hanafi Idris

[1]Laboratory of Marine Science and Aquaculture, Institute of Bioscience, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2]Department of Aquaculture, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[3]Department of Animal Science and Fishery, Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Sarawak Campus, Nyabau Road, Malaysia

Corresponding Author: Aziz Arshad, Department of Aquaculture , Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia, P.O.Box 396, 97008 Bintulu, Sarawak, Malaysia

ABSTRACT

Growth, mortalities (natural and fishing) recruitment percentage and exploitation status of *Acetes intermedius* were examined of samples collected from the coastal waters of Bintulu, Sarawak between January and December 2009. Monthly length frequency data were analyzed using FiSAT software for estimating population parameters, including asymptotic length (L_∞), growth co-efficient (K) and exploitation rate (E) to assess the status of the stock. The asymptotic length (L_∞) and growth co-efficient (K) was estimated as 43.05 mm and 1.90 yr^{-1}. The maximum life span (t_{max}) *A. intermedius* was estimated at 1.58 yr^{-1}. Total mortality (Z) was estimated at 4.68 yr^{-1}. The rate of natural mortality (M) and fishing mortality was calculated as 2.49 yr^{-1} and 2.195 yr^{-1}, respectively. The recruitment pattern of *A. intermedius* was continuous throughout the year with two major peaks. The exploitation rate (E) was estimated at 0.47 during the study period. The exploitation rate was slightly below the optimum level of exploitation (E = 0.50) and the condition of the stock is still under-fishing status.

Key words: Natural mortality, *A. intermedius*, fishing mortality, recuitment pattern, fishing status

INTRODUCTION

Acetes is a group of small planktonic shrimps that are known as "udang geragau" among the local people. They come from subphylum Crustacea and belong to the family of Sergestidae. *Acetes* consists of fourteen species and five subspecies (Omori, 1975). *Acetes intermedius* are considered as a new species. The genus *Acetes* are widely distributed in the world. In Malaysia, the species *A. intermedius* occurs in the shallow coastal waters of the Malacca Straits, Peninsular Malaysia (Arshad *et al*., 2007) and in the coastal waters of Bintulu, Sarawak (Amin *et al*., 2008b). They are also found throughout the western coast of Peninsular Malaysia, from Perlis to Johor of which Perak, Selangor and Penang as the major fishing state (Arshad *et al*., 2007).

The very first distribution record of *A. intermedius* from Bintulu was recorded by Amin *et al*. (2008b). At present, very little information is available on the population parameters such as growth and mortalities for *A. intermedius* although other biological and ecological aspects of this

species has been reported by Amin *et al.* (2008a,b), and Arshad *et al.* (2007). According to Omori (1975), *Acetes* is one of the major sources of protein in Asia that are widely exploited and considered as a subsistence fishery source. For the management purpose, it is necessary to understand the important biological aspects and population parameters of *Acetes* shrimps such as growth, mortality and recruitment. Without the knowledge of these parameters, it is not possible to undertake any effective management program on *Acetes* stock. But most of the previous works on the biological aspects of *Acetes* are focusing in the coastal waters of Peninsular Malaysia (Arshad *et al.*, 2007, 2008; Amin *et al.*, 2008a, 2009a, b, c, 2010a, b). No work has been done in Sabah and Sarawak coastal waters. In order to maintain the natural stock of *A. intermedius* as well as to avoid over exploitation, an attempt has been taken to study the population biology of *Acetes intermedius* from the coastal waters of Bintulu, Sarawak. The present study is specifically aimed to establish *A. intermedius* growth parameters, K and $L\infty$ and to find mortality and exploitation rates for this species in the Bintulu coastal waters.

MATERIALS AND METHODS

Sampling: Monthly sample of *A. intermedius* specimens were collected between January 2009 and December 2009 from Bintulu coastal waters, Sarawak, Malaysia. Samples were fixed in 10% formalin at the sampling site before transported to UPM Serdang, Selangor. The samples were analyzed after 2 to 3 days upon arrival. In the laboratory, specimens were identified using Nikon dissecting microscope (Nikon-122764, Japan). The *A. intermedius* was identified based on Omori (1975). Sexes were determined by the presence or absence of petasma on the first pleopods and clasping spine on the lower antennular flagellum (Omori, 1975). Total Length (TL) of 1571 individuals (approximately 200 individuals each month) was measured from the tip of the rostrum to the tip of the telson to the nearest 0.1 mm. The length-frequency data are shown in Table 1.

Data analysis: Monthly length-frequency data of *A. intermedius* 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. intermedius* using the following equation:

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

Total mortality (Z) was estimated by using the Jones and van zalinge plot. 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_∞ 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:

$$F = Z - M$$

Table 1: Length-frequency data of *Acetes intermedius* in Bintulu coastal water, Sarawak (January-December 2009)

Middle Length (mm)	February	March	April	May	June	August	September	October
14.5	0	0	0	0	0	0	0	0
15.5	0	0	0	9	0	0	0	0
16.5	0	0	0	11	0	0	0	0
17.5	2	0	0	6	0	0	0	0
18.5	1	0	0	30	2	0	0	0
19.5	5	0	0	9	12	0	0	0
20.5	0	0	3	44	4	0	0	0
21.5	10	0	6	12	18	0	5	0
22.5	21	0	4	10	21	0	12	2
23.5	15	2	7	1	36	1	6	0
24.5	0	2	12	8	30	2	15	0
25.5	10	6	48	8	26	9	30	3
26.5	5	7	24	1	21	4	20	4
27.5	14	26	28	1	15	6	13	15
28.5	9	23	33	13	5	25	17	6
29.5	7	42	22	4	1	13	4	18
30.5	22	59	8	9	3	37	22	37
31.5	27	21	2	2	0	31	11	27
32.5	21	10	0	6	6	38	6	27
33.5	15	0	3	0	0	13	2	18
34.5	4	0	0	6	0	9	3	19
35.5	3	0	0	5	0	4	3	18
36.5	1	0	0	2	0	3	3	4
37.5	6	0	0	0	0	2	2	1
38.5	0	0	0	2	0	1	0	0
39.5	0	0	0	0	0	0	0	1
40.5	0	0	0	1	0	2	0	0
Total	198	198	200	200	200	200	174	200

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

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

RESULTS

Growth parameters: This initial extreme length value was fed into ELEFAN-I, incorporated in FiSAT software package to produce the optimum growth curve. The best value of VBGF growth constant (K) was estimated as 1.90 yr^{-1} by ELEFAN-I (Fig. 1). The response surface (Rn) was calculated as (0.249) which selected the best combine set of growth parameters; which are $L\infty$ = 43.05 mm and K = 1.90 yr^{-1}. The optimized growth curve was superimposed on the restructured length-frequency histograms (Fig. 2). The calculated value for the growth performance index (ϕ') of *A. intermedius* was 3.556.

Mortality: Total mortality coefficient (Z) was estimated as 4.68 yr^{-1} using Jones and Van Zalinge (1981) method (Fig. 3). Natural mortality (M) was estimated at 2.49 yr^{-1}. Based on Z

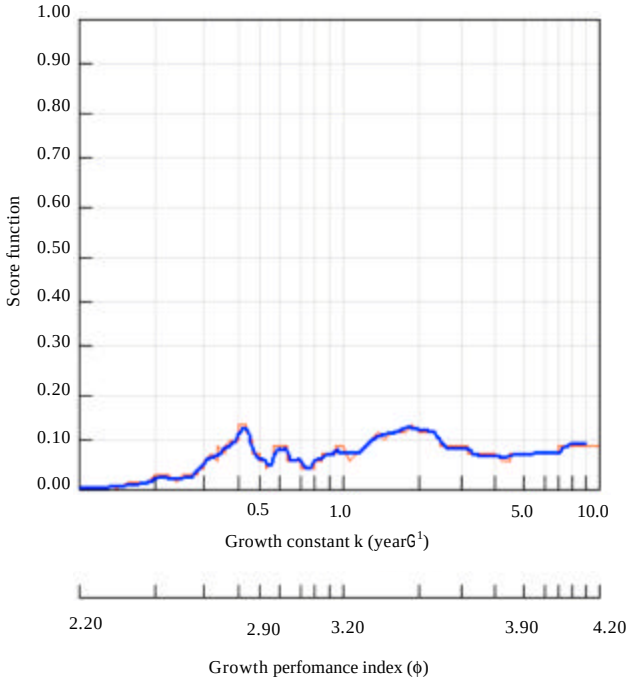

Fig. 1: Estimation of growth constant K value of *Acetes intermedius*

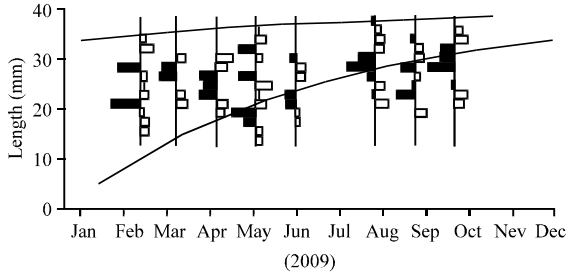

Fig. 2: Von Bertalanffy growth curves of *Acetes intermedius* superimposed on the restructured length-frequency histograms. The black and white bars are positive and negative deviation from the "weighted" moving average of three length classes and they represent pseudo-cohorts

fishing mortality (F) was found to be 2.195 yr^{-1}. The exploitation rate (E) was calculated at 0.47. The fishery in the coastal waters of Bintulu, Sarawak is seemed to be close the optimum level of exploitation (E = 0.50).

Recruitment pattern: The recruitment pattern of *A. intermedius* was continuous throughout the year with two major peaks (Fig.4). The recruitment varied from 1.72 to 25.79% during the study period. The highest recruitment occurred in the month of August while the lowest recruitment was observed in the month of January (Fig. 4). This study showed two major recruitment events per year i.e., April and August.

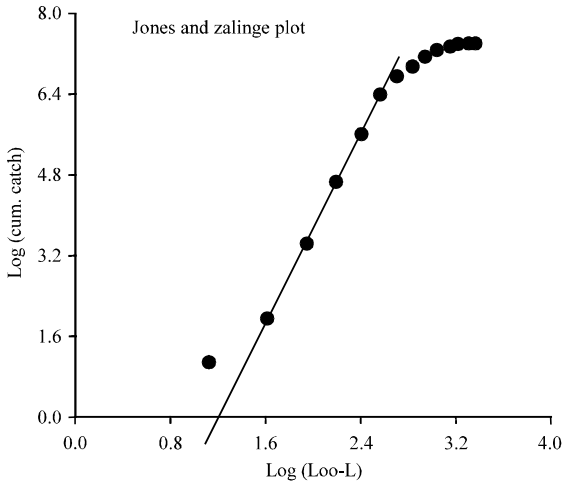

Fig. 3: Jones and van Zalinge plot

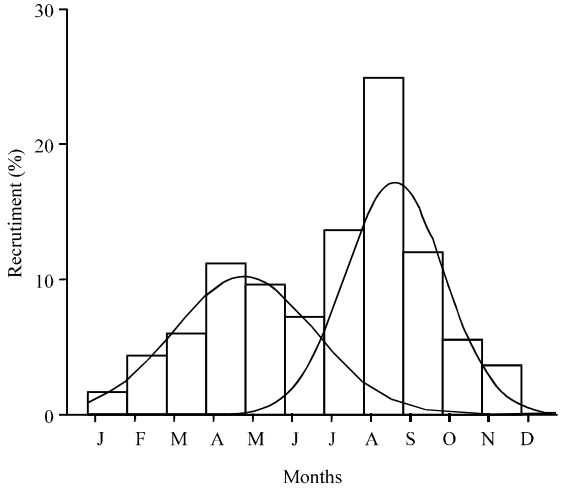

Fig. 4: Estimated recruitment pattern of *Acetes intermedius*

DISCUSSION

The estimated asymptotic length (L8) is 43.05 mm and VBGF growth co-efficient (K) is 1.90 yr^{-1} for the present study of *A. intermedius*. Comparisons with population parameters obtained in other studies (Table 3) shows that differences exist for different species of the genus *Acetes* from different geographical areas in the world. The highest value of $L\infty$ (43.05 mm) is recorded in this present study for *A. intermedius* and the lowest value (31.0 mm) for *A. indicus* (Zafar *et al.* (1997) was reported from Bangladesh. The value of $L\infty$ in the previous study on *A. intermedius* in Malacca was 34.65 yr^{-1} (Amin *et al.*, 2008a). The highest value of K (1.90 yr^{-1}) is observed in this study and lowest value of K (0.69 yr^{-1}) is observed in Korean waters (Oh and Jeong, 2003) for *A. indicus*. The index of phi prime by Munro and Pauly (1983) is suitable for comparing and computing the overall growth performance of different species of fish or shrimps stock. The phi prime for this species with the present estimates of L8 and K is 3.556 yr^{-1}. The highest phi prime values (3.556 yr^{-1}) were recorded in this study while the lowest phi prime was recorded for *A. chinensis* (Oh and Jeong,

Table 2: Estimated population parameters of *Acetes intermedius* from Bintulu coastal waters, Sarawak

Parameter	Unit
Asymptotic length (L_∞)	43.05 mm
Growth co-efficient (K)	1.90 yr^{-1}
Growth performance index	3.56 yr^{-1}
Maximum life span (t_{max})	1.58 years
Total mortality (Z)	4.69 yr^{-1}
Fishing mortality (F)	2.20 yr^{-1}
Natural mortality (M)	2.49 yr^{-1}
Exploitation level (E)	0.47 years

Table 3: Growth parameters ($L\alpha$ and K) and computed growth performance index (ϕ') of the genus *Acetes* from different tropical countries

Location	Species	$L\infty$ (mm)	K yr^{-1}	ϕ'	E	T (°C)	Source
Malaysia	*A. intermedius*	43.05 TL	1.9	3.556	0.47	-	Present study
Malaysia	*A. intermedius*	34.65 TL	1.5	3.25	0.43	31	Amin *et al.* (2008a)
Bangladesh	*A. indicus*	31.00 TL	1.7	3.22	0.22	28	Zafar *et al.* (1997)
Bangladesh	*A. erythraeus*	37.00 TL	1.2	3.21	0.24	28	Zafar and Amin (2002)
Bangladesh	*A. chinensis*	40.00 TL	1.6	3.4	0.21	28	Zafar *et al.* (1998)
Korea	*A. chinensis (F)*	13.51 CL	0.69	2.1	-	-	Oh and Jeong (2003)
Korea	*A. chinensis (M)*	10.48 CL	0.84	1.97	-	-	Oh and Jeong (2003)

2003). Generally, shrimps are not long-lived crustacean (Etim and Sankare, 1998). The estimated longevity (t_{max}) for *A. intermedius* is 1.58 years of age, indicating that it is a short-lived species.

Total mortality (Z) (4.689 yr^{-1}) estimated using Jones and Van Zalinge (1981) method is higher than the value obtained (4.15 yr^{-1}) by Amin *et al.* (2008a) in the coastal water of Malacca. Mortality rates can be partitioned into two components; fishing and natural mortality. Higher natural mortality (2.49 yr^{-1}) verses the fishing mortality (2.20 yr^{-1}) observed for *A. intermedius* in the current study (Table 2) indicate the unbalanced position in the stock. Fishing mortality is the result of harvest and natural predation of this shrimp. *Acetes* are highly abundance in the coastal area in Malaysia. Therefore, it is extensively exploited and had become one of the important sources of protein in Asia (Omori, 1975). Exploitation level (E) was calculated as 0.47. It shows that the fishery of *A. intermedius* in the coastal waters of Bintulu is slightly under exploited. This is based on the assumption that a stock is optimally exploited when fishing mortality (F) is equal to natural mortality (M). In other words, when E = (F/Z) = 0.5 (Gulland, 1971).

This study indicated that the recruitment pattern of *A. intermedius* is a continuous process with two major peaks per year (Fig. 4). It indicates that there are two major cohorts that are produced per year. However, Amin *et al.* (2008a) reported one main recruitment event per year for *A. intermedius* in his study at the coastal waters of Malacca. It has been reported that the *Acetes* spawns throughout the year in the tropics and subtropics areas, of which spawning peaks can be recognized and frequently occurs in the warmer months (Nataraj, 1947). Spawning patterns in these areas (tropical and subtropical) are probably related to monsoonal influences on precipitation and wind direction (Omori, 1974). For this study, it is observed that the major spawning occurs in the months of April and August (Fig. 4) in the coastal waters of Bintulu.

CONCLUSION

The asymptotic length (L_∞) of *A. intermedius* was 43.05 mm and the growth coefficient (K) was 1.90 yr^{-1}. The fishing mortality (F) was 2.195 yr^{-1}. The value of natural mortality (M) was 2.49 yr^{-1}. The whole recruitment pattern was continuous though there were two major peaks per year. The exploitation level (E) of *A. intermedius* in Bintulu coastal waters is 0.47 while the optimum level of exploitation is 0.50. Thus, the stock of *A. intermedius* is very close to the optimum level of exploitation in the coastal waters of Bintulu, Sarawak.

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