Indian J. Fish., 63(4): 22-27, 2016
DOI: 10.21077/ijf.2016.63.4.45856-04

Age and growth of the deep water mud shrimp *Solenocera melantho* (De Man, 1907) off Visakhapatnam coast, India

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ABSTRACT

Age and growth of the deep water mud shrimp *Solenocera melantho* (De Man, 1907) was estimated using von Bertalanffy growth model employing modal progression analysis, Ford-Walford method for L_∞ and K and t_0 by Gulland's method as well as ELEFAN I (FiSAT II software version 1.2.2) method. The growth parameters estimated by the former method were: L_∞ = 107.9 mm, K = 2.61 y^{-1}, t_0 = 0.1344, φ' = 4.4825 for males and L_∞ = 116.4 mm, K = 3.69 y^{-1}, t_0 = 0.1346, φ' = 4.6997 for females and by the latter method were : L_∞ = 106.1 mm, K = 2.17 y^{-1}, t_0 = -0.05, φ' = 4.3879 for males and L_∞ = 116.8 mm, K = 2.1 y^{-1}, t_0 = -0.05, φ' = 4.4571 for females. The longevity estimated for both males and females of *S. melantho* was about 36 months. The females were observed to grow faster than the males.

Keywords: Age, Deep water mud shrimp, Growth, *Solenocera melantho*

Introduction

Shrimps have a short life span. They may have one or two identifiable characteristics in a sample and their data have to originate from samples caught at different times (Pauly, 1983). A common approach is to analyse length frequency data to a mixture of finite number of normal distributions, each of which corresponds to a different age class (Niamaimandi *et al.*, 2007). According to Yano and Kobayashi (1969), assessment of growth parameters and age is difficult in shrimps, since they do not have bony structures. Though there is an increase in the number of lamellae in the endocuticle with size, periodic moulting and discontinuous growth makes tagging experiments unreliable (Rao and Krishnamurthy, 1990). The use of a polymodal length-frequency curve analysis to distinguish and separate age groups from modes in the curves is difficult because shrimps have a protracted breeding season (Rao and Krishnamurthy, 1990). Growth parameters differ between species, but they may also vary from stock to stock within the same species (Sparre and Venema, 1992).

According to Garcia and Le Reste (1981), the best estimate of growth in shrimps is by tag-recapture. Electronic Length-Frequency Analysis (ELEFAN) is the most commonly used computer programme for shrimp growth (Pauly and David, 1981). Hall (1962) reported the growth rate from frequency histograms of carapace length and total length of selected shrimps of Indo-West Pacific. The age and growth of *Solenocera crassicornis* of Bombay waters was studied by Sukumaran (1978) and that of *Solenocera membranacea* from the central Adriatic Sea by Froglia and Gramitto (1987). Demestre and Abello (1993) made investigations on the growth of *S. membranacea* in the North-western Mediterranean Sea. Baelde (1994) applied the MULTIFAN method to analyse the age composition, growth, mortality and yield-per-recruit in deep water royal red shrimp *Haliporoides sibogae* off Eastern Australia. Ohtomi and Irieda (1997) described the growth of the deepwater mud shrimp *Solenocera melantho* (De Man, 1907) using length-frequency analysis in Kagoshima Bay. Oh *et al.* (2005) studied the growth of *S. melantho* around Geomun Island, Korea. Dineshbabu and Joseph (2007) determined the age and growth of *S. choprai* using length-frequency analysis and Li *et al.* (2012) reported the growth of *S. melantho* from the East China Sea.

According to Maheswarudu *et al.* (2014; 2015), 24 species of penaeid shrimps contribute on an average 13.7% to the total fish landings of Visakhapatnam and the share of *S. melantho* was 7.2%. It is commercially important in local markets as a source of protein. Since there is no information on age and growth of the species in Indian waters, an attempt is made in the present study to estimate age and growth of *S. melantho* off Visakhapatnam coast.

Materials and methods

Specimens of *S. melantho* were collected fortnightly from the trawl catches at Visakhapatnam Fishing Harbour for two years *i.e.,* from November, 2004 to October,

2006 except during fishing holiday in May. The specimens were segregated into males and females and their total length was measured (±1 mm). For growth studies, 1485 males (60-101 mm) and 1614 females (54-114 mm) were examined. They were grouped into 3 mm class intervals and the data collected twice in a month were pooled. Length-frequency distribution was analysed for males and females separately. The age and growth of the males and females were studied using von Bertalanffy growth equation (1938).

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

where, L_t is the length at age, t; L_∞ is the average asymptotic length to which the individual grows; K is the growth coefficient and t_0 is the theoretical age of the individual at zero size.

Parameters for the growth equation were estimated by: a) tracing of modal progression by length-frequency analysis and following their progression over ages (Rao and Krishnamoorthi, 1990; Maheswarudu *et al*., 1994); estimation of L_∞ and K by Ford (1933)-Walford method (1946) and estimation of t_0 by Gulland's method (1969). b) The month-wise length frequency data was also analysed by ELEFAN I (Pauly and David, 1981) (FiSAT II Software package, version 1.2.2) module to get the estimate of L_∞ and K. Using these values, t_o was calculated by Pauly's equation (Pauly, 1979):

$$\log(-t_o) = -0.392 - 0.275 \log(L_\infty) - 1.038 \log K.$$

The values of L_∞, K and t_0 thus obtained were fitted in the von Bertalanffy growth equation.

Growth performance index (φ') *(Pauly and Munro, 1984)*

The growth performance index (φ') was estimated using the formula:

$$\varphi' = \log K + 2 \log L_\infty$$

where, K = growth constant per year and L_∞ = asymptotic length

Growth rate (Ohtomi and Iredia, 1997)

The monthly growth rate (MGR) was calculated using the equation:

$$MGR\ (\%) = 100 \times \frac{(L_{t+1} - L_t)}{L_t}$$

where, L_t and L_{t+1} = lengths at age t and t+1(months)

The value of growth constant obtained was for two months as the time interval between L_t and L_{t+1} was two months.

Results and discussion

Length-frequency analysis

The modes traceable up to two months were taken into consideration since the modes lost their identity afterwards in the length-frequency distribution. A total of 13 modes for males and 15 for females were traced as scatter diagrams (Fig. 1 a, b). The modes of the modal-chains were used to estimate the growth parameters L_∞ and K.

Asymptotic length (L_∞) and growth coefficient (K)

Modes traceable for two months were plotted by Walford method (1946). Initial mode was L_t and the final mode L_{t+1}. Growth constant (K) was calculated for males and females from the graphical representation (Fig. 2 a,b) of L_{t+1} and L_t. Values of L_∞ for males and females were found to be in close agreement with the maximum length recorded (L_{max}) for males (101 mm) and females (114 mm). L_∞ for males and females were 107.88 and 116.39 mm respectively. Bimonthly growth coefficient for males was 0.43 and for females 0.61 whereas the annual values were 2.61 and 3.69 respectively.

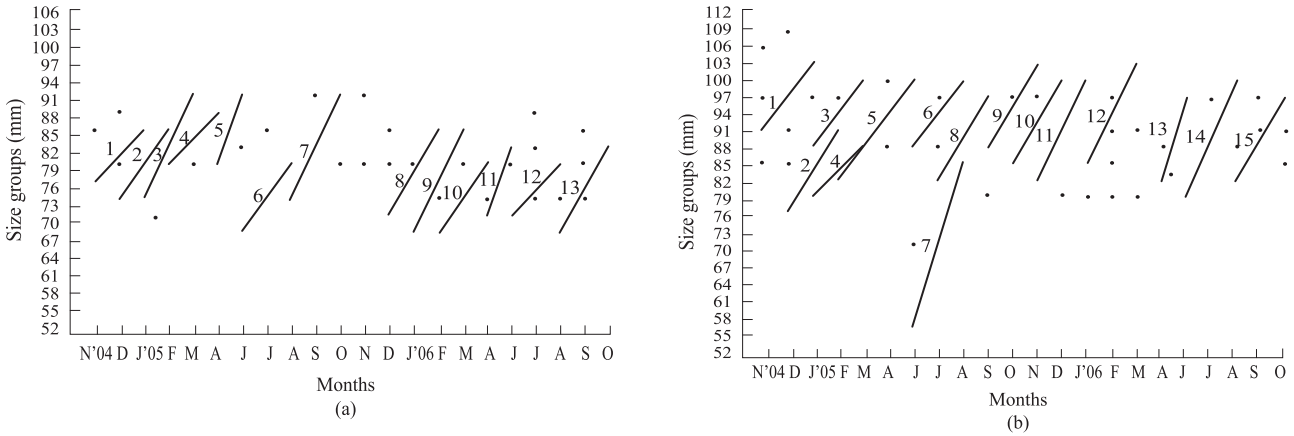


Fig. 1. Scatter diagram of modal values and mode-chains of different size groups in *S. melantho.* (a): Male, (b): Female

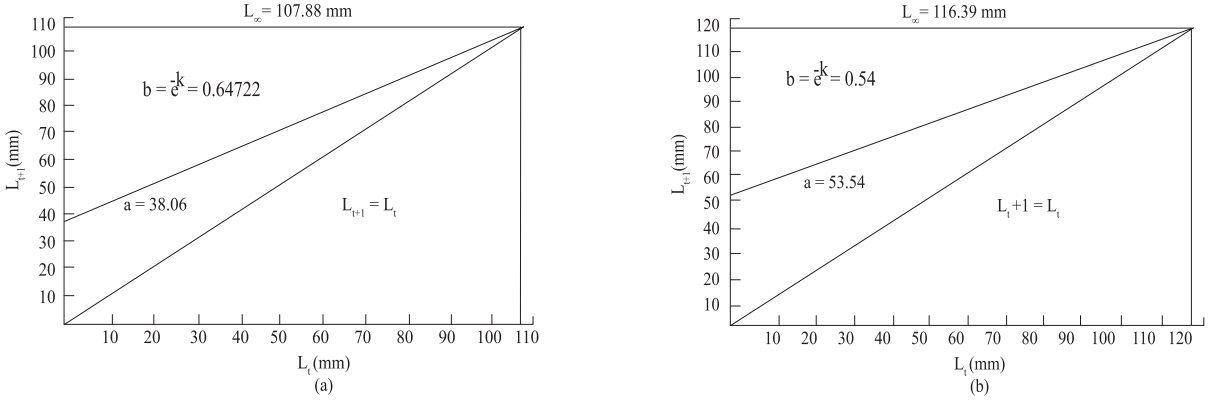


Fig. 2. Estimation of growth parameters by Ford-Walford plot for *S. melantho.* (a): Male, (b): Female

Growth in both sexes showed rapid increase in length in the initial months *i.e*., males attained a size of 62.69 mm in four months while females attained 82.45 mm. Then onwards both males and females showed steady growth without much increase in size, with males attaining 96.75 mm and females reaching 111.72 mm at 12 months (Fig. 3).

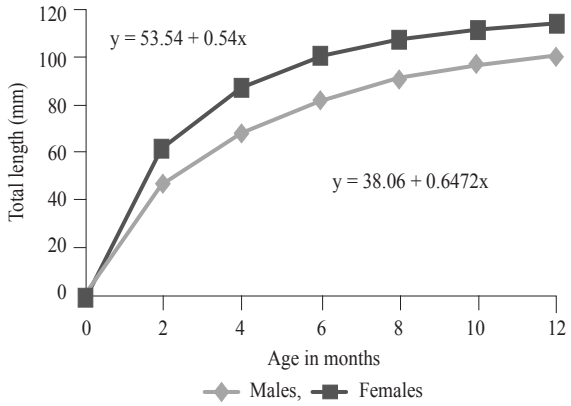


Fig. 3. Ford-Walford growth curves of males and females in *S. melantho*

Age at zero length

The age at zero length (t_0) was calculated by substituting the growth parameters, asymptotic length (L_∞) and growth coefficient (K) in von Bertalanffy growth equation and the t_0 age was 1.61 in male and 1.62 in female per month and 0.13 and 0.13 y^{-1} in male and female respectively (Fig. 4).

von Bertalanffy growth equation

The length of the shrimp at specific time (age) in both the sexes was obtained by substituting L_∞, K and t_0 in the von Bertalanaffy growth equation:

Males : $L_t = 107.88\ (1\text{-}e^{-2.6016(t-0.1344)})$

Females : $L_t = 116.39(1\text{-}e^{-3.6972(t-0.1346)})$

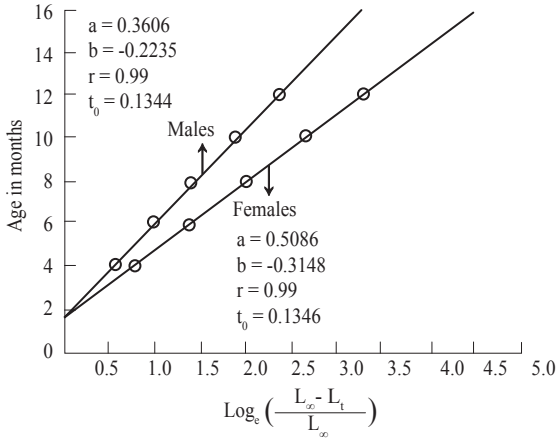


Fig. 4. Relationship between age in months and $\log_e(\frac{L_\infty - L_t}{L_\infty})$ in males and females of *S. melantho*

Accordingly the length attained at 3, 6, 9 and 12 months of age were 29.01, 66.8, 92.65 and 96.75 mm for males and 41.71, 86.76, 109.12 and 111.72 mm in females respectively. Based on these values, growth curves for males and females were drawn (Fig. 5). The rate of growth in females was faster than males. The longevity of males and females was estimated as 3 years. It was found that males attained a total length of 96.75 mm at the end of first year and 107.06 mm at the end of second year. Similarly females attained a total length of 111.73 mm at the end of first year and 116.28 mm at the end of second year.

ELEFAN I (FiSAT II software version 1.2.2)

The L_∞ obtained by ELEFAN I for males was 106.1 mm and K = 2.17 yr^{-1} with highest R_n value (0.150). In case of females, L_∞ was 116.8 mm and K = 2.10 yr^{-1} with a highest R_n value of 0.153 (Fig. 6 a, b). t_0 for males and females calculated by substituting L_∞ and K in Pauly's equation was -0.05. These values were fitted in the von Bertalanffy growth equation. Males attained a

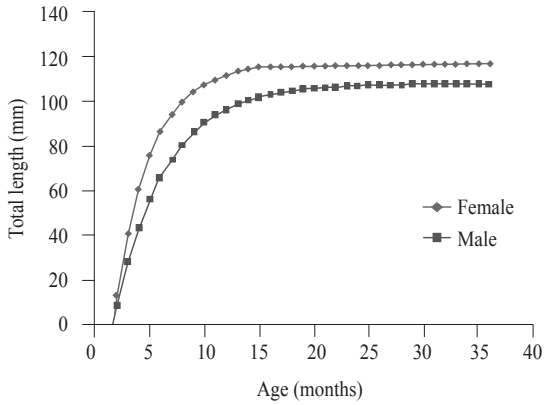
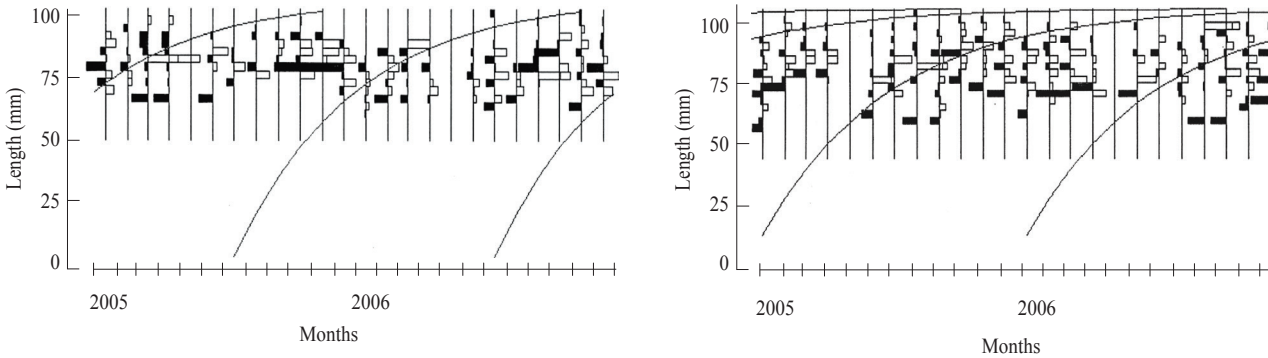


Fig. 5. von Bertalanffy growth curves of *S. melantho*

in the subsequent months (Fig. 7). The percentage growth rate was more in females than males and was almost negligible after 22 months in both the sexes.

Age and growth in crustaceans is estimated by identifying the successive age groups of the populations from the modes of the length frequency distributions due to lack of well defined characteristics of age determination (Yano and Koboyashi, 1969). Cheung (1963) observed the growth of *Solenocera subnuda* as 6.49 mm in males and 6.96 mm in females per month and it was found to be the same in *S. indica* (Kunju, 1968). A life span of 16-20 months with an average monthly growth rate of 3.80 mm for males and 5.20 mm



L_∞ = 106.1, K = 2.17, SS (Starting sample) = 24.00, SL (Starting length) = 101.50

(a)

L_∞ = 116.8, K = 2.10, SS = 24.00, SL = 115.00

(b)

Fig. 6. Estimate of L_∞ and K of *S. melantho* using ELEFAN I. (a): Male, (b): Female

total length of 95.24 mm during first year and 104.86 mm during second year while in females it was 103.92 mm in first year and 115.22 mm in the second year. The method confirmed the longevity of *S. melantho* as 36 months.

Growth performance index (φ')

Growth performance index was 4.48 for males and 4.69 for females based on the parameters from modal progression method and that of ELEFAN I the values were 4.38 and 4.45 for males and females respectively. A comparison of L_∞, K, t_0 and φ' from both the methods are given in Table 1.

Growth rate

The percentage of growth rate of both males and females in the initial months was high which decreased for females was reported in *Solenocera crassicornis* by Sukumaran (1978). Demestre and Abello (1993) noticed maximum asymptotic length in females of *Solenocera membranacea* in the North-western Mediterranean Sea. Baelde (1994) analysed monthly length-frequency distribution of deepwater royal red shrimp, *Haliporoides sibogoe* using MULTIFAN method (Fournier *et al.,* 1991) and found that females grew faster and attained larger sizes than males. Ohtomi and Irieda (1997) noticed faster growth rate in females than males and recorded the longevity of both males and females of *S. melantho* as 37 months in Kagoshima Bay, Southern Japan.

Oh *et al.* (2005) reported higher values for growth parameters in female *S. melatho* from Korean waters

Table 1. Growth parameters, indices and size attained in *S. melantho* estimated by modal progression and ELEFAN I

Method	Sex	L_∞	K y^{-1}	t_0	R_n	φ'	Size I year (mm)	Size II year (mm)
Modal progression analysis	Male	107.8	2.61	0.13	-	4.4825	96.75	107.06
	Female	116.3	3.96	0.13	-	4.6997	111.73	116.28
ELEFAN I	Male	106.1	2.17	-0.05	0.150	4.3879	95.24	104.86
	Female	116.8	2.10	-0.05	0.153	4.4571	103.92	115.22

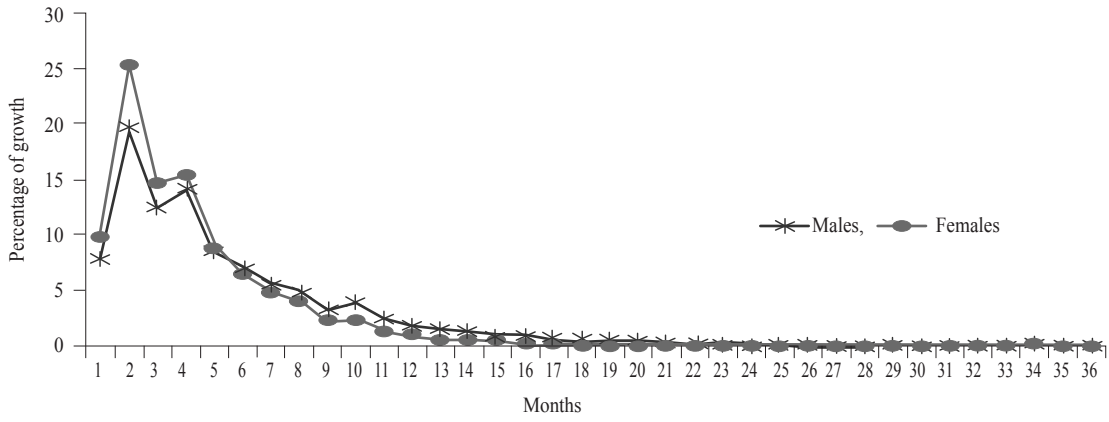


Fig. 7. Percentage growth rate per month in males and females of *S. melantho*

than males with performance indices (φ') of 3.29 and 3.15 for females and males respectively. Dineshbabu and Manissery (2007) observed the life span of ridge back shrimp *S. choprai* as 30 months with the males attaining 66 mm at the end of 12 months; 88 mm at the end of 24 months and females attaining 83 mm in 12 months and 109 mm at the end of 24 months. According to them growth performance index (φ') and the growth parameters (L_∞ and K) in males and females were 1.22; 99 mm; 1.1 y^{-1} and 1.49; 120 mm; 1.18 y^{-1} respectively. In the East China Sea, Li *et al.* (2012) estimated the growth parameters of *S. melantho* using the modified von Bertalanffy growth equations as: L_∞ = 46.75 mm CL, K = 1.14 /y^{-1}, φ' = 3.115 for males and L_∞ = 33.6 mm CL, K = 1.26 /y^{-1}, φ' = 3.28 for females. According to them the life span of females is 2.43 years and 2.20 years for males.

In the present study the growth parameters estimated for *S. melantho* are: L_∞ = 107.9 mm, K = 2.6106, t_0 = 0.1344, φ' = 4.4825 for males and for females L_∞= 116.4 mm, K = 3.6972 y^{-1}, t_0 = 0.1346, φ' = 4.6997. By ELEFAN I (FiSAT), the growth parameters obtained for males are L_∞= 106.1 mm, K = 2.17 y^{-1}, t_0 = -0.05, φ' = 4.3879 and for females L_∞= 116.8 mm, K = 2.1 y^{-1}, t_0 = -0.05, φ' = 4.4571. The longevity of both males and females of *S. melantho* has been estimated as 36 months by both the methods, whereas Ohtomi and Iridea (1997) have reported the longevity of *S. melantho* to be around 37 months in Kagoshima Bay of Southern Japan. Li *et al.* (2012) found the maximum life span of *S. melantho* to be 2.43 years for females and 2.20 years for males in the East China Sea. Females grow faster than males, growth being rapid in initial months *i.e.,* 62.69 mm in males and 82.45 mm in females for four months and then onwards both males and females showed steady growth without much increase in size.

Acknowledgements

The authors are grateful to the Head, Department of Marine Living Resources, Andhra University, Visakhapatnam for providing facilities to carry out the work.

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Date of Receipt : 11.01.2015
Date of Acceptance : 17.10.2016