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AGE AND GROWTH OF *METAPENAEUS MONOCEROS* (FABRICIUS) ALONG THE KAKINADA COAST*

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ABSTRACT

Age and growth of *Metapenaeus monoceros* have been estimated separately for males and females by length-frequency analysis in view of the differential growth observed in the species. Modes traceable for three months were considered for the application of Food-Walford plot to estimate growth parameters. L_∞ for males and females is estimated as 178.4 mm and 207.3 mm respectively. The K values are estimated as 1.68 for males and 1.62 for females. Values of t_0 obtained by the method of Gulland are 0.048 years and 0.066 years for males and females respectively. Von Bertalanfly equations are derived as :

Males .. $l_t = 178.4\,[1-e^{-1.68\,(t-0.048)}]$

Females .. $l_t = 207.3\,[1-e^{-1.62\,(t-0.066)}]$

The females are found to grow faster and attain higher asymptotic length with lower K value compared to males. The lengths attained by males and females respectively are 95 mm and 105 mm at the end of 6 months, 142 mm and 162 mm at the end of 12 months and 163 mm and 187 mm at the end of 18 months.

INTRODUCTION

FISHERY research, aimed at resources management must consider the simultaneous additions and losses by weight that would occur in a population and find that point in time when these opposing factors are of equal magnitude. This point represents the average at which individuals should be harvested to obtain the greatest yield from a population. Hence, a knowledge of age and growth is one of the basic requirements for the study of population dynamics of animals which would ultimately help to evolve management policies to get the maximum from populations of commercially important resources, be it fisheries or otherwise.

Penaeids, in this regard, pose several difficulties to arrive at growth parameters and from them age. Firstly, they do not have bony structures which would record imprints of internal and environmental variations that may allow age reading directly, although an increase in the number of lamellae in the endocuticle with size may suggest some possibility in that direction (Yano and Kobayashi, 1969). Secondly, periodic moulting and discontinuous growth make tagging techniques and the use of external tags in particular an unreliable operation. Finally, like many tropical animals, penaeid prawns most often show a protracted spawning period with frequent entry of broods into the fishery to permit distinction between broods difficult for the use of polymodal length-frequency

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curve analysis that aids in distinguishing and separating age groups from modes in the curves.

Metapenaneus monoceros is an important component of the prawn fishery along both the coasts of India. It is commercially very important contributing annually 1,200 tonnes to the Andhra Pradesh marine fish landings, fetching Rs. 36 million in terms of export earnings. It forms about 50% of the backwater prawn fishery and 12% of the inshore prawn fishery by trawlers along the Kakinada coast. Except for the studies on the growth of juveniles in laboratory tanks (George, 1959 ; Subrahmanyam, 1973) virtually nothing is known about the age and growth of *M. monoceros* in Indian waters. Results of studies on age and growth made on the two sexes separately for the first time on this species are presented in this paper. Age and growth of the species have been estimated applying sequentially four methods.

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Material and Methods

Data for the study of age and growth of *M. monoceros* were collected from samples obtained from the trawler catches at Kakinada. Samples were obtained once a week. All the specimens in a sample were sexed and their lengths and weights measured. Length measurements were grouped into 5 mm class intervals *e.g.*, 51-55, 56-60, 61-65, *etc.* with mid-points at 53, 58, 63 respectively. Length-frequency distribution was studied for males and females separately. The numbers in the length-frequency distribution were raised to the total catch of the day based on sample weights. The data so obtained for different sample days in a month were pooled to get catch in numbers for all the sample days which in turn was raised to the monthly catch. The data thus obtained during the period 1974-1977 formed the basis for the monthly length-frequency analysis.

Age and growth were estimated applying sequentially the following four methods :

1. Modal tracing by length-frequency analysis.
2. Estimation of $L\infty$ and K by Ford-Walford method (1946).
3. Estimation of t_0 by Gulland's method (1969) and
4. Fitting of Von Bertalanffy growth equation.

Details and application of different methods have been given while presenting results obtained under each method. Length-weight relationship estimated by Rao (1985) was taken to represent growth formulae in respect of weight.

Results

Length frequency analysis

The methods conventionally used for the analysis of length-frequency data were introduced by Peterson (1892) and can be reduced to two basic techniques. They are (1) the "Peterson method" (sensu stricto) *i.e.*, the attribution of relative ages to the peaks of a length-frequency distribution, and (2) the "modal progression analysis" (Menon, 1953), that is, the linking up of the peaks in the length-frequency distributions sequentially arranged in time by means of growth segments.

With the first method, the problem consists of identifying those peaks representing broods spawned at known or assumed time intervals. The method generally involves the separation of the length-frequency distribution into normally or otherwise distributed sub-sets by graphical methods, such as those proposed by Harding (1949), Cassie (1954), Tanaka (1956) or by means of computer programmes such as NORMSEP (Abramson, 1971) or ENORMSEP (Yong and Skillman, 1975).

In the second method, the length-frequency distribution of a number of samples at regular intervals, generally at monthly intervals are studied to trace the progression of modes. The progression of modes from the first to subsequent months gives an idea of the growth by computer programme ELEFAN I. Although they claimed superiority of their method over the previous methods, Gulland (1983) is of the view that this method too is as subjective as the earlier methods.

In the present study modal progression analysis was used in studying the age and growth of *M. monoceros* by sequentially arranging the monthly length-frequency distribution and tracing the progression of different modes. It was observed that most of the modes could be traced over 3 to 4 months after

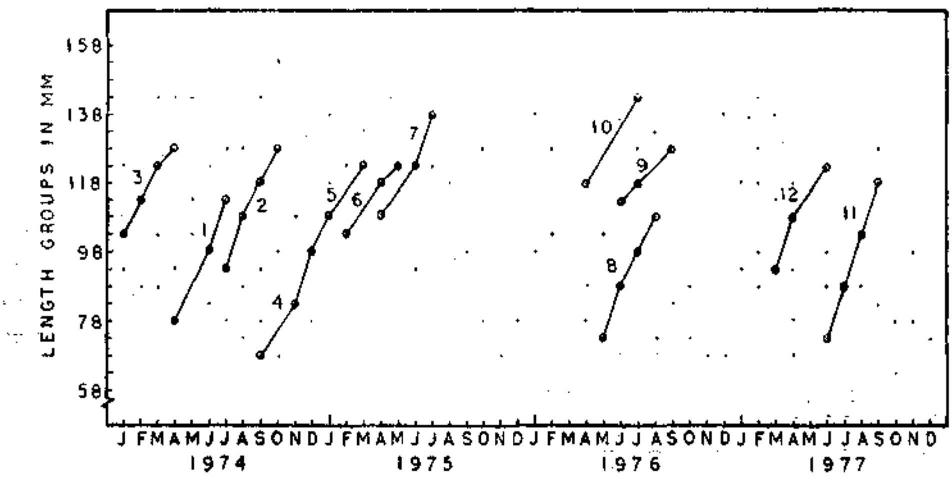

Fig. 1. Scatter diagram of mode chains used in the estimation of growth parameters of males of *M. monoceros*.

of different broods in the population. This is the most commonly used methods in the study of tropical fisheries because of its simplicity rather than precision (Pauly and David, 1981). It has been used by Menon (1953), Banerji and George (1967), Neiva *et al.* (1971), Garcia (1977) and Rao (1979) with some degree of success.

Pauly and David (1981) discussed the merits and demerits of these two methods and proposed an integrated method of finding age and growth from length-frequency analysis which they lost their identity in the length frequency distribution. Hence, the modes traceable for 3 months duration were taken into consideration to calculate age and growth.

Monthly length-frequency distribution for the period January, 1974 to December, 1977 for males and January, 1974 to December, 1976 for females is considered for the estimation of age and growth. Scatter diagrams of modal values for males and females are presented in Figures 1 and 2 respectively. All the modes traceable for 3 months are indicated. These mode-chains formed the basis for the estimation of growth parameters L_∞ and K by Ford-Walford (1946) method.

Estimation of L_∞ and K

Walford (1946) showed that when l_{t+1} is plotted against l_t and a straight line is adjusted to these points, this line has a slope and cuts the 45° diagonal at $l_t = L_\infty$. This follows the formula $l_{t+1} = L_\infty (1-e^{-k})\ K l_t$

where l_{t+1} is length at time t+1

l_t is length at time t

K is Ford's growth co-efficient ($=e^{-k}$)

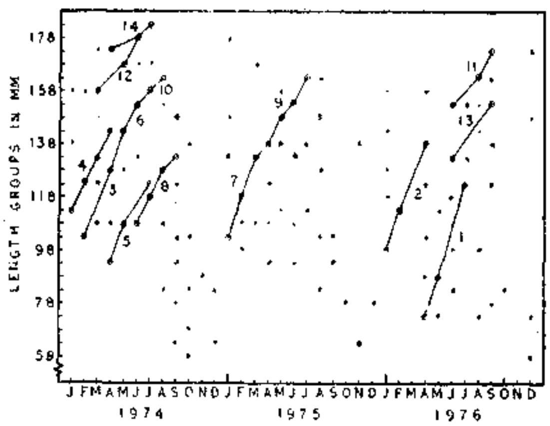

Fig. 2. Scatter diagram of mode chains used in the estimation of growth parameters of females of *M. monoceros*.

This method has been successfully used to study the age and growth of penaeid prawns using data obtained from tagging experiments by Lindner and Anderson (1956), Iversen and Jones (1961), Kutkhun (1962) Klima (1964) and Berry (1967) among others.

The values of the parameters obtained by Ford-Walford method are given below :

Parameter	*a*	*b*	*K* (3 *months*)	*K* (*annual*)	L_∞
Males	62.20	0.6571	0.4200	1.68	178.4mm
Females	69.11	0.6667	0.4054	1.62	207.3mm

The values obtained by this method for L_∞ are very close to the l_{max} (maximum length recorded) observed for males and females in the catches during the present investigation. These confirm the validity of the Ford-Walford method in describing the growth of *M. monoceros*. Provisional age-at-length was calculated with the help of these regression constants based on the relationship.

$$Y = a + bX$$

The age at the smallest length was fixed on the basis of the values obtained from rearing experiments (Subrahmanyam, 1973).

Estimation of t_0

It is necessary to estimate t_0 (age when length is 0) to obtain absolute age. In the present study t_0 was estimated by the method of Gulland (1969).

The graphical representation of t_0 estimation is shown in Figure 3. The estimates obtained for the sexes are given below.

Sex	*a*	*b*	t_0 *in months*	t_0 *in years*
Males	0.0809	—0.1401	0.577	0.048
Females	0.1063	—0.1351	0.787	0.066

Fitting the growth equation

The most frequently used expression of growth is that of von Bertalanffy (1938) because Beverton and Holt (1957) developed the necessary science to integrate it into the yield equation. Other models have been proposed such as those of Gompertz (1825), logistic (Pearl and Read, 1920) and an exponential model (Ricker, 1958). Silliman (1969) compared the Gompertz and von Bertalanffy models and found that the latter represented the growth of fish better. Parrack (1979) also compared the growth of *P. aztecus* by von Bertalanffy, Gompertz and logistic models and found the first model to be superior to the other two models.

The properties of the von Bertalanffy model have been studied by Fabens (1965) and Southward and Chapman (1961). A few modifications or generalisations of the Bertalanffy model have also been proposed by several workers such as Richards (1959), Chapman (1961) and Tayler (1962). Although application of the modified Beverton and Holt model is attempted (Paulik and Gales, 1964), these models do not yet seem to have

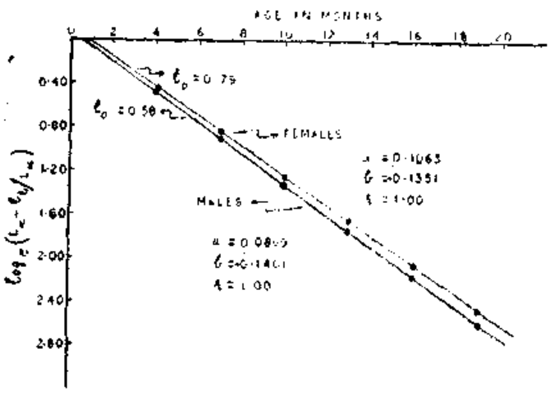

Fig. 3. Estimation of t_0 in *M. monoceros*.

been much accepted. Knight (1968) questioned the validity of asymptotic growth in general and proposed a modified equation in which the true growth rate appears as a parameter. von Bertalanffy (1938, 1964) tries to impart biological significance to his model which was later questioned by Ricker (1975). However, Ricker (1975) accepted the model as it most often agrees with what is observed and can be applied as an empirical method, an opinion expressed by Broady (1945) when he laid the original basis for the model.

Fitting of the von Bertalanffy equation to the data of males and females of *M. monoceros* is shown below :

Males : $l_t = 178.4\ [1 - e^{-1.68\ (t-0.048)}]$

Females : $l_t = 207.3\ [1 - e^{-1.62\ (t-0.066)}]$

The same may be given in respect of weight as follows :

Males : $W_t = 36\ [1 - e^{-1.68\ (t-0.048)}]\ 2.9521$

Females : $W_t = 68\ [1 - e^{-1.62\ (t-0.066)}]\ 3.1509$

Based on these formulae age-at-length curves (growth curves) for males and fameles are presented in Figure 4. The age-at-length (in mm) at ages 6,12 and 18 months for males and females is given below :

Age (months)	6	12	18
Males	94.89	142.36	162.83
Females	104.71	161.67	187.01

It is seen that females grow at a faster rate than males. The differential growth in sexes is established even at the early age of 3 months (Fig. 4).

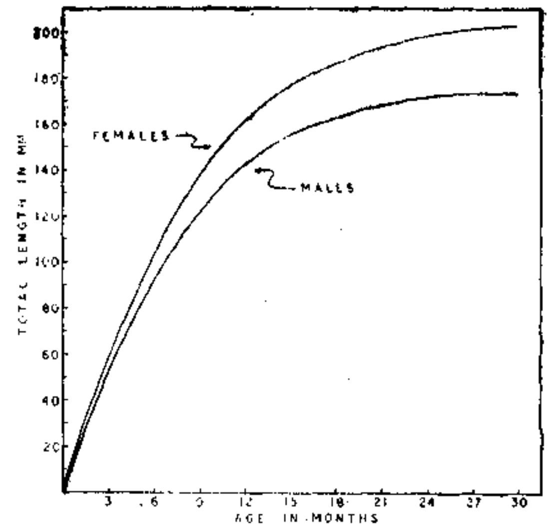

Fig. 4. Growth curves of *M. monoceros* based on von Bertalanffy growth equation.

Discussion

Most of the early Indian workers studying age and growth in penaeid prawns suffered from certain misconceptions. Firstly, they did not distinguish differential growth rates in the two sexes or perhaps chose to ignore the same. They pooled the length data of both sexes while analysing the frequency distribution. Secondly, they gave yearly status to the modes in the length frequency distribution, borrowing the idea from works in temperate waters not considering the fact that in most of the tropical species the spawning period is prolonged with a number of spawning peaks in an year. These workers failed to realise that most of the modes depicted in the length-frequency distribution are but different broods of the same year group. Thirdly, quite a few workers reported very slow rates of growth, and either too high or too low L∞ values; low L∞ values even when they themselves encountered specimens of greater length than their L∞ in their own samples.

Differential growth in sexes was observed in various other species of penaeid prawns by a number of workers (Iversen and Jones, 1961; Rajyalakshmi, 1961; Kutkhum, 1966; Banerji and George, 1967 ; Ramamurthy, 1967; Garcia, 1977 ; Pauly *et al.*, 1984). Yet Banerji and George (1967) pooled the length data of the two sexes and arrived at a combined growth equation for *M. dobsoni*. Kurup and Rao (1974) estimated L∞ of 144.6 mm for females of *M. dobsoni* from the Cochin waters, whereas the recorded maximum length of *M. dobsoni* females from Indian waters is only 128 mm. On the other hand, Ramamurthy *et al.* (1978) estimated a low L∞ of 120.9 mm for female *M. dobsoni* when they themselves encountered specimens of 128 mm length. In the case of *M. brevicornis* and *M. kutchensis* also Ramamurthy (1967) combined the data of males and females and arrived at such slow rates of growth, which when applied to large specimens encountered by other workers (Rao, MS) would give improbably high ages. Kurup and Rao (1974) and Ramamurthy (1980) reported L∞ values for males and females separately in *P. stylifera*. These were questioned by Rao (MS) on the basis that some of their specimens were larger than their L∞ values.

George (1959) studying *M. monoceros* from the Cochin backwaters observed 3 modes in the length frequency distribution at 106-110, 131-135 and 151-155 mm, and assigned them to three different year classes. He combined the data of males and females. This is clearly unacceptable, in view of the established fact that there is differential growth in the two sexes of this species. In the present work the authors analysed the data for males and females separately and estimated that males attained average lengths of 142.32 mm and 161.67 mm and for females 162.8 2 mm and 187.01 mm at the end of 12 and 18 months respectively.

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