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Age and growth of the speckled shrimp *Metapenaeus monoceros* (Fabricius) along the Cochin coast

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Abstract

Age and growth of the speckled shrimp *Metapenaeus monoceros* have been studied using von Bertalanffy growth model in two ways (1) by applying the modal progression analysis, L_∞ and K estimated by Ford - Walford method and t_o estimated by Gulland method, so as to facilitate comparison of the present results with earlier growth studies and (2) by application of ELEFAN I method. It has been observed that the results on growth obtained by these two procedures are almost similar at the end of 18 months. The L_∞ and K (annual) values of *M. monoceros* estimated by ELEFAN I method are 204 mm and 1.8 for females; 170 mm and 1.5 for males respectively. The total length attained by females and males respectively are 113 and 84 mm at the end of 6 months, 167 and 129 mm at the end of 12 months and 189 and 151 mm at the end of 18 months.

Introduction

Studies on age and growth are of paramount importance in fishery biological investigations, since these are required both in assessing the changes in abundance of populations in relation to fluctuations in fishing pressure as well as in estimation of rates of mortality. Determination of age and growth of a species further helps in the study of biological characteristics such as, longevity, rate of growth, age at first maturity and age structure of the stock. The growth of penaeids, as in other crustaceans, varies with sex as well as other factors such as food quality, quantity, population density, light, temperature and salinity. The conclusions on growth on penaeid prawns presented by various authors represent overall increments in dimensions in a given period of time, which are summations of individual spurt of growth that has taken place at different moultings. The crustaceans do not have a bony structure which records an imprint of internal and environmental variations which would allow age to be read directly. Hence, reliance has perforce to be placed on methods of analysis of length frequency distributions in age determination (Bhimachar, 1965). Yano and Kobayashi (1969) stated that the number of lamellae in the endocuticle increases with size and thus may give some possibility of age determination. Sheehy (1990) suggested that morphological lipofuscin quantified by image analysis has significant potential as a means of age determination for crustaceans.

The studies on age and growth of penaeid prawns in India are mainly based on length frequency method. Some of the important works on age and growth of penaeid prawns along the Indian coasts are by Menon (1953, 1955), Rajyalakshmi

(1961), George *et al* (1963), Banerji and George (1967), Ramamurthy (1967, 1980), Kurup and Rao (1974), Thomas (1975), Ramamurthy *et al* (1975, 1978), Lalitha Devi (1986, 1988) Sriraman *et al* (1989), Suseelan and Rajan (1989), Rao *et al* (1993) and Sukumaran *et al* (1993). The growth of *M. monoceros* from mysis to early juvenile stage was given by Rao (1973) based on rearing experiments. George (1959, 1975) and Menon and Raman (1961) studied the growth of juvenile brown shrimp based on the samples colleted from Cochin backwaters and nearby prawn farms. Subrahmanyam (1973) and Lalitha Devi (1988) observed the growth rate of *M. monoceros* in the Godavary estuarine system. The age and growth of *M. monoceros* along Kakinada coast was studied by Rao and Krishnamoorthi (1990) based on the trawl landings of 1974-1977.

Due to absence of regular catches of *M. monoceros* in appreciable quantities from the nearshore waters of Kerala, there has been no information on its age and growth from this state till now. From 1990 onwards, the trawlers extended their fishing trips from single day to 2-3 days, including shrimp trawling in deeper grounds during night. This multiday trawling has yielded better catch of speckled shrimp. The situation thus facilitated to study the age and growth of *M. monoceros* along the Kerala coast based on data and samples collected during 1991-93. The present work gains importance as it is the first attempt to study the age and growth of *M. monoceros* along Kerala coast.

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Material and methods

Data on length and weight of the speckled shrimp *M. monoceros* were collected from trawl landings at Cochin Fisheries Harbour. Length measurements were grouped into 5 mm class intervals (e.g. 81-85, 86-90, 91-95 etc, with mid points at 83, 88 and 93 mm). Length distribution was studied for males and females separately. The numbers in the length frequency distribution were raised to the total catch of the sampling day based on the sample weights. The data thus obtained for different sampling days in a month were pooled to get catch in numbers for all the sampling days which in turn, was raised to monthly catch. The monthly data so obtained during the three years period between 1991 and 1993 from Cochin Fisheries Harbour formed the basis for studies on length frequency analysis.

The age and growth of *M. monoceros* has been studied using von Bertalanffy growth model.

$$l_t = L_\infty (1-e^{-k(t-t_o)})$$

where, l_t is the length at age, t; L_∞ is the average asymptotic size to which the individual grows; k is the growth coefficient; and t_o is the theoritical age of the individual fish at zero size.

The parameters for this growth equation were estimated by different ways: a)

Length frequency analysis to identify modes of different broods and study their progression over ages b) Ford - Walford method (Ford, 1933; Walford, 1946) for estimation of L_∞ and k, and c) Gulland method (1969) for estimation of t_0 and by applying the ELEFAN I (Electronic Length Frequency Analysis) method (Pauly and David 1981).

Results

Length frequency analysis and estimation of L_∞, K and t_0

In order to learn the age and growth of *M. monoceros* in the present study, "the modal progression analysis" method (George and Banerji, 1964) was used in which the length frequency distribution of a number of samples, generally at monthly intervals, are studied to trace the progress of modes. The progression of modes from the first to those of subsequent months gives an idea of the growth of different broods in the population. Based on the monthly size distribution of *M. monoceros* landed by shrimp trawlers at Cochin Fisheries Harbour during 1991-93, the scatter diagrams of modal values

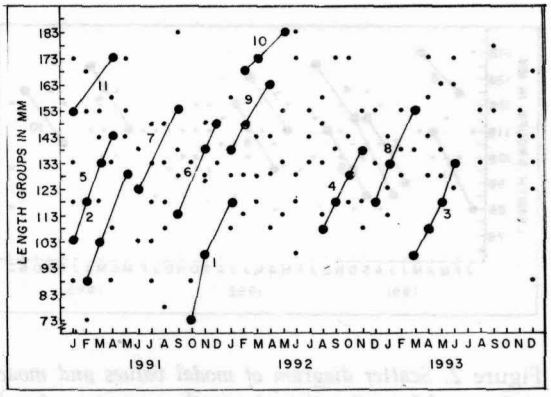

Figure 1. *Scatter diagram of modal values and mode-chains used for estimation of growth parameters of female M. monoceros.*

distribution. The modes traceable for 3 months are indicated in the scatter diagrams. These mode chains formed the basis for the estimation of the growth parameters, L_∞ and K.

The Ford - Walford method has been used to estimate L_∞ and K and it is based on the following form of von Bertalanffy equation (Ford, 1933) : $l_{t+l} = L_\infty^{(l-k)} + Kl_t$ where, l_{t+1} is length at time t + 1, l_t is length at time t and K is the growth Coefficient (=e^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

Sex	a	b	k (3 months)	k (annual)	L_∞
Females	69.0	0.67907	0.38703	1.5481	215 mm
Males	57.0	0.68156	0.38337	1.5335	179 mm

for females and males of *M. monoceros* are shown in Figures 1 and 2 respectively. It was observed that most of the modes culd be traced upto 3 months after which they lost their identity in the length frequency

has a slope K and cuts the 45° diagonal at $L_t = L_\infty$. The plot of l_{t+1} on l_t is shown in Figure 3 for females and in Figure 4 for males. In the case of females this line adjusted to the points intercepts the 45°

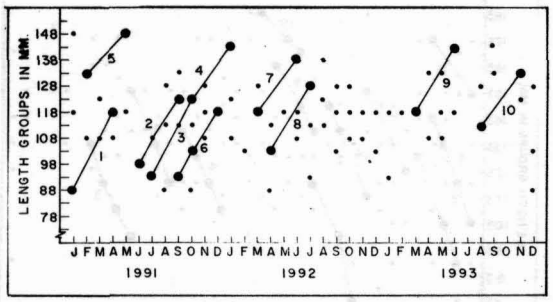

Figure 2. *Scatter diagram of modal values and modechains used for estimation of growth parameters of male M. monoceros.*

line at 215 mm which is the estimate of L_∞ (asymptotic growth). The line at the other end cuts the Y axis at 69.0 giving the estimate constant 'a' of the regression describing the elevation of line. Slope of the line 'b' is related to K, the growth constant as $b = e^{-k}$ or $K = \log_e (1/b)$. Thus k was estimated as 0.38703 for 3 months and 1.5481 for an year (annual k). Similarly, the growth parameters for males were also estimated.

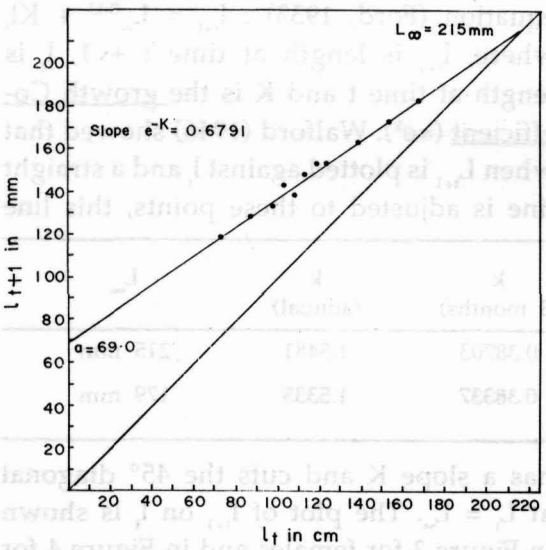

Figure 3. *Graphical representation of estimation of growth parameters by Ford - Walford plot for females of M. monoceros.*

Provisional age at length for *M. monoceros* was calculated with the help of these regression constants based on the relationship Y = a + b x which formed the basis for estimation of t_o. The age at smallest length was fixed based on the studies on the growth of early juveniles of this species (George, 1959, 1975, Rao, 1973; Subrahmanyam 1973 and Lalitha Devi, 1988).

The t_o in the present study was estimated by the method of Gulland (1969) and obtained from the equation

$$Kt_o - k\ t = \log_e (L_\infty - l_t/L_\infty)$$

Details showing the estimation of t_o for females and males of *M. monoceros* are given in Tables 1 and 2 respectively. The estimated t_o (in months) are 0.7235 and 0.3106 for females and males of *M. monoceros* respectively. The t_o (in years) amounted to 0.0603 for females and 0.0259 for males. The growth parameters estimated by the methods, as explained earlier, are given below.

Sex	L_∞	k (annual)	t_o (in years)
Females	215 mm	1.5481	0.0603
Males	179 mm	1.5335	0.0259

Details indicating the fitting of von Bertalanffy equation to the growth data of females and males of *M. monoceros* are given in Tables. 3 and 4 respectively. The formulae thus derived are as follows:

Females : $l_t = 215\ 1\text{-}e^{-1.5481\ (t-0.0603)}$

Males : $l_t = 179\ 1\text{-}e^{-1.5335\ (t-0.0259)}$

Table 1. *Details showing the estimation of t_0 for females of M. monoceros*

L_∞ = 215 mm derived from Ford - Walford plot

t in months	l_t	$(L_\infty - l_t)$	$L_\infty - l_t/L_\infty$	$\log_e(L_\infty - l_t/L_\infty)$
3	64	151	0.7023	-0.3534
6	113	102	0.4744	-0.7457
9	148	67	0.3116	-1.1660
12	173	42	0.1953	-1.6332
15	188	27	0.1256	-2.0747

Regression of $\log_e(L_\infty - l_t/L_\infty)$ on t gives the value of constants.

a = 0.1044 b = -0.1443

t_0 = -a/b = -0.1044/-0.1443 = 0.7235 month (or) 0.0603 year

The total length (in mm) at different age (in months) calculated for *M. monoceros* based on the application of von Bertalanffy growth equation in the present study are as follows.

Age (Months)	6	12	18
Length (mm)			
Females	106.15	164.81	191.85
Males	92.48	138.81	160.33

The weight converted von Bertalanffy equation can be written as

$$W_t = W_\infty (1-e^{-k(t-to)\ n})$$

where 'n' is the exponent of the length-weight relationship. Based on the length-weight relationships worked out (Nandakumar, 1998) the weight converted von Bertalanffy equations fitted to data for *M. monoceros* are given below.

Females : $W_t = 80.83\ (1-e^{-1.5481(t-0.0603)})$

Males : $W_t = 37.63\ (1-e^{-1.5335\ (t-0.0259)})$

Application of ELEFAN I method

The "Compleat Elefan" is a package of

Table 2. *Details showing the estimation of t_0 for males of M. monoceros*

L_∞ = 179 derived from Ford-Walford Plot

t in months	l_t	$(L_\infty - l_t)$	$L_\infty - l_t/L_\infty$	$\log_e(L_\infty - l_t/L_\infty)$
3	60	119	0.6648	-0.4083
6	98	81	0.4525	-0.7930
9	123	56	0.3128	-1.1622
12	143	36	0.2011	-1.6040
15	157	22	0.1229	-2.0964

Regression of $\log_e(L_\infty - l_t/L_\infty)$ on t gives the value of constants.

a = 0.04336b = -0.1396

t_0 = -a/b = -0.04336/-0.1396 = 0.3106 month (or) 0.0259 year

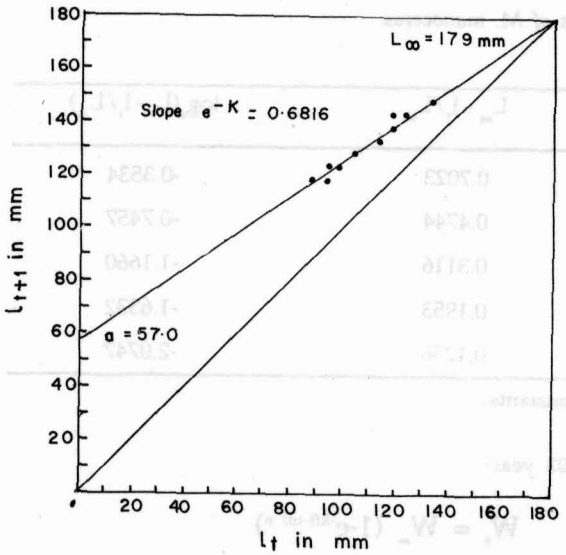

Figure 4. Graphical representation of estimation of growth parameters by Ford - Walford plot for males of M. monoceros.

microcomputer programmes written in the language BASIC (Gayanilo *et al.*, 1988). It contains a number of programmes for fish stock assessment of which, "ELEFAN - I" deals with estimation of growth parameters using length frequency analysis. It is assumed that the value of the third parameter of von Bertalanffy growth function, t_0 is Zero (Pauly and David 1981, Pauly 1988).

Gulland (1983) stated that the best procedure in practice is first to analyse length data by simple graphical method and to attempt to fit growth curves by well known methods; and if this produces sensible results, the ELEFAN or similar programmes can be used to extract the maximum amount of information from the data available. In the present study it has been learnt that the von Bertalanffy growth formula describes the mean growth of *M. monoceros* in the population and hence, the computer based length frequency analysis 'ELEFAN I method" was applied to study the age and growth of this species.

The L_∞ and K values of *M. monoceros* estimated by ELEFAN I method are 204 mm and 1.8 for females; and 170 mm and 1.5 for males respectively. The growth curves derived by this method for females and males of the speckled shrimp are shown in Figures 5 and 6 respectively. It was observed that if a female *M. monoceros* was assumed to be born during August the expected length after 12 months (July) would be 166.53 mm. It will grow to 188.88 mm in January i. e. in 18 months (1 1/2 years old). In the same manner if a male was considered to be born in the month of September, the expected length it would reach at one year of age (September - August) would be 129.12 mm. In the month of February when the male speckled shrimp is 1.5 years (18 months) old, it would measure 150.81 mm in total length. Based on the results thus obtained from the application of computer based length frequency analysis (ELEFAN I method) growth curves depicting age at length for *M. monoceros* are shown in Figure 7. The age of *M. monoceros* (in months) in relation to different length (in mm) as estimated by ELEFAN I method is given below :

Age (months)	6	12	18
Length (mm)			
Female	112.51	166.53	188.88
Male	83.98	129.12	150.81

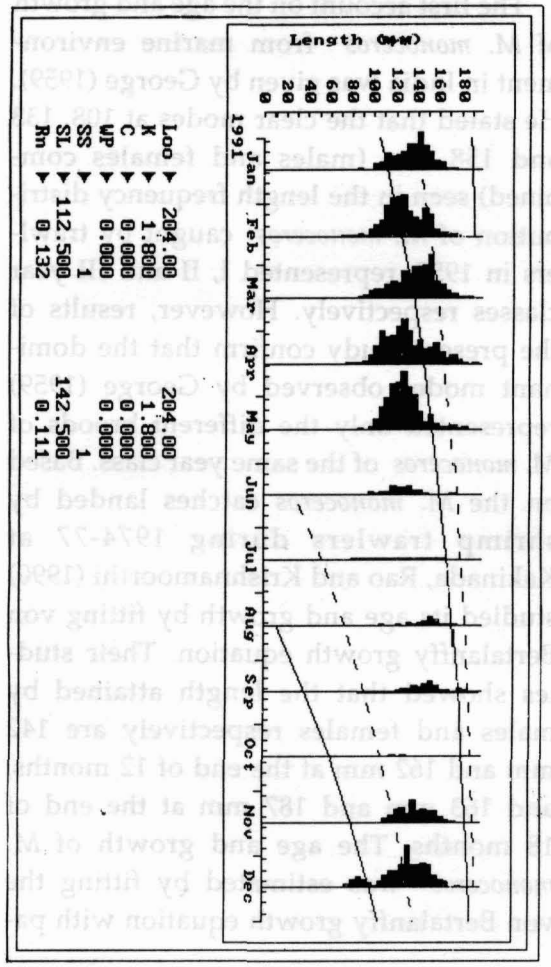

Fig. 5. *Growth curves derived by the ELEFAN I computer programme for female M. monoceros.*

Discussion

Most of the available studies on growth for *M. monoceros* are restricted to its juvenile phase. A monthly growth rate between 5.0 and 7.98 mm was recorded during the juvenile phase in the life history of brown shrimp from Cochin backwaters (George 1959; Menon and Raman 1961; and Mohamed and Rao, 1971). Rearing experiments of *M. monoceros* from mysis to early juvenile stage showed a growth rate of 0.32 mm per day (Rao, 1973). Subrahmanyam (1973) recorded monthly growth rate ranging from 15-25 mm for juveniles of this species from Adayar and Ennore Estuary when they remain closed. The species was observed to grow at the rate of 14.61 mm per month in the prawn culture fields around Cochin (George, 1975). Chen (1976) stated that

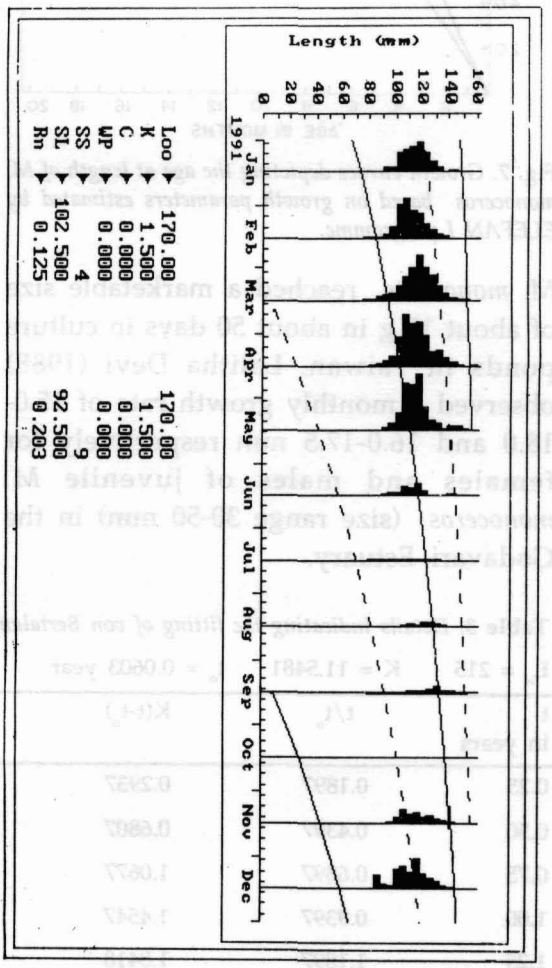

Fig. 6. Growth curves derived by the ELEFAN I computer programme for male M. monoceros.

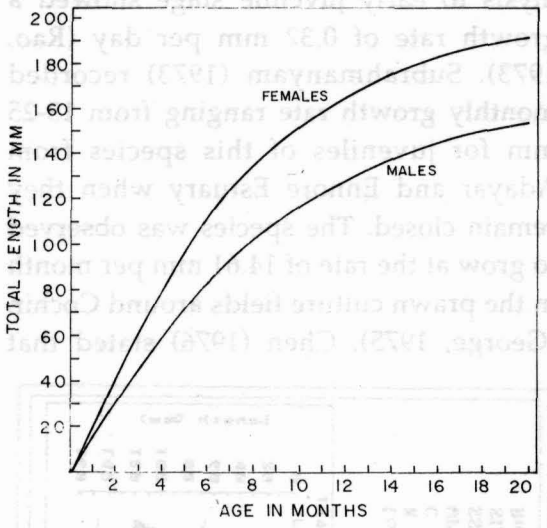

Fig. 7. *Growth curves depicting the age at length of M. monoceros based on growth parameters estimated by ELEFAN I programme.*

M. monoceros reached a marketable size of about 15 g in about 50 days in culture ponds in Taiwan. Lalitha Devi (1988) observed a monthly growth rate of 15.0-18.0 and 16.0-17.5 mm respectively for females and males of juvenile *M. monoceros* (size range 30-50 mm) in the Godavari Estuary.

The first account on the age and growth of *M. monoceros* from marine environment in India was given by George (1959). He stated that the clear modes at 108, 133 and 158 mm (males and females combined) seen in the length frequency distribution of *M. monoceros* caught by trawlers in 1957, represented I, II and III year classes respectively. However, results of the present study confirm that the dominant modes observed by George (1959) represented only the different broods of *M. monoceros* of the same year class. Based on the *M. monoceros* catches landed by shrimp trawlers during 1974-77 at Kakinada, Rao and Krishnamoorthi (1990) studied its age and growth by fitting von Bertalanffy growth equation. Their studies showed that the length attained by males and females respectively are 142 mm and 162 mm at the end of 12 months; and 163 mm and 187 mm at the end of 18 months. The age and growth of *M. monoceros* was estimated by fitting the von Bertalanffy growth equation with pa-

Table 3. *Details indicating the fitting of von Bertalanffy equation to the growth data of female of M. monoceros*

$L_\infty = 215$ K = 11.5481 $t_o = 0.0603$ year

t in years	t/t_o	$K(t-t_o)$	$e^{-k(t-to)}$	$1-e^{-k(t-to)}$	$l_t = L_\infty (1-e^{-k(t-to)})$
0.25	0.1897	0.2937	0.7455	0.2545	54.71
0.50	0.4397	0.6807	0.5063	0.4937	106.15
0.75	0.6897	1.0677	0.3438	0.6562	141.09
1.00	0.9397	1.4547	0.2335	0.7665	164.81
1.25	1.1897	1.8418	0.1585	0.8415	180.91
1.50	1.4397	2.2288	0.1077	0.8923	191.85
1.75	1.6897	2.6158	0.0731	0.9269	199.28

Table 4. *Details indicating the fitting of von Bertalanffy eqation to the growth data of males of M. monoceros*

L_∞ = 179 *mm* K = 1.5335 t_o = 0.0259 year

t in years	t/t_o	$K(t-t_o)$	$e^{-k(t-to)}$	$1-e^{-k(t-to)}$	$l_t = L_\infty (1-e^{-k(t-to)})$
0.25	0.2241	0.3437	0.7092	0.2908	52.06
0.50	0.4741	0.7270	0.4833	0.5167	92.48
0.75	0.7241	1.1104	0.3294	0.6706	120.03
1.00	0.9741	1.4938	0.2245	0.7755	138.81
1.25	1.2241	1.8772	0.1530	0.8470	151.61
1.50	1.4741	2.2605	0.1043	0.8957	160.33

rameters estimated by Ford-Walford method as well as by application of ELEFAN I method. Estimation of growth in the earlier procedure has enabled to compare the results obtained with those from other sources.

Fitting the von Bertalanffy growth equation based on the estimates obtained by Ford - Walford method (L_∞ and K) and Gulland method (t_o) showed that the length attained by females and males of *M. monoceros* respectively in the present study are 164.81 mm and 138.81 mm at the end of 12 months and 191.85 mm and 160.33 mm at the end of 18 months. These results agree with those observed for the same species along Kakinada coast (Rao and Krishnamoorthi, 1990) upto 12 months; beyond which the growth rate showed slight variation in the two geographical locations Kakinada (East coast) and Cochin (West coast). At the end of 18 months, female *M. monoceros* along Cochin coast showed a marginal increase in growth (4.84 mm in length; 2.52%) while males exhibited a slight decrease in length (2.5 mm; 1.56%) when compared with the growth of females and males of *M. monoceros* respectively from the Kakinada coast.

In the present study, the application of ELEFAN I method showed a length of 188.88 mm for females and 150.81 mm for males of brown shrimp after 18 months of life-span. When results on growth at the end of 18 months obtained by applying von Bertalanffy growth model by adopting these two procedures are compared, it has been observed that they are almost similar with a difference of only 1.55% in females and 5.94% in males. In the first procedure the estimates of parameters of von Bertalanffy growth model are found to describe satisfactorily the growth of *M. monoceros*. However, in the model progression analysis in identifying modes a little subjectivity is likely to creep in vitiating the reliability of estimates. This subjectivity is minimum in the use of ELEFAN I Programme which is based on an objective criterion. One of the main features of ELEFAN I method is that a

number of different growth curves are tested in the process of finding the best fit curve. This method is rapid, reliable and highly recommended objective method, for studying single species dynamics in a multispecies context (Pauly, 1980, 1982). The L_∞ values derived by the ELEFAN I method for *M. monoceros* (204 mm for females and 170 mm for males) in the present study was found to be reasonable not far away from the maximum length observed in the fishery (195 mm and 160 mm for females and males respectively).

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