

Population Dynamics of Monsoon River Prawn *Macrobrachium malcolmsonii* (Milne Edwards) in Wyra, a Tropical Reservoir in India

M.F. KHAN^{1*}, P. PANIKKAR¹, A.K. DAS², R.K. MANNA³ and D.N. SINGH⁴

¹Reservoir Fisheries Division, Central Inland Fisheries Research Institute
Hessarghatta Lake Post, Bangalore 560-089 India

²Central Inland Fisheries Research Institute, Barrackpore, India

³Central Inland Fisheries Research Institute, Guwahati, India

⁴Central Inland Fisheries Research Institute, Allahabad, India

Abstract

Population Dynamics of *Macrobrachium malcolmsonii* in Wyra, a tropical reservoir in India was studied. The growth parameters, mortality rates exploitation rates and maximum sustainable yield and corresponding fishing mortalities were evaluated. The von Bertalanffy parameters of growth are estimated as $L_{\infty} = 20.3$ cm and $K = 0.63$ per yr. The instantaneous rate of mortality during the period is estimated at $Z = 2.23$. Length at first capture is 4.0 cm. The maximum sustainable yield MSY is obtained at an E value of 0.48 and present E is only 0.33. Hence there is scope for further expansion of the fishery for *M. malcolmsonii* at the Wyra reservoir.

* Corresponding author. Tel.: +91 80 2356 4530, Fax: +91 80 2844 6428
E-mail address: ferosekhan23@gmail.com

Introduction

Wyra reservoir a tropical water body located in the Khammam District of Andhra Pradesh in South India is one of the oldest reservoirs constructed in 1930 over the Wyra River, which is a tributary of river Krishna (Fig. 1). The catchment area of this reservoir lies in the dry Deccan Plateau, which includes forests and intensely cultivated agricultural and wastelands with moderate to low rainfall. The area of the reservoir at FRL is 1626 ha and the mean depth is 3.9 m. This reservoir was studied by Gopalakrishnayya et al. (1998) during 1995-1996 and has classified the reservoir as productive. Wyra has a good population of zooplankton and a fairly rich bottom fauna consisting of *Tendipes* and other dipteran larvae. The freshwater prawn *Macrobrachium malcolmsonii* contributes substantially to the catch, the reservoir getting natural recruitment from River Krishna contributing to auto-stocking (Gopalakrishnayya et al. 1998).

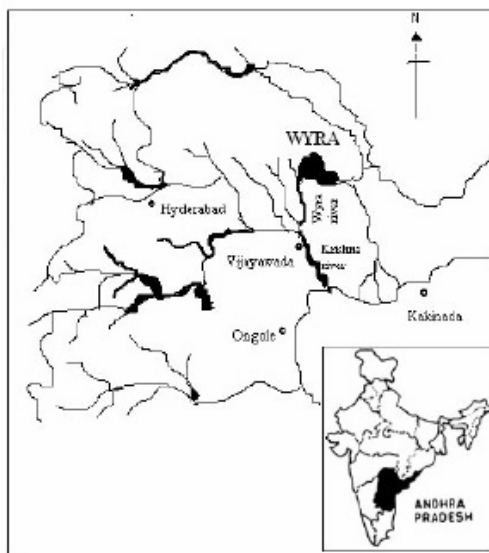


Figure 1. Map of Wyra, a tropical reservoir in India

Macrobrachium malcolmsonii is the dominant freshwater prawn having commercial importance. Its annual average yield of about 113 tons makes up about 59 % of the landings of total catch from this reservoir. Fishermen using dragnets catch the prawns. This species is common in Chilka Lake (Kemp 1915; Chopra 1939) in Central India and parts of Peninsular India and is one of the common Palaemonids of South India (Henderson and Mathai 1910). In India major proportion of this prawn is exported and only a small component of the catch is available for local consumption.

From the year 2001 onwards, every year there was a self imposed ban on fishing by Wyra Fishermen Co-operative Society for three months starting from January (Panikkar and Khan 2008). The socioeconomics of

the fishermen is dependent on the landings of prawns which fetches premium price and they have been successful in imposing this ban on fishing for conserving this species. Ibrahim (1962) studied the fishery and biology of this species in river Godavari but there is no published information on the population dynamics of this species from a reservoir in India.

Material and Methods

Length based stock assessment method was used for the present study. Monthly samples of *M. malcolmsonii* were collected at random from the Wyra Reservoir during July 2003 to April 2004. Samples were immediately preserved in 5% formalin in the field after length weight measurements and analyzed after 1-2 days of preservation for biological studies. Total length (mm) of the prawns was measured from the tip of the rostrum to the tip of the telson (FAO 1981), to the nearest 1 mm and weight measurements were made to the nearest 1 g. These data were grouped into 5 mm class intervals. The data length frequencies were suitably weighted to get the monthly estimates.

For estimating growth parameters pooled length-frequency data were analysed following the FISAT package (Gayani et al. 1995). The procedures given in Sparre and Venema (1992) were followed. An initial estimate of L_{∞} was made using the Powell-Wetherall plot. The data were subjected to Bhattacharya analysis to separate the modes and growth parameters were estimated by ELEFAN I method (Pauly and David 1981).

An additional estimate of L_{∞} and Z/K value was obtained by plotting $\bar{L} - L'$ (Wetherall 1986 as modified by Pauly 1986) i.e.

$$\bar{L} - L' = a + b \bar{L}$$

$$L_{\infty} = - a/b \text{ and}$$

$$Z/K = (1 + b) / - b$$

Where \bar{L} is defined as mean length computed from L' upward, in a given length frequency sample while \bar{L} is the limit of first length class used in computing a value of \bar{L} .

The growth performance of *M. malcolmsonii* population in terms of length growth was compared using the index of Pauly and Munro (1984)

$$L' = \text{Log}_{10} K + 2 \text{Log}_{10} L_{\infty}$$

ELEFAN II estimates Z from catch curve is based on the equation

$$Z = K [(L_{\infty} - L) / (\bar{L} - L')] \quad (1)$$

Where, \bar{L} is the mean length in the sample computed from upward L' is the lower limit of the smallest length class used in the computation of L (Beverton and Holt 1956). The parameter M was estimated using the empirical relationship derived by Pauly (1980) i.e.

$$\text{Log}_{10} M = -0.0066 - 0.279 \text{Log}_{10} L_{\infty} = +0.6543 \text{Log}_{10} K + 0.4634 \text{Log}_{10} T \quad (2)$$

Where L_{∞} is expressed in mm T ($^{\circ}\text{C}$) the mean annual environmental temperature (here it is taken as 29.4°C).

The estimate of F was taken by subtracting M from Z ; the exploitation rate (E) was then computed from the expression

$$E = F/Z = F / (F+M) \quad (\text{Gulland 1971}).$$

Recruitment pattern was obtained by backward projection on the length axis of a set of length frequency data as described in the FISAT routine. Relative yield-per-recruit (Y/R) and Relative Biomass per recruit (R/B) values as a function of E were determined from the estimated growth parameters and probability of capture by length (Pauly and Soriano 1986). The calculations were done using the FISAT 1.2.1.

A length structured virtual population analysis (VPA) of *M. malcolmsonii* was carried out (Sparre and Venema 1992) with $L_{\infty} = 20.03$ cm, $K = 0.63$ per year, $M = 1.50$, $F = 0.73$, $a = 0.00002$ and $b = 2.907$ as inputs. The t_0 value is taken as zero.

Results and Discussion

Growth parameters

The growth parameters obtained by different methods do not vary much. The asymptotic length obtained by Wetherall method and ELEFAN I method is close at 20.82 and 20.30 cm, respectively. Growth parameters of von Bertalanffy growth formula for *M. malcolmsonii* were estimated as $L_{\infty} = 20.30$ cm and $K = 0.63 \cdot \text{yr}^{-1}$ from Wyra reservoir. For these estimates through ELEFAN I the response surface R_n was (0.186) for the curve. In

figure 2 the computed growth curve produced with those parameters are shown over its restructured length distribution.

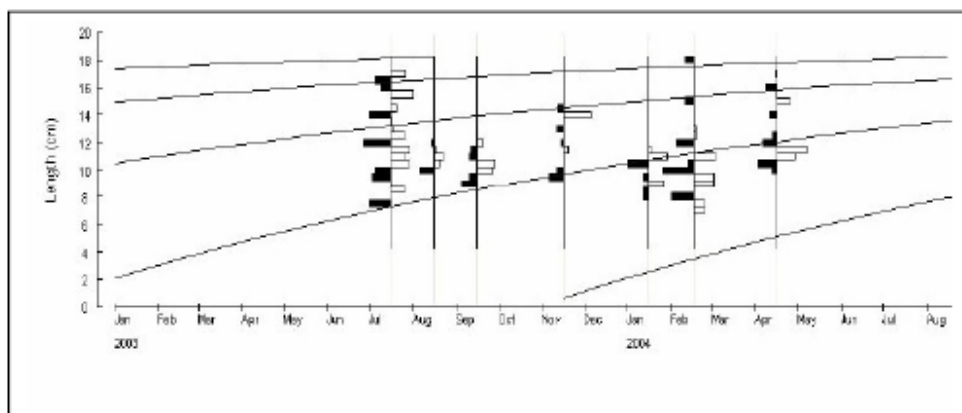


Figure 2. Growth curve of *Macrobrachium malcolmsonii* from Wyra reservoir in India by ELEFAN I superimposed on the length-frequency diagram ($L_{\infty}=20.3$ cm and $K=0.63 \cdot \text{yr}^{-1}$)

Asymptotic length (L_{∞}) is the largest theoretical size a species could attain should it grow indefinitely. This growth coefficient K , as well as mortality rates, are easily estimated using the ELEFAN routine of FiSAT. Pauly et al. (1984) first demonstrated applicability of ELEFAN routine to shrimp length-frequency data. Further, Sparre and Venema (1992) showed that the growth of a cohort of crustaceans conforms to the von Bertalanffy growth function, hence justifying the use of length-frequency analysis tools of FiSAT for shrimps. A sample size of 1,500 or more collected over a minimum period of 6 months is termed adequate by Pauly (1987). The sample size in this study met this requirement.

The Powell-Wetherall plot is shown in figure 3. The corresponding estimates of L_{∞} and Z/K are 20.02 and 2.242, respectively. The correlation co-efficient for the regression was 0.88. Calculated growth performance index (!') for *M. malcolmsonii* in Wyra reservoir was found to be 2.41.

The growth of most fish species apparently conforms to the von Bertalanffy growth model. For crustaceans, the individual growth does not conform to this model, but to some stepwise curve, with each step accounting for a moult (Sparre and Venema 1992). However, since members of a cohort of crustaceans do not moult at the same time, the average growth curve of a cohort smoothens out, approximating the von Bertalanffy growth function (Pauly et al. 1984).

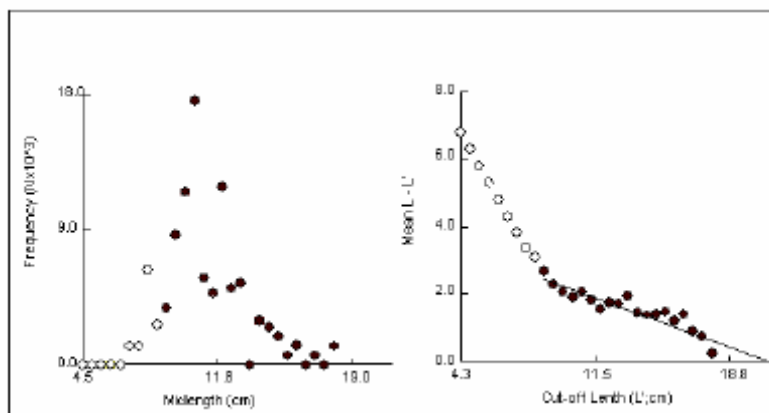


Figure 3. Estimation of L_{∞} and Z/K using the methods of Wetherall for *Macrobrachium malcolmsonii* in Wyra reservoir (estimated $L_{\infty} = 20.03$ cm and $Z/K = 2.242$).

Length weight relationship

A total of 200 specimens of *M. malcolmsonii* ranging from 4.5 to 18.5 cm in total length were measured. From these samples length weight relationship was estimated of the form $W = a L^b$ using the logarithmic transformation $\text{Log}W = \text{Log} a + b \text{Log} TL$ where a and b are constants estimated by linear regression of the log transformation varieties (Fig. 4). The regression takes the form $\text{Log} W = 0.00002 + 2.907 \text{Log} TL$ ($r = 0.90$) or $W = 1.00005 L^{2.907}$.

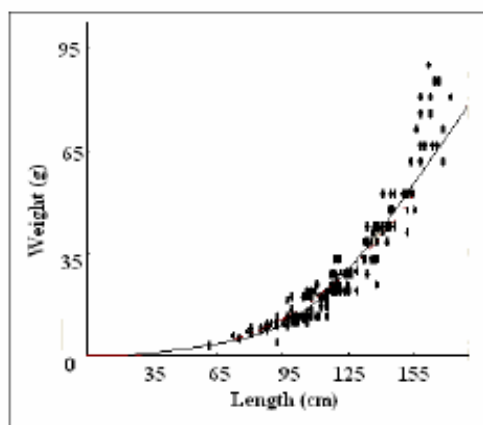


Figure 4. Length-weight relationship of *Macrobrachium malcolmsonii* in Wyra reservoir in India

Mortality

The Natural mortality (M), Total instantaneous mortality (Z) and Fishing mortality (F) co-efficients are 1.50, 2.23 and 0.73, respectively. Information on Instantaneous rate of Mortality on *M. malcolmsonii* is scanty in this ecosystem. The length converted catch curves utilized for estimation of Z is given in figure 5. The darkened circles are the points selected in calculating through least squares lines regression. The blank

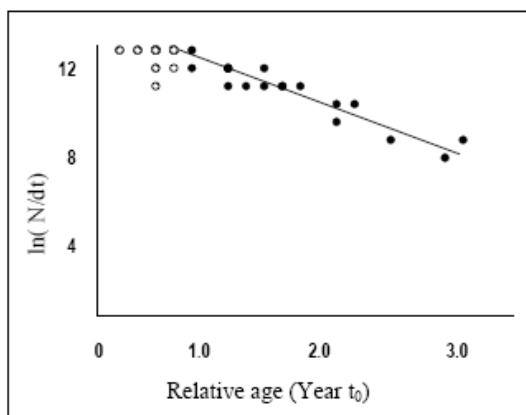


Figure 5. Length converted catch curve of *Macrobrachium malcolmsonii* in Wyra reservoir in India

circles represent points either not fully recruited on nearing to L_{∞} or hence discarded from calculation. Goodness of the fit to the descending right limb limits of the catch curve was considered.

The correlation coefficient for the regression was 0.86 ($a = 15.68$). The natural mortality rate was estimated from the empirical equation. Pauly (1980) suggested that this method gives reasonable value of M . This method of

estimating M is widely used throughout the tropics where time series reliable catch and effort data and several years of Z values are not available. So the described method is the common procedure to estimate the M and F . The fishing mortality rate F was derived by subtracting M from Z and was found to be 0.73.

Recruitment pattern

The recruitment pattern (Fig. 6) shows that this species was recruited in the fishery with peaks in June and September. The breeding period of *M. malcolmsonii* extends over a period of eight months from April to November. There are at least two peaks spawning once in June and again August/October. Intensive breeding commences immediately after the first heavy rains. The smallest sizes of 3.7 and 4.7 cm among males and females appear in the commercial catches during the months of June to November (Ibrahim 1962). The recruitment in the present study also shows a similar pattern.

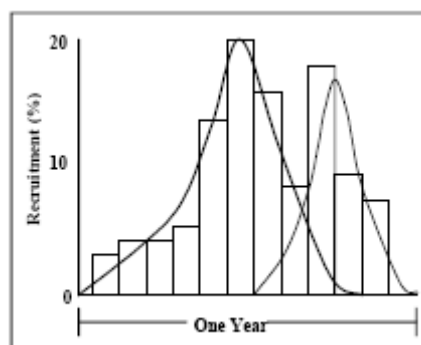


Figure 6. Recruitment pattern of *Macrobrachium malcolmsonii* in Wyra reservoir in India

The recruitment in the pre-

Virtual Population Analysis

The results of length structured VPA of *M. malcolmsonii* are shown in figure 7. The values for the mean fishing mortality and the mean exploitation rate (E) estimated by the analysis were 0.69 and 0.31, respectively. The estimated values for the exploitation rate (E) using length converted catch curve and VPA were 0.33 and 0.31, respectively.

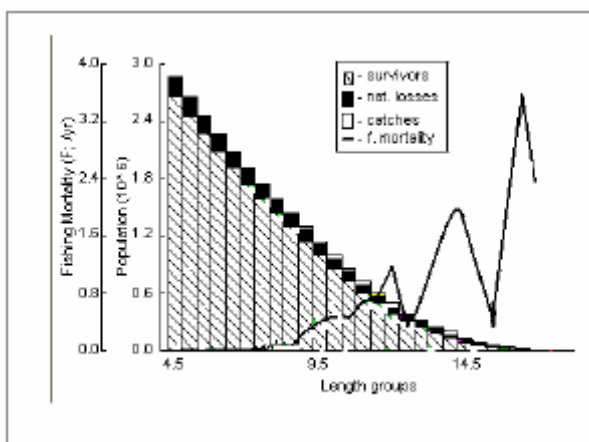


Figure 7. Length structured Virtual Population Analysis of *Macrobrachium malcolmsonii* in Wyra reservoir in India

This indicates that *M. malcolmsonii* is not fully exploited. Results of the length structured VPA indicated three peaks of fishing mortality (F). The highest peak of F occurs at the length range between 16.0 and 17.0 cm, the second peak occurs in the length range between 14.0 and 15.0 cm, and the third peak at the range between 11.5 and 12.5 cm (Fig. 7).

Yield per recruit and biomass per recruit

The relative yield per recruit and biomass per recruit were determined as a function of L_c/L_∞ and M/K were 0.23 and 1.0, respectively. Figure 8 shows that the present exploitation rate ($E=0.32$) The expected yield at different levels of fishing mortality shows that the yield increases with increased F suggesting that the yield can be increased by enhancing the effort up to an E value of 0.48. Though it is possible to enhance the yield by increasing effort, the increment in yield will not be remunerative beyond an E value of 0.41. Though the exploitation rate can be increased one and a half fold than the present rate to reach the maximum sustainable yield it would be ideal to exploit till an E value of 0.41 which is the most economical for *M. malcolmsonii* fishery at the Wyra reservoir.

It is recommended that the fishing days in this fishery be further reduced particularly during the breeding period to enable more females to breed. Two peaks of reproduction were identified for the species (June and again August/October). Therefore, a closure of the fishery, recommended

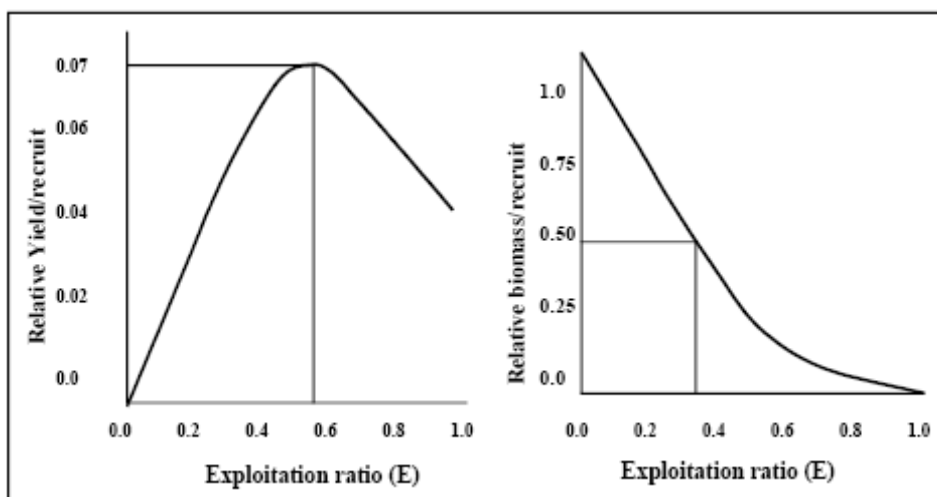


Figure 8. Relative yield per recruit (left) and biomass per recruit (right) of *Macrobrachium malcolmsonii* in Wyra reservoir, India

here, should be implemented within the reproductive period. Also, return of egg-bearing females into the waters during the peak of reproduction should be adopted, and the fishermen should be encouraged to cooperate with this management option.

Acknowledgements

We wish to thank Dr. K.K. Vass, Director, Central Inland Fisheries Research Institute, Barrackpore, India for his support and encouragement. We would like to thank the technical officer and supporting staff of Eluru Research Center of Central Inland Fisheries Research Institute, Andhra Pradesh, India for their assistance in fish sampling. We are also thankful to the anonymous reviewers for their valuable suggestions.

References

- Beverton, R.J.H. and S.J. Holt. 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. *Rapports et proces-verbaux des Reunion Conseil International pour l'Exploration de la Mer* 140:67-83.

- Chopra, B.N. 1939. Some food prawns and crabs of India and their fisheries. Journal of Bombay Natural History Society 41(2).
- FAO. 1981. Methods of collecting and analysing size and age data for fish stock assessment. FAO Fisheries Circular 736. 100p.
- Gayanilo, F.C.Jr., P. Sparre and D. Pauly. 1995. FAO-ICLARM Stock Assessment Tools (FiSAT) User's Manual FAO Comp. Information Series (Fisheries) 8. 126p.
- Gopalakrishnayya, C., A.K. Das, M. Ramakrishniah and P.K. Sukumaran. 1998. Ecology and Fisheries of selected Reservoirs of Andhra Pradesh. Central Inland Fisheries Research Institute Bulletin No. 85. 39p.
- Gulland, J.A. 1971. Estimation of mortality rates. Annexe to Arctic fisheries working group report. ICES, C.M. Gadoid Fish, Community 3. 9 p. (mimeogr.).
- Henderson, J.R. and G. Mathai. 1910. On certain species of Palaemon from South India Records of Indian Museum 5(18).
- Ibrahim, K.H. 1962. Observations on the fishery and biology of the freshwater prawn (*Macrobrachium malcolmsonii*) Milne Edwards of River Godavari 9(2):433-467.
- Kemp, S. 1915. Fauna of Chilka Lake, Crustacea Decapoda. Memoirs of Indian Museum V:200-325.
- Panikkar, P. and M.F. Khan. 2008. Comparative mass-balanced trophic models to assess the impact of environmental management measures in a tropical reservoir ecosystem. Ecological Modeling 212:280-291.
- Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. Journal du Conseil. Conseil International Exploration de la Mer 39 (3): 175-192.
- Pauly, D. 1986. On improving operation and use of the ELEFAN programs. Part II. Improving the estimation of L_{∞} . Fishbyte 4(1):18-20.
- Pauly, D. 1987. A review of the ELEFAN System for analysis of length frequency data in fish and aquatic invertebrates. ICLARM Conference Proceedings 13:7-34?
- Pauly, D. and N. David. 1981. ELEFAN-I BASIC program for the objective extraction of growth parameters from length frequency data. Meeresforsch 28(4):205-211.
- Pauly, D and J.L. Munro. 1984. Once more on the composition of growth in fish and invertebrates. Fishbyte 2(1):21.
- Pauly, D. and M.L. Soriano. 1986. Some practical extensions to Beverton and Holt's relative yield-per-recruit model. In: The First Asian Fisheries Forum (ed. J.L. Maclean, L.B. Dizon and L.V. Hosillo), pp. 491-496. Asian Fisheries Society, Manila, Philippines.
- Pauly D., J. Ingles and R. Neal. 1984. Application to shrimps of objective methods for the estimation of growth, mortality and recruitment parameters from length-frequency data. (ELEFAN I and II). In: Penaeid shrimps – Their Biology and Management. (ed. J.A. Gulland and B. Rothschild), pp. 220–234. Fishing News Books, UK.
- Sparre, P. and S.C. Venema. 1992. Introduction to tropical fish stock assessment, Part I Manual. FAO Fisheries Technical Paper (306.1) Review 1. 376p.
- Wetherall, J.A. 1986. A new method for estimating growth and mortality parameters from length-frequency data. Fishbyte 4(1):12-15.