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Assessment of population parameters of Indian major carps and common carp in a culture based reservoir

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ABSTRACT

Length frequency data of fin clipped Indian major carps and common carp stocked in Thirumoorthy Reservoir (388 ha at full rreservoir level), Tamil Nadu were analysed by using ELEFAN to estimate the von Bertalanffy growth parameters and mortality rates. The high values of growth coefficient (K > 0.845) and asymptotic length (L_∞> 567.5 mm) estimated for these fishes indicated the effectiveness of the stocking density at the rate of 395 no. /ha in this culture based fisheries system. The lower natural mortality rate describes the higher survival rate of advanced fingerlings of >100 mm size. Based on the recapture rate of stocked fishes, the strategies for optimum stocking to be adopted in the reservoir have been analysed.

Keywords: Common carp, Growth parameters, Indian major carps, Mortality, Stocking density

Introduction

Culture based fisheries are capture fisheries which are mostly or entirely maintained by the regular stocking of seed fish. Culture based fisheries rely entirely on the natural productivity of the water for growth, and on artificial stocking for recruitment (Lorenzen, 1995). This system is being operated in Thirumoorthy Reservoir for many years and since then the Indian major carps (IMC) are regularly stocked in this reservoir where there is no natural recruitment for these species. Thirumoorthy Reservoir with a water spread area of 388 ha at full reservoir level and 234 ha at average storage level is located at 10° 28’ N and 77° 09’ E in Coimbatore District of Tamil Nadu, India.

In earlier age structured fisheries assessment models, stocking was effected through a stock recruitment relationship, while mortality, growth and reproductive parameters in the recruited population are assumed to be density independent (Hilborn and Walters, 1992). But later, Lorenzen (1996, 2008) has reported from several studies that density dependent growth is a common and important mechanism in the regulation of fish population and optimisation of production. The present study analyses the population dynamics of major carps and common carp cultured in Thirumoorthy Reservoir. In developing culture based fishery, it is important to optimize the stocking density and to harvest at the minimum marketable size in a balanced way to obtain maximum production and therefore the population dynamics of stocked fishes were studied through the recapture of fin clipped fishes.

Materials and methods

A total of 14,315 numbers of fin clipped *Catla catla, Cirrihinus mrigala, Labeo rohita* and *Cyprinus carpio* var. *communis* were artificially recruited into the reservoir. The details of the date of release and the recapture period are given in Table 1.

The length frequency data were collected using monofilament gillnets of 100 – 180 mm mesh size through recapturing fin clipped fishes belonging to single cohort. The mean length of stocked fishes varied from 85.1 to 107.8 mm. Total length and weight of recaptured fishes were measured by standard methods (Sparre and Venema, 1992).

Table 1. Details of release and recapture of fin clipped fishes recruited into Thirumoorthy Reservoir

Species	Date of release	Av. initial length (mm)	Av. initial weight (g)	No. stocked	No. recovered	Recovery (%)	Recapture period from the time of release (months)
Catla	14.12.93	94.5	12.0	3172	1370	43.2	34
Rohu	02.07.93	107.4	14.1	2302	133	5.8	42
Mrigal	04.05.93	107.8	10.0	4659	1365	29.3	43
Common carp	31.03.93	85.1	8.8	4182	1153	27.6	42

The data were pooled month wise and grouped into classes of 50 mm intervals using MS ACCESS software. Asymptotic length (L_∞) and growth coefficient (K) of the VBGF equation were estimated by means of ELEFAN-II (Pauly and David, 1981). The FiSAT software was used to compute the growth performance of stocked fishes (Z/K).

Total mortality (Z) was estimated using the length converted catch curve method as explained in ELEFFAN II. Natural mortality rate was estimated using Pauly's empirical relationship (Pauly, 1980):

$$\text{Log}_{10} M = -0.0066 - 0.279 \, \text{Log}_{10} L_\infty + 0.6543 \, \text{Log}_{10} K + 0.4643 \, \text{Log}_{10} T$$

where L_∞ is expressed in mm and T is the mean annual environmental temperature which was 28 ^{o}C in the present case. Fishing mortality (F) was obtained by subtracting M from Z and exploitation rate (E) was obtained from E = F/Z = F/(F+M) (Gulland, 1971). The length–weight relationship has been reported for these major carps and common carp by Selvaraj *et al.* (2000).

Results and discussion

Growth parameters

The estimated population parameters are given in Table 2. The L_∞ value was the highest for *C. catla* (943.0 mm) followed by *C. mrigala* (710 mm), *C. carpio* (587 mm) and *L. rohita* (565 mm). Ahmed *et al.* (2003) estimated L_∞ values ranging from 919.5 to 936.8 mm for catla in Kaptai Lake where *C. catla* fishery is sustained with natural recruitment and supplemental stocking. The L_∞ values for *C. catla* reported in Govindgarh Lake (Shreeprakash and Gupta, 1986) and River Yamuna (Natarajan and Jhingran, 1963) were 1150 mm and 1280 mm respectively. Lorenzen and Enberg (2002) have described in their model that the asymptotic length (L_α) is a linear declining function of population biomass density. It is evident that the asymptotic length for *C. catla* decrease in the Thirumoorthy Reservoir where stocking density is maintained high compared to the open unmanaged reservoirs and rivers. The asymptotic length of catla in the present study has not significantly declined from the reported values mentioned above, which calls for further enhancement in the proportion of stocking density of this species.

The length frequency pattern for different quarters commencing from the quarter of first recapture for catla, mrigal, rohu and common carp are depicted in Fig. 1-4 respectively. The age at first recapture for catla, common carp, mrigal and rohu were 5th, 4th, 13th and 14th month after their release into the reservoir. The mean length and weight of catla were 381.2 mm and 800 g on first recapture (5th month). This species attained an ideal marketable size of more than 1 kg in weight by 6th month. The maximum number of catla recovered were in the length interval of 441 - 490 mm during the 2nd quarter and 491 - 540 mm in the 3rd quarter, which indicates that the fish of the younger age groups grew more rapidly to the harvesting size (Fig. 1).

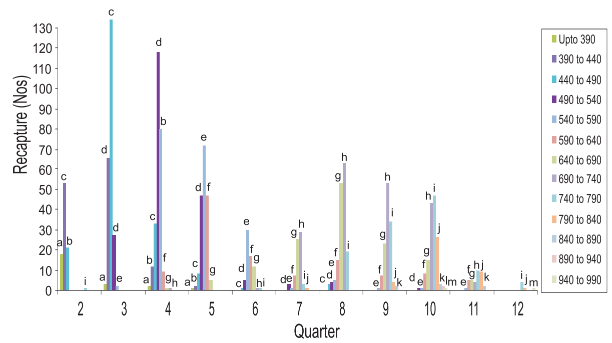

Fig. 1. Length frequency pattern of catla

The asymptotic length of *C. mrigala* has been reported as 771 mm from Govindgarh Lake, 1060 mm in River Ganga and 1400 mm in River Godavary (Froese and Pauly, 2000) which also explains that the asymptotic length is higher in low population biomass. However, the growth performance of mrigal was poor in this reservoir as length and weight attained was only 425 mm and 700 g respectively at first capture (13th month) after stocking, where yearly crops of individuals weighing approximately 1 kg is preferred. At the end of the 2nd year from the release, the species reached an average length of 532.7 mm and weight of 1555 g.

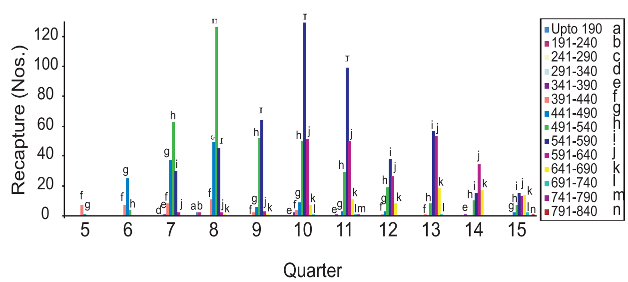

Fig. 2. Length frequency pattern of mrigal

For *L. rohita,* the L_∞ has been reported as 912 mm in Govindgarh Lake (Shreeprakash and Gupta, 1986) and 1020 mm in Aligarh waters in India (Khan and Siddqui, 1973). Very low recovery was recorded for the species till the 9th quarter (Fig. 3). The first marked specimen of rohu was recaptured during the 14th month of free life period and the fish had attained a total length of 382 mm.

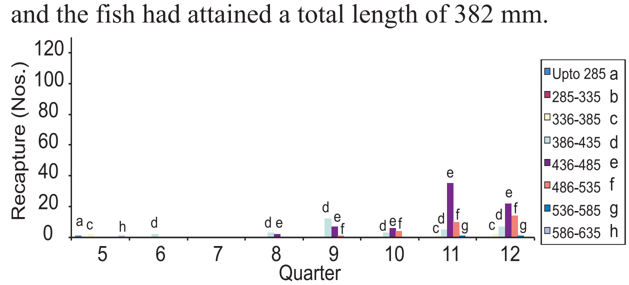

Fig. 3. Length frequency pattern of rohu

The first recapture of common carp after stocking was in the 4th month of its free life span. They measured an average weight of 325.5 mm and length of 664.4 g. Various studies reported high values of L_α for common carp ranging from 748 to 1230 mm in many lakes (Froese and Pauly, 2000) than the present observation. Much of the recovery was restricted in the first two quarters after the commencement of recapture (Fig. 4).

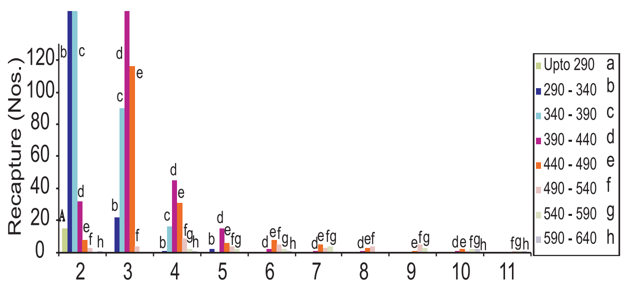

Fig. 4. Length frequency pattern of common carp

The growth coefficient (K) value for *C. catla* and other fishes ranged from 0.845 to 0.959 indicating the stocking numbers of fingerlings of this reservoir is good so as to utilize the biological productivity of the reservoir. The K value for catla (0.324), mrigal (0.084) and rohu (0.382) reported in Govindgarh lake is very low compared to the present study. Several other studies have also reported very low values for mrigal, rohu and common carp in reservoirs and lakes (Froese and Pauly, 2000) compared to the values obtained in the present study. The growth performance index in the Thirumoorthy Reservoir is excellent for the entire stocked species (Table 2) recording more than 5.0 compared to their respective performances in the other reported investigations (Froese and Pauly, 2000).

Mortality

The Z value for stocked fishes in Thirumoorthy Reservoir was calculated using length converted catch curve. The total mortality value (Z) was high for catla (3.230) compared to other stocked species in this reservoir. The fishing mortality is also higher than the natural mortality showing the fish catch is significantly higher particularly for catla. In the present study, the fishing mortality recorded was higher than the natural mortality for all the species except for rohu which indicates that all these species are harvested at maximum levels Rohu showed natural mortality slightly higher than fishing mortality (Table 2).

Exploitation rate

The exploitation rate (E) was estimated using the Gulland's (1971) equation E = F/Z. The rate of exploitation for catla (0.805) is higher than mrigal and common carp. The latter two species also recorded higher than 0.5, which is considered being ideal for exploitation in marine ecosystems and above which indicates high fishing pressure. In culture based fishery ecosystems, the fishes are harvested in proportion to stocking. Lorenzen (1995) has stated that the recapture rate of fishes depend on the stocking density. At very low stocking densities, the recapture rate is higher (about 30%) due to the fast growth of individuals. In the present observation, the recapture rate for catla is 43.2% indicating that catla was stocked at low density and its stocking density can still be increased. The recapture rate is much lower (about 15%) in the region of optimal stocking density, and declines further when the fishery is overstocked. Rohu registered recapture rate of 5.8% which shows that the species is overstocked. However, the overall optimum production is reached when the recapture rate and the consequent return per seed fish are at an intermediate level. The recapture percentage for mrigal (29.3%) and common carp (27.6%) indicated their stocking density as optimum.

The growth curves for catla, mrigal, rohu and common carp using the estimated values of the growth equation are presented in Fig. 5. It can be seen that the growth is rapid in the initial quarter and is slower in the subsequent quarters. The recommended harvestable length and period for carps drawn from VBGF model is given in Table 3. Beyond these lengths the growth of carps was marginal.

Table 2. Population parameters of stocked fishes in Thirumoorthy Reservoir

Parameters	Catla	Common carp	Mrigal	Rohu
Growth coefficient (K/yr)	0.959	0.958	0.845	0.924
Asymptotic length (L_∞)	943.03	586.66	710.00	564.53
t_o	-0.51	-0.95	-0.05	-0.08
Total mortality	3.230	2.120	2.100	1.290
Natural mortality	0.629	0.708	0.627	0.718
Fishing mortality	2.601	1.412	1.473	0.572
Exploitation rate (E) = (F/Z)	0.805	0.663	0.701	0.447
Growth performance index (Ø)	5.931	5.518	5.629	5.469
Sample size	1370	1128	1365	133
Length at first capture (mm)	381	326	317	274
Age at first capture (months)	5	4	13	14
Weight at first capture (g)	800	664	700	550

Table 3. Parameters deciding harvestable size

Parameters	Catla	Common carp	Mrigal	Rohu
Harvestable max. length (mm)	720	490	415	380
Harvestable max. size (kg)	5.3	1.4	1.3	0.750
Harvestable period (quarter)	3	3	4	4

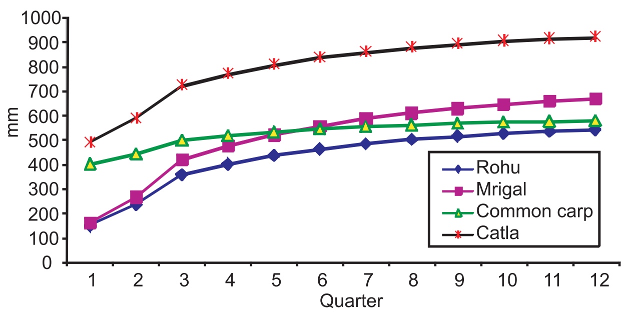

Fig. 5. Growth curve for carps with different curvature parameters

The maximal biomass harvested from this reservoir was 182.1 kg ha^{-1} y^{-1}, at a stocking density of 395 individuals ha^{-1} y^{-1} (Selvaraj *et al.,* 2000) at a gear selection length of 100 mm. The present analysis clearly indicated that in developing culture based fisheries, increasing the share of *C. catla* seeds during stocking would certainly increase the production at this particular gear selection length.

The assessment of population parameters revealed that the fishery of *C. catla* in this reservoir is good but the asymptotic length has not reduced significantly thus showing scope for increasing the stocking density. In the case of *C. carpio* and *L. rohita,* the present stocking density appeared to be close to being optimum. However, recapture of rohu is very poor, discouraging additional stocking; rather reducing the stocking density would avoid incurring monetary loss. But for mrigal, the present stocking density is suboptimal but the minimum harvestable size takes more than one year. Hence increasing the stocking density of mrigal will further delay the minimum harvesting size.

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