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Original Article

Stock assessment and reproductive biology of *Puntius sarana* (Hamilton, 1822) in Tamiraparani River basin of south Tamilnadu, India

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Abstract

Length weight frequency data were collected on weekly intervals for studying the length frequency analysis, species composition, catch and effort and reproductive biological aspects of *puntius sarana* in Tamiraparani riverine system (8° 42'N and 77.15° 24'E) of Western Ghats of India. The estimated b and z value was found 2.246 and 1.16 respectively. As per Virtual Population Analysis the maximum fishing mortality occurs at 30.3 cm. Reasonable fishing mortality started from 22.8 cm. The maximum steady state biomass was observed in the size group of 21.3 cm. The catch per unit effort (CPUE) was found to be high during the month of January and February. The decayed organic matter, algae and sand grains were also recorded in this species. The number of ova was found to vary 34,218 to 43,296 in the size range of 170 mm - 260 mm for *P. sarana*. The length at 50% maturity was estimated was 200 mm in total length for females. We observed that the fecundity was relatively low which indicates that, this species should be exploited carefully. To avoid growth over fishing and conservation of this species, the minimum legal size (MLS) for capture can be fixed below 200 mm for female.

Keywords:- *Puntius sarana*, Fecundity, length at first maturity, catch per unit effort, minimum legal size.

1. Introduction

The Peninsular olive barb (*Puntius sarana)* are small indigenous ornamental fishes occur in large numbers in the Tamiraparani riverine system of Western Ghats of India which is a gold mine of native ornamental fishes. It is used as food fish in Kerala. It belongs to the genus *puntius* which comes under the family Cyprinidae. Of the three recognized species under this genus *P. sarana* is the largest one. *P. filamentosus and P. bimaculatus,* are the other two species which occurs in backwaters of Kerala and in coastal wetlands of Karnataka. They are found in still or slow-moving freshwaters, natural habitats.

The determination of breeding season is an essential part of biological investigations of fishes [1]. Variability in reproductive traits is extremely crucial for the long term viability of any species; as such variations form the base material for natural selection. Among fishes, such variability is also due to large environmental effects. Knowledge of the fecundity of fish is also crucial for appraising the commercial potential, stock study, like history study, practical culture and actual management of the fishery. A clear understanding of the reproductive biology of fishes is of vital importance not only for successful natural fishery management but also for planning aquaculture strategies. Assessment of the breeding habits of *P. filamentosus* in Tamiraparani River was also studied by Arunachalam and Sankaranarayanan [2]. Phukon and biswas [3] studied certain aspects of the reproductive biology of the ornamental fish, *Erethistes pussilus* in different peninsular waters. This Peninsular olive barb, *P. sarana* small indigenous fishes occur in good numbers in the Tamiraparani riverine system. In Bangladesh *P. sarana* reported as critically endangered [4] [5] [6] while in India it has been enlisted as vulnerable as per CAMP report [7]. Considering present status of this species, it is really needed to take some proper initiative to conserve this fish species. Captive breeding is one of the important approaches to promote conservation of any fish species, but to get success in that detail information on reproductive biology of that particular fish species is required. In the present study, an attempt has been made to study the, stock biomass, fecundity and length at first maturity of *P. sarana from* the Tamiraparani riverine system, Western Ghats of India.

2. Materials and methods

The study was carried out during June 2012 to May 2013. Length frequency data of *P. sarana* covering different length groups were collected on weekly intervals from Tamiraparani river basins (Manimutthar, Tirunelveli, Srivaikundam) of south Tamilnadu, India. Specimens were identified as per Talwar & Jhingran [8]. After collection, total lengths (L) were measured with digital caliper (Mitutoyo Corporation, Japan); total body weight (W) of individual fish was measured to the nearest 0.001 g using an electronic balance (Meller Toledo, Switzerland).

2.1. Stock assessment

Length frequency data were collected on weekly intervals for studying the length frequency analysis, species composition, and catch and effort. Since there was no external sexual dimorphism in these two species, data were not collected sex wise. A total of 450 specimens of *P. sarana* specimens were collected from the Tamiraparani river basins.The length weight relationship (LWR) was estimated using the equation given by Le Cren [9] $W = a L^b$, where, a = proportionality constant, b = growth exponent, W = weight (g) and L = length (mm). A logarithmic transformation was used to make the relationship linear (Log W = log a + b log L).

2.2. Length - Frequency analysis (Age and Growth)

Age and growth were assessed using the FiSAT computer software [10]. The $L\infty$ and K values were analysed by non - parametric scoring of VBGF fit using ELEFAN-I. The length frequency data were subjected to model progression technique by splitting the modes using Bhattacharya's analysis followed by linking of the means. The seasonality of growth was confirmed using Apeldoorn's method in FiSAT software.

2.3. Estimation of Mortality parameters

The total mortality rate (Z) was estimated by length converted catch curve method using FiSAT. The natural mortality (M) was estimated by Pauly's equation [11] considering the mean annual habitat temperature, $L\infty$ (asymptotic length) and K (curvature parameter) of *E. suratensis* and *P. sarana*. The co - efficient of fishing mortality (F) was derived using the relationship Z = F + M. The length structured VPA of FiSAT was used to find out the size of each length group *P. sarana* with their natural mortality and fishing mortality. Recruitment pulses of *P. sarana* were analysed from the length frequency data using FiSAT. The total stock (Y/U) and the annual stock (Y/F) were estimated for *P. sarana* using annual catch (Y). The exploitation rate (U) was estimated using the equation $U = F/Z (1-e^{-z})$ [12]. The MSY was estimated using the equation MSY = Z (Y/F) 0.5 described by Gulland [13].The optimum relative yield per recruit of *P. sarana* was estimated using FiSAT. Yield isopleth diagrams of *P. sarana* were derived by feeding M/K and Lc values as inputs in FiSAT.

To assess the standing stock, total annual stock, maximum sustainable yield (MSY) and to optimize the effort, catch and effort data were collected during the study period. The catches of *P. sarana* were recorded in a fishing day and were multiplied with effort made in hours in the day of observation to obtain the daily estimates. The daily catch estimates were used to estimate the monthly mean catch, which was multiplied by the number of fishing days of the corresponding month to obtain the monthly catch. Total effort in fishing days was estimated by multiplying the mean monthly effort.

2.4. Food and feeding

A total of 125, specimens of *P. sarana* were collected to analyse the gut contents to understand their food and feeding habits. Special attention was given to the regurgitation problem. During sampling, freshly caught fish with empty stomach was shrunken and contained only mucus whilest some other stomach loosely expanded and empty. The latter ones were considered as regurgitated ones [14] and such stomachs were not included in the present study. For evaluating the different food organisms, the occurrence method [15] was followed. Decayed organic matter, sand and mud were assessed by "Eye estimation method". The other food items were analysed by using as microscope. The various food items present in the stomach of *P. sarana* was expressed in terms of percentage.

2.5. Fecundity

The relationship between fecundity and total length was studied. The fecundity was estimated in matured specimens of size ranging in length group of 170 mm to 260 mm for *P. sarana* from 11 species. The Fecundity was estimated by manually counting the number of ova in the matured individuals. The fecundity length relationship was calculated by the least square method after converting the total length and number in to log scale.

2.6. Size at first maturity

The total length of each specimen was recorded to study the size at first maturity. Two groupings were taken viz., (i) immature and maturing group and (ii) matured, spent, spent recovering group. The maturity stages of the fishes were determined based on colour, shape, size and the microscopic structure of the fresh ovary. The class interval used was 1cm for the estimation. From this, the percentage occurrence of mature specimens was calculated and plotted against the length groups. The length groups at which 50 % of the *P. sarana* attained maturity was considered as length at first maturity.

3. Results and discussion

3.1. Length - Weight relationship

The parabolic and logarithmic linear relationship equation between the length and weight for *P. sarana* was presented in Fig.1. The 'b' value of *P. sarana* was found 2.246. The

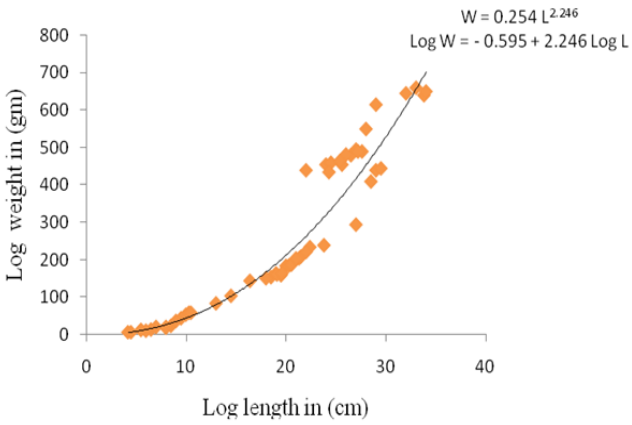

Fig. 1. Length - Weight relationship of *P. sarana* calculated

Table 1. Growth and Mortality parameters of *P. sarana*

Growth parameter		Mortality parameter	
Asymptotic length L∞ (cm)	40.8	Natural mortality (M)	0.91
Growth coefficient (K)	0.49	Fishing mortality (F)	0.24
M/K	1.86	Total instantaneous mortality (Z)	1.16
t_0	-0.53	Exploitation ratio (E = F/Z)	0.21

Table 2. Stock and the Optimum effort for the exploitation of *P. sarana*

Stock assessment		Optimum effort for the exploitation	
Annual catch (Y) (kg)	28899.95	Catch (Kg)	29449.97
Exploitation rate (U)	0.07	MSY (kg)	81805.47
Total stock (Y/U)	412856.42	Difference between Catch and MSY (kg)	52355.502 (Less)
Annual stock (Y/F) (kg)	120416.458	Present effort (fishing days)	229
(E = F / Z)	0.21	CPUE (kg)	126.200
Status	Less exploited	Fishing days to increased or decreased to achieve MSY	148 (Less)
		% of increase or decrease in effort to achieve MSY	62.08 (Increase)

'b' value was estimated to be < 3 which indicates relatively lesser weight in relation to increment in length. The slope value calculated presently for this species is within the limits of most fishes [16]. According to Pauly [11], the change of slope value depends on primarily on the shape and patterns of species and also upon various factors like temperature, salinity, food and habitat.

3.2. Age and growth

The von Bertalanffy's Growth Function plot and the growth curves of *P. sarana* were represented in Fig. 2 and 3 respectively. The maximum life span was found 6 years.

The estimated growth and mortality parameters of *P. sarana* are shown in Table.1. The generalized von Bertalanffy's growth equation was found $L(t) = 40.8\ \{1-_{exp} - 0.49\ (t - 0.53)\}$. The estimated 'Z' value by length converted catch curve method 1.16 (Fig. 3). The result of the length structured virtual population analysis (VPA) employed to recognize the level of mortality on various length groups are shown in Fig. 4. As per VPA the maximum fishing mortality occurs at 30.3 cm. Reasonable fishing mortality started from 22.8 cm. The maximum steady state biomass was observed in the size group of 21.3 cm. Generally, a high M/K value indicates that animal concerned are mostly stress in due to high metabolic rate and fast growth rate ultimately leading to a high natural mortality. The estimated M/K value was 1.86 indicating lower stress. The observed less M/K value for *P. sarana* may also be due to less natural mortality which might be due to natural food availability in this freshwater riverine system compared to *P. bimaculatus* in Sri Lankan riverine system [17]. The fishing mortality was found to be < 1 for the species up to 2 cm, and increase at higher length groups. This may be due to vulnerability of maturing and mature fishes to the cast net. The recruits were recorded throughout the year with peak in May and August. The stock (annual catch, total stock, annual stock) and the exploitation parameters (MSY, f_{MSY} exploitation ratio) were estimated (table 2) and the present effort could be increased to 62.08 % with the f_{MSY} as 148 fishing days. The recruitment pattern analysis by using length frequency data

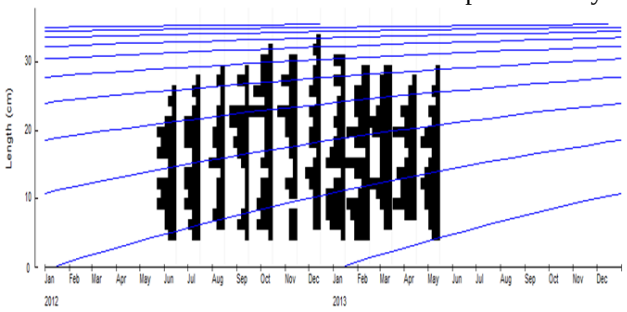

Fig. 2. von Bertalanffy' growth function plot of *P. sarana*

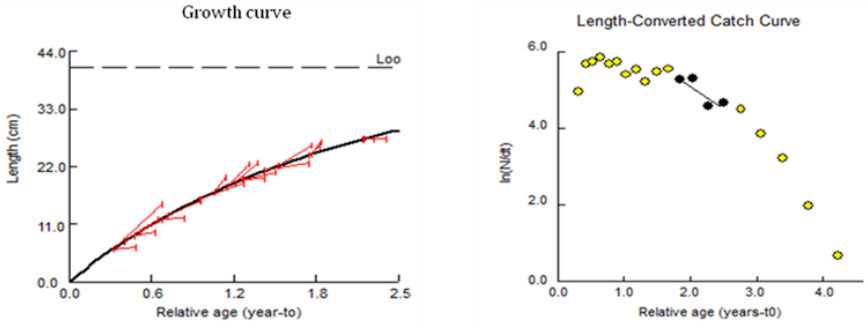

Fig. 3. Growth curve and Length converted catch curve of *P. sarana*

Table 3. Average catch, effort and CPUE of *P. sarana* landed from Tamiraparani riverine System

Month	Total catch	Fishing days	Catch per unit effort
June (2012)	1333.33	14	95.23786
July	1633.33	17	96.07824
August	1850	18	102.7778
September	1616.66	15	107.7773
October	1783.33	18	99.07389
November	1983.33	19	104.3858
December	3516.66	24	146.5275
January(2013)	**3266.66**	**23**	**148.4845**
February	**2733.33**	**18**	**151.8517**
March	2816.66	19	148.2453
April	3216.66	23	139.8548
May	3150	21	150
TOTAL	**28899.95**	**229**	**1490.295**

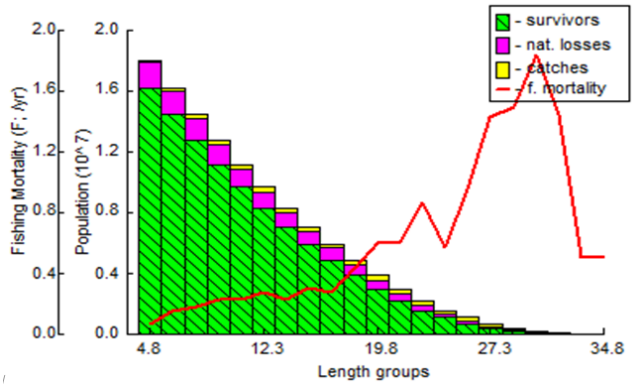

Fig. 4. Length structured Virtual Population Analysis of *P. sarana*

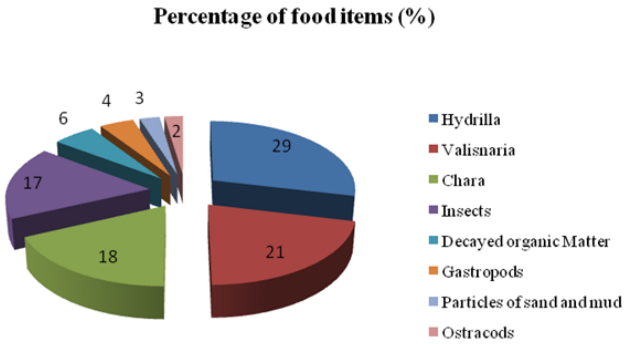

Fig. 5. Gut contents of *P. sarana*

revealed a minor May and major in August for *P. sarana*. This species spawn throughout the year, confirmed with availability of recruits around the year. The peak season for this species coincides with monsoon season.

Yield isopleth is one of the prediction tools in stock assessment studies. By using yield isopleths, one can get an idea about the present level of yield per recruit with various possible combinations of exploitation rate and gear (L50/L∞). From the L50/L∞ for the present exploitation ratio of *P. sarana* is 0.367 with the exploitation ratio of 0.21 (Table. 1.) and the value yield at 6.7 g it could be enhanced to 7.8 g by the exploitation ratio 0.5 and L50/L∞. The average catch and CPUE of *P. sarana* landed along the Tamiraparani riverine system are represented in the Table 3. The CPUE was found to be high during the month of January and February.

3.3. Food and feeding

The gut contents of *P. sarana* were presented Fig .5. The algae occurred in major quantities (68.07 %) in the gut content of these species. Insects, gastropods, and small ostrocods, were also recorded in the gut contents. This species feeds mostly on algal items. The decayed organic matter and sand grains were also recorded in this species inferring that they feed occasionally on detritus items which included decomposed sand and clay particles. It feeds on variety of aquatic plants like *Hydrilla*, *Valisneria*, and *Chara*. A similar feeding habit of this species was also observed by David and Rajagopal [18] in Tungabhadra reservoir. It could be observed that most of the cyprinids feed mostly on detritus and filamentous algae and higher aquatic plants and molluscs and insects [19]. Such a food preference was also seen in the *P. sarana* presently. As in *P. vittatus* reported by Geetha *et al.*, [19] the intestine of *P. sarana* was also long and coiled which could be seen in herbivore and planktivore fishes The preferential food habits of *P. sarana* was similar to *P. vittatus* [19].

3.4. Reproductive biology

The number of ova was found to vary from 34,218 to 43,296, in the size range of 170 mm - 260 mm for *P. sarana*. The resultant equation for the relationship between total length and fecundity is Log y -0.076 + 1.95 x, where log 'y' fecundity and log, 'x' is total length in mm. The correlation coefficient between fecundity and total length was found to be 0.97 ($P < 0.001$) *P. sarana* for confirming higher degree of correlation. It could be seen from (Fig. 6.) that no female *P. sarana* was found to be mature at 140 mm TL, but the percentage of mature females increased with the length of the fishes, percentage maturity was found in size groups above 230 mm. The 50 % level in maturity curve which may be taken to represent the mean length at which maturity attained was 200 mm in TL. In the case of male, no specimen was found to be mature in length group 110 mm TL. However, 100 % maturity was registered from 180 mm (TL) onwards (Fig.7.). The 50 % level in curve was 150 mm in TL. Sobhana and Balakrishnan [20]

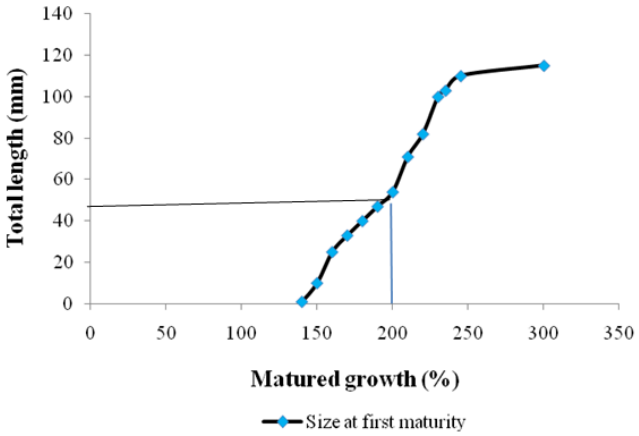

Fig. 6. Length at first maturity of *P. sarana* (Female)

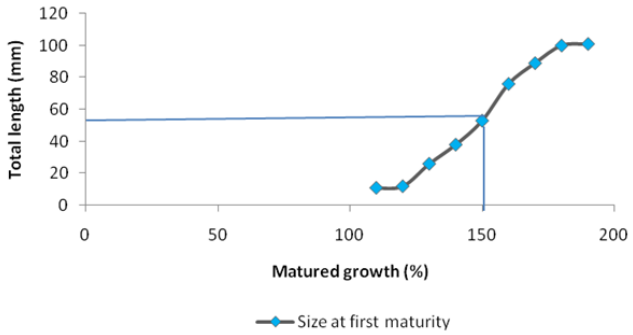

Fig. 7. Length at first maturity of *P. sarana* (Male)

reported that the total number of ova varies from 12,238 to 74,376 (184 mm to 223 mm) for same species. The ecological factors influence the number and size of the egg of the brood fish. In addition to this, change in abundance of food has been considered as most important factors that influence fecundity and various factors like food productivity, rainfall, salinity of water and genetic differences of stock also affect the fecundity of fishes [21]. As observed by Svardson [22] fecundity shows variation even in same population in the same water body in different years. According to Nikolskii, [23] the quantity and quality of food consumed by the parent population also determines not only the fecundity but also the sexual products. Sobhana and Balakrishnan [20] fixed the size at first maturity at 183 mm in Veli lake of Trivandrum coast for *P. sarana*. The size at first maturity observed for different species of the genus for *Puntius* infers that *P. filamentosus* attain maturity at 81 to 118 mm [24]; *P. denisoni* 85 mm for male and 95 mm for female [25] *P. pookodensis* 325 mm for male and 385 mm for female [26]. It could be inferred *P. sarana* that attained maturity at a higher length range compared to *P. filamentosus* and *P. denisoni*. As conclude that relatively lower fecundity indicates this species should be exploited carefully and size below 200 mm for female should be dispensed to avoid growth over fishing.

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Conflict of interests

The author(s) have not declared any Conflict of interests

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