

RERODUCTIVE BIOLOGY AND POPULATION DYNAMICS OF RED SIDE BARB (*PUNTIUS BIMACULATUS*), AN INDIGENOUS CYPRINID IN SRI LANKA.

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ABSTRACT

Reproductive biology and population dynamics of two varieties of red side barb, *Puntius bimaculatus*, an indigenous cyprinid in Sri Lanka which is highly popular in the ornamental fish industry were studied for a period of 12 months. Although breeding of both varieties takes place throughout the year, the main spawning season of the bright orange striped variety (variety I) was found to be March, May and from October to December and that of the uniformly silver coloured variety (variety II) appeared to be December to April indicating that breeding peaks of variety II occur even in the non-rainy season. The mean lengths at maturity for the male and females of both varieties were 4.4 cm and 3.7 cm respectively. Fecundity varied from 182 to 1438 eggs. Significant correlation between fecundity and body size was observed only for the variety II ($P < 0.05$). The asymptotic lengths (L_{∞}) were 6.2 cm and 5.9 cm, Von Bertalanffy growth coefficient (K) were 0.95 year^{-1} and 0.96 year^{-1} , the total mortality coefficient (Z) were 2.68 year^{-1} and 2.95 year^{-1} and the natural mortality coefficient (M) were 2.63 year^{-1} and 2.66 year^{-1} for variety I and II respectively. The exploitation rates, which were less than 0.10, indicate that these populations are not exploited at the optimum level. High values for K and M indicate a high population turnover rate and therefore these populations appear to be capable of withstanding removal of biomass. Therefore, there is a high potential to exploit these populations for the ornamental fish industry. The optimum total lengths at first capture for the varieties I and II were estimated to be 3.7 cm and 3.5 cm respectively.

INTRODUCTION

The red side barb *Puntius bimaculatus*, an indigenous fish in Sri Lanka is highly popular as an ornamental species. It is found throughout the country but is more abundant in the river systems of the wet zone where the annual rainfall is above 2000 mm (De Silva *et al.* 1985). It inhabits different types of aquatic habitats including dry zone rivers, lowland swamps, reservoirs and hill streams. It is one of the fish species found at elevations of $>1500 \text{ m}$ above the mean sea level (Pethiyagoda 1991). It tends to avoid direct sun light (Schut *et al.* 1984) and hides under the stones when disturbed (De Silva *et al.* 1977).

Some aspects of its biology in Sri Lankan streams have already been documented (De Silva *et al.* 1977; 1984; Schut *et al.* 1984; Pethiyagoda 1991). *Puntius bimaculatus* is a substrate feeder mainly feeding on green algae and detritus (Schut *et al.* 1984). When reared in aquaria it readily accepts formulated aquarium feed (Pethiyagoda 1991). The adult *Puntius bimaculatus* has been recorded to migrate upstream with the onset of rains to spawn in shallow marshy areas (Schut *et al.* 1984). Until recently *Puntius bimaculatus* was considered as

a threatened species in the national context (Wijesinghe *et al.* 1993). However, according to most recent evaluation of the conservation status, it is considered as a non - threatened species (IUCN 2000).

Two varieties of this species have been described from Sri Lanka; one with a bright orange coloured lateral stripe (Variety I) and other with a more or less uniform silver colour (Variety II) (Pethiyagoda 1991). Both these varieties are highly popular among hobbyists. The more colourful variety with a bright orange coloured lateral stripe is exported in large numbers for the ornamental fish industry. The present study was carried out to determine whether there are differences in the reproductive biology of the two varieties with a view of making recommendations for their sustainable exploitation.

MATERIALS AND METHODS

The present study was carried out from March 2000 to February 2001 in two sampling sites each in the Kelani river basin and Kalu river basin in the southwestern region of Sri Lanka (Fig. 1). Sampling site 1 was at Parakaduwa ($6^{\circ}50'N$, $80^{\circ}18'E$) in the Kalu river basin and

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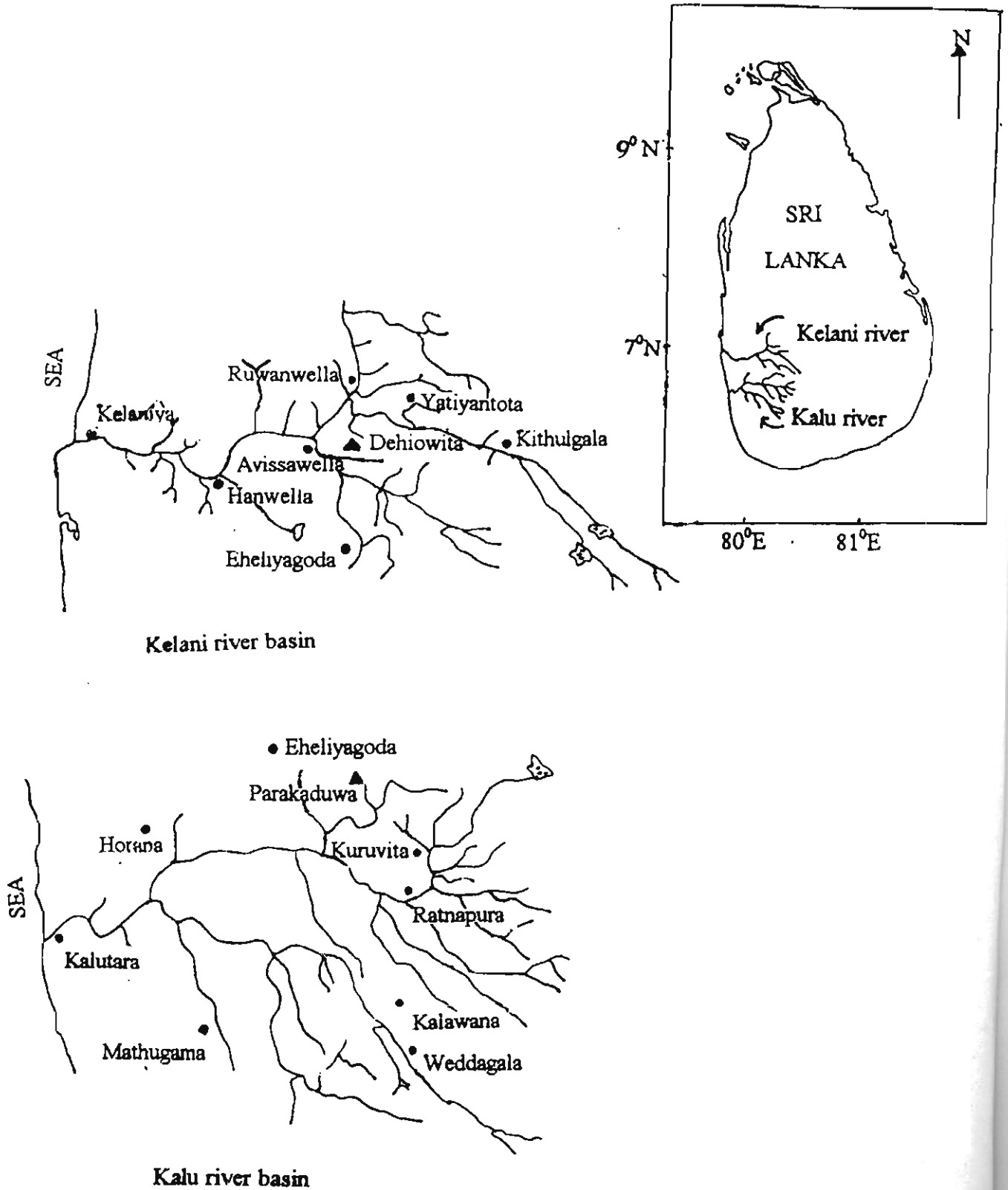


Fig.1: Location of the 2 sampling sites (▲sampling site) Scale 1:1000000

the sampling site 2 was at Dehiowtia ($7^{\circ}00'N$, $80^{\circ}15'E$) in Kelani river basin.

nearest 0.1 mg and the Gonadosomatic Index $\{(weight\ of\ gonads / body\ weight) \times 100\}$ of each fish was determined.

Table 01: Gonadal development stages of *Puntius bimaculatus*. (Modified from Wijeyaratne and Costa 1988)

Development stage	Female	Male
Virgin	Gonads are thread like- Ovaries and testes can not be distinguish from each other	
Developing	Ovaries extend up to 1/3 of the body cavity. Small eggs are visible as granules	Testes extend up to 1/3 of the body cavity. No granules are visible.
Developed	Ovaries extend up to 1/2 of the body cavity. Eggs are larger than those of the developing stage.	Testes extend up to 1/2 of the body cavity. They are uniformly white in colour
Mature	Ovaries extend up to 2/3 of the body cavity. Eggs are round and some are translucent.	Testes extend up to 1/2 of the body cavity. They are creamy white in colour
Spent	Ovaries are empty with few small eggs clumped in various places. Ovaries are shrink and reddish in colour.	Testes are shrunken and reddish in colour.

Both sampling sites were in second order streams in the wet zone of Sri Lanka where the annual rain fall is above 2000 mm. At sampling site 1, stream was 1-1.5 m wide and the maximum depth was 20 cm. The water flow rate was $0.33\ m\ s^{-1}$. At sampling site 2 the stream was 2-3.1m wide and the maximum depth was 35 cm. The water flow rate was $0.36\ m\ s^{-1}$. Both sampling sites were mostly shaded during daytime due to the rubber (*Hevea brasiliensis*) plantations on the borderlands. The shrubs, small trees, bamboo trees and overhanging grass at the banks also contributed to shading.

Sampling was done once a month at each sampling site between 1300 h and 1600 h using a cast net of 1.0 cm stretched mesh and a hand net made up of mosquito netting. The specimens with bright orange lateral stripe (variety I) were collected from the Parakaduwa sampling site while the uniformly silver coloured specimens (variety II) were collected from the Dehiowita sampling site. On each sampling day minimum of 40 individuals from each variety were caught and preserved in 10% formalin and transported to the laboratory. In the laboratory, after determining the total length, standard length and body weight, the fish were dissected open and the gonadal development state was identified using the maturity scale described in Table 1. The percentage of mature individuals in each length group was determined

and the mean total length at maturity was estimated. The gonads were weighed to the

The mature ovaries were preserved in Gilson's fluid and left for one week and the fecundity was estimated by counting the eggs under the optical microscope.

Length frequency data were analyzed using the FiSAT software programme. Asymptotic length (L_{∞}) was estimated using the Gulland's equation (Gulland 1969), i.e., $L_{\infty} = L_{max} / 0.95$ where L_{max} is the length of the largest individual caught, and the Von Bertalanffy growth coefficient (K) was determined by scanning for the highest R_n value in a response surface analysis. The L_{∞} and K value combination, which gave the highest R_n value was considered as the most appropriate for the fish stock analyzed.

The total mortality coefficient was determined using the length converted catch curve method (Sparre and Venema 1992) incorporated in to the FiSAT software package. The natural mortality coefficient was determined using Pauly's empirical formula (Pauly 1980), which was also incorporated in to the FiSAT package. For this analysis, mean annual temperature was considered as $27^{\circ}C$.

The yield per recruit values were estimated using Beverton and Holt's model (Beverton and Holt

1957) incorporated in to the FiSAT software package.

The length converted catch curves for the two varieties are given in Fig. 6.

Table 2: Relationships of fecundity (F) and relative fecundity (RF) to standard length (L in cm) and body weight (W in g). (Values denoted by * are significant at 5% level).

Variety I			Variety II		
Regression equation	n	R	Regression equation	n	r
F = 24 L + 282	17	0.047	F = 1005 L - 3278	20	0.785*
F = 14.5 W + 351	17	0.040	F = 734 W - 588	20	0.918*
RF = -107 L + 659	17	0.500*	RF = -166 L - 468	20	0.644*
RF = 77.3 W + 370	17	0.481*	RF = 4.6 W + 170	20	0.662*
Ln F = 0.52 Ln L + 5.12	17	0.049	Ln F = 7.48 Ln L - 3.93	20	0.849*
Ln F = 0.24 Ln W + 5.72	17	0.112	Ln F = 0.97 Ln W + 5.12	20	0.904*

RESULTS

The percentage abundance of different maturity stages of the two varieties is shown in fig. 2. No individuals of the spawning stage were found during the study period. However, at the Parakaduwa sampling site spent individuals of variety I and were recorded in June and July. High abundance of mature individuals of variety I was recorded in March, May and from October to December and that of variety II were recorded from December to April. During these periods the gonadosomatic index was also high (Fig. 3).

The variation of the percentage of mature individuals with the total length is shown in Fig. 4. Fifty percent of the males and females in the populations of both varieties were found to be mature at a total length of 4.4 cm and 3.7 cm respectively.

The fecundity of *Puntius bimaculatus* was highly variable. In variety I, it varied from 216 to 1100 eggs while in variety II, the range was higher, varying from 182 to 1438 eggs. However, when the relative fecundity was considered, the range of values was higher for variety I (89-611 eggs g⁻¹).

A significant relationship between fecundity and body size was evident only for the variety II ($p < 0.05$). However, a significant relationship between the relative fecundity and body size was found for both varieties (Table 2).

The length frequency distribution of *Puntius bimaculatus* at the two sampling sites with the fitted growth curves are shown in Fig 5. The asymptotic length and growth coefficient for the variety I were 6.2 cm 0.95 year⁻¹ respectively while those for the variety II were 5.90 cm and 0.96 year⁻¹ respectively.

The total mortality coefficient (Z) calculated based on these catch curves were 2.68 year⁻¹ and 2.95 year⁻¹ for the variety I and variety II respectively. These natural mortality coefficients calculated using Pauly's empirical formula were 2.63 year⁻¹ and 2.66 year⁻¹ for the variety I and variety II respectively. These values indicate that fishing mortality of these two populations is very low being 0.05 year⁻¹ for variety I and 0.29 year⁻¹ for variety II. These are only 2% and 10 % of the total mortality coefficients for the variety I and variety II respectively.

The recruitment patterns for the two populations are given in Fig. 7. From this analysis, it is evident that for both varieties there are two recruitment pulses, and first one being the smaller one. In variety I these are separate by six months while in variety II these are separated by four months.

The variations of yield per recruit with exploitation rate and L_{50} / L_{∞} for the variety I and variety II are shown in Figs 8 and 9 respectively. The highest yield per recruit for variety I could be obtained at an exploitation rate of 0.6 and L_{50} / L_{∞} value of 0.6. Thus optimum size at first capture is estimated as (0.6) L_{∞} , which is 3.7 cm. The highest yield per recruit for variety II could be obtained at an exploitation rate of 0.55 and L_{50} / L_{∞} value of 0.6. Therefore, the optimum size at first capture for variety II is estimated as 3.5 cm.

DISCUSSION

Breeding of tropical fresh water fish is found to be either seasonal or continuous with or without peak spawning activities in certain months (Welcomme, 1969; De Silva and Somaratne, 1994). All indigenous cyprinids in Sri Lanka have been found to breed throughout the year with most species having breeding

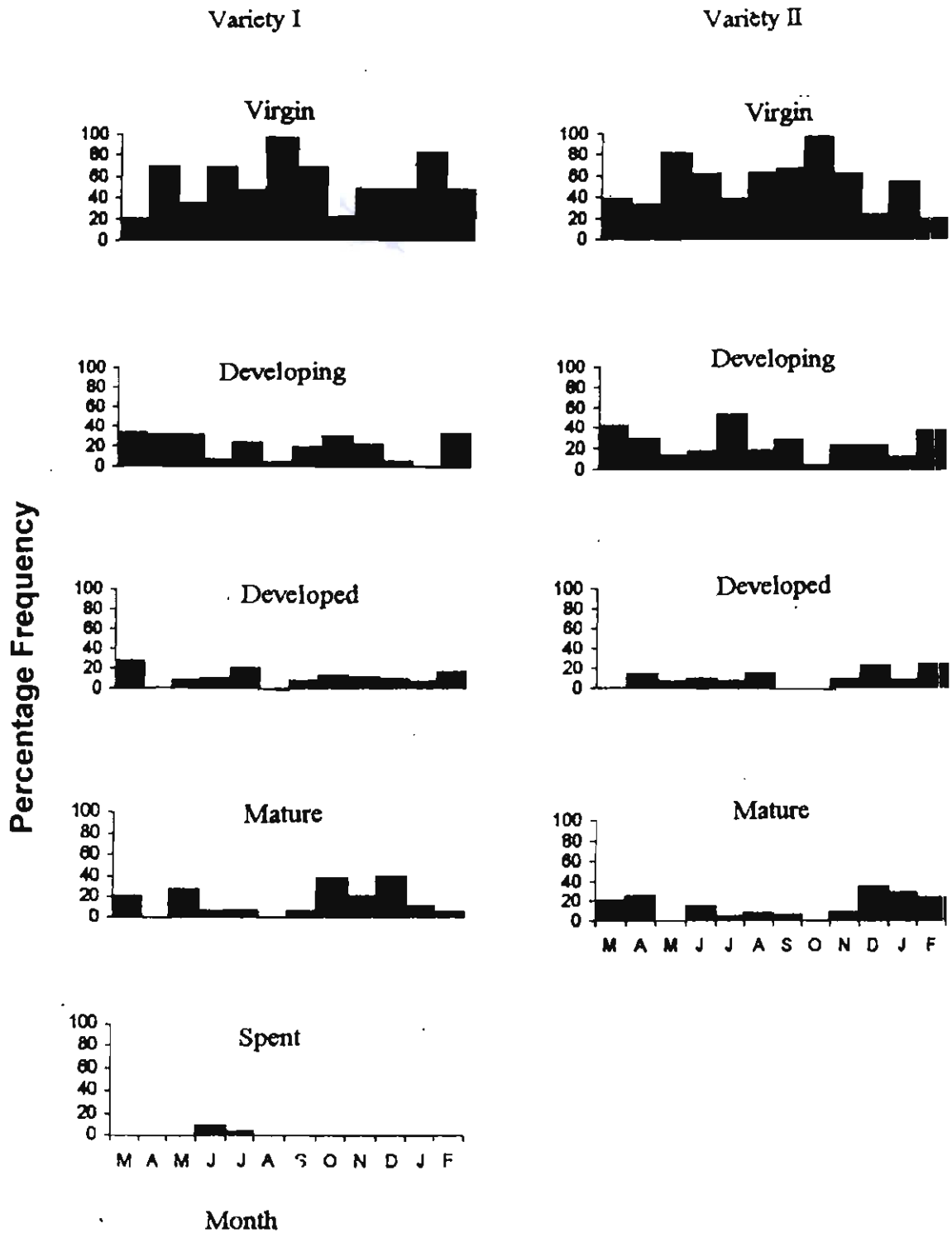


Fig. 2 : Monthly abundance of maturity stages of the two varieties of *Puntius bimaculatus*

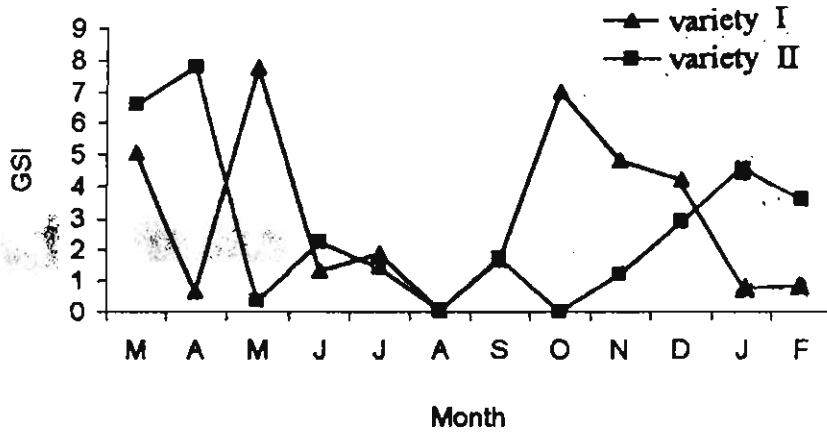


Fig.3: Monthly variation of the Gonadosmatic Index (GSI)

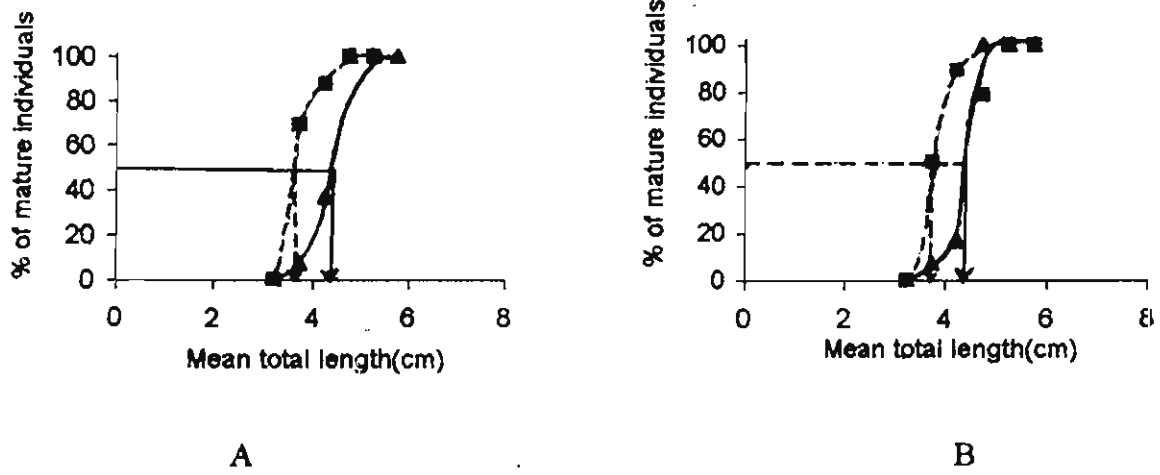


Fig. 4 : Percentage of mature individuals in each size group. (A- Variety I; B- Variety II.)

▲—▲ Male ■—■ Female

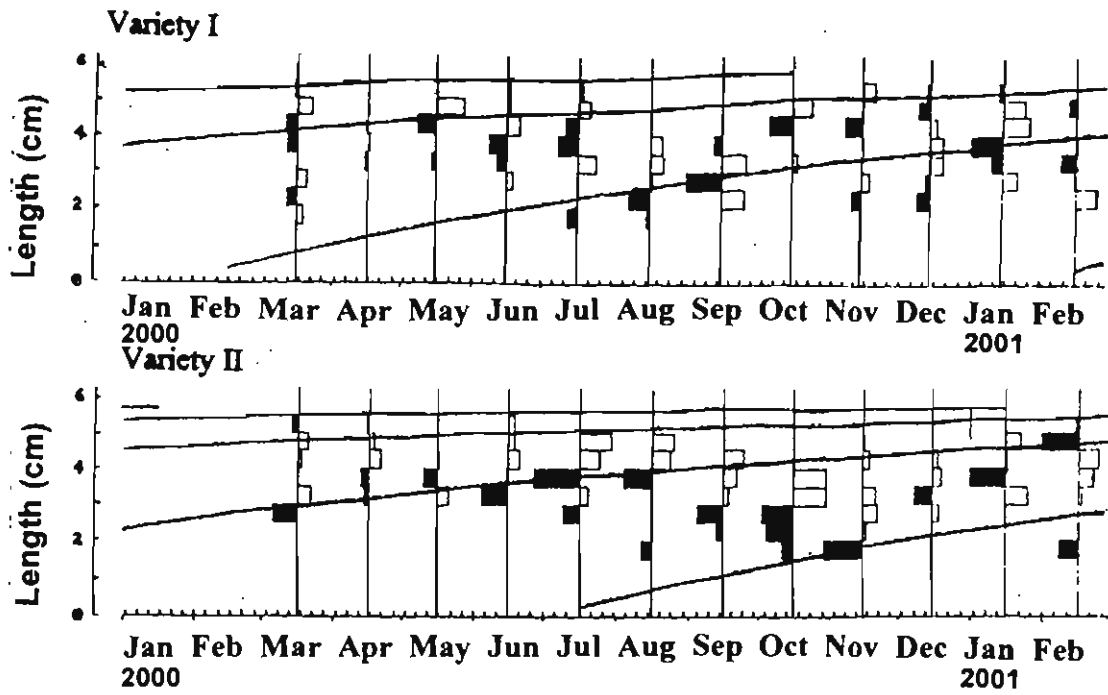


Fig. 5 : Length frequency distribution of *Puntius bimaculatus* at the two sampling sites

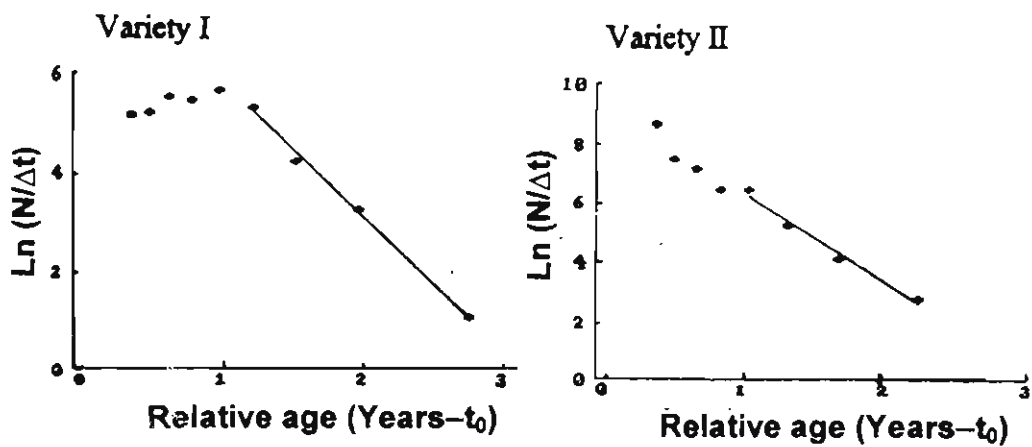


Fig. 6 : Length converted catch curves for the two varieties

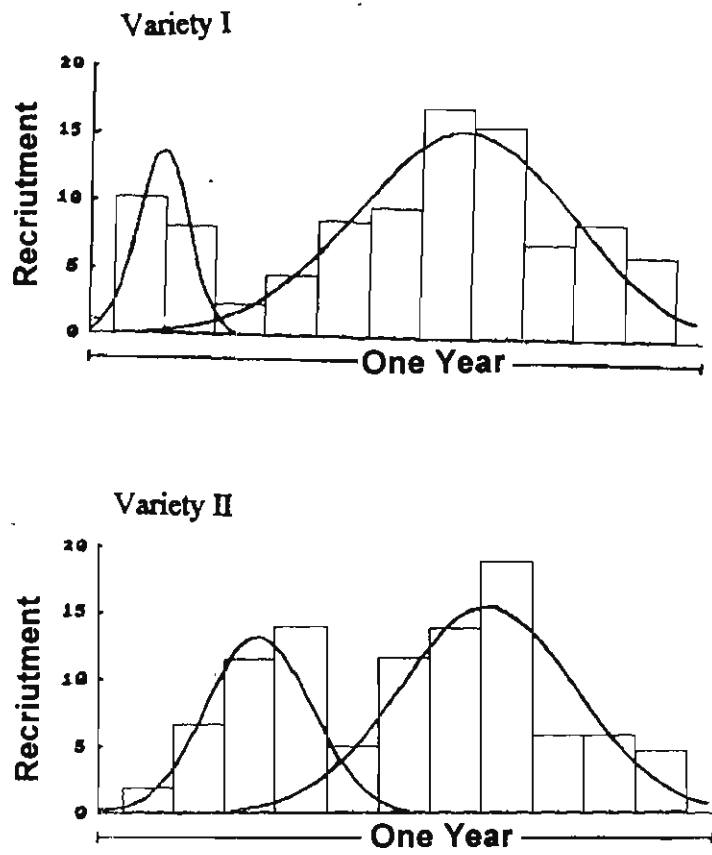


Fig. 7.: Recruitment patterns for two *Puntius bimaculatus* populations

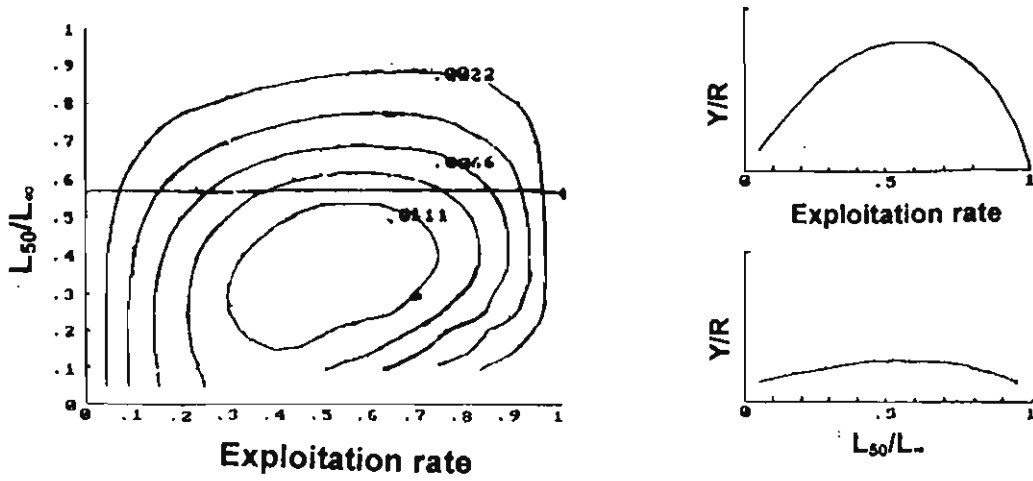


Fig.8: Variation of Yield per recruit with exploitation rate and L_{50}/L_{∞} for variety I

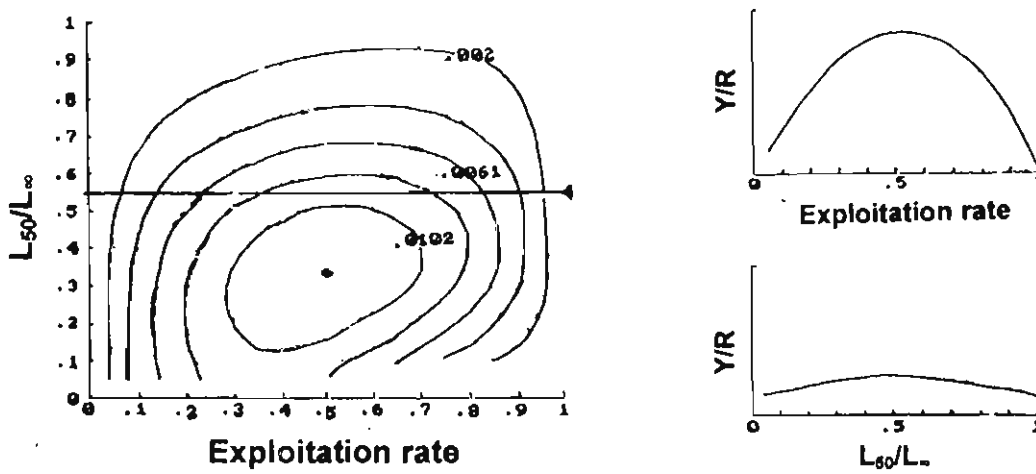


Fig.9: Variation of Yield per recruit with exploitation rate and L_{50}/L_{∞} for variety II

peaks in certain months (De Silva and Kortmulder, 1977; De Silva *et al.* 1985; Kortmulder 1987; De Silva and Somaratne, 1994). In the present study both varieties of *Puntius bimaculatus* appear to be breeding throughout the year since mature individuals were recorded in all months. However, the peak breeding season for the bright orange stripe variety collected from the Kalu river basin appears to be May and from October to December, while that of the uniformly silver coloured variety collected from the Kelani river basin appears to be in March-April and from December to February. In the tropics, at a particular locality, the temperature and photoperiod remain more or less constant throughout the year with minor seasonal variation. However, the rainfall varies widely over the months. Spawning of many tropical freshwater fish including *Puntius bimaculatus* has been found to be related to rainfall (Schut *et al.* 1984; Kortmuler, 1987; De Silva and Somaratne, 1994). The Southwestern region of Sri Lanka where the sampling sites are located gets a high rainfall from May to September during the southwest monsoons and in March-April and October-November due to intermonsoonal rains. However, the period from December to February is fairly dry in this region. Therefore, the results of the present study indicate that although the peak spawning period of the bright orange striped variety coincides with the rainy season, one of the breeding peaks of uniformly silver coloured variety is in the dry season from December to February.

Absence of spawning individuals in the sampling sites indicates that both varieties migrate to another area for spawning. It has been recorded that the adults of *Puntius bimaculatus* migrate upstream to spawn in the marshy areas during the rainy seasons (Schut *et al.* 1984). However, present study indicates that these migrations may occur throughout year and even during the non-rainy months. Further, some of the individuals at least of the bright orange striped variety appear to be returning to the adult population after spawning.

The present study also indicates that the fecundity - body weight and fecundity - standard length relationships of the same species vary with the variety. The fecundity of the bright orange striped variety although highly variable, is not correlated with the standard length or weight of the female. However, in the uniformly silver coloured variety, the fecundity is

significantly correlated with the standard length and weight of female. De Silva *et al.* (1985) have also recorded that the fecundity of *Puntius bimaculatus* is correlated with length and weight of the female fish. The values for asymptotic length of the two populations studied are very similar. However, both these values are lower than the highest length recorded for this species in Sri Lanka which is 7.0 cm (Pethiyagoda, 1991).

The values for the Von Bertalanffy growth coefficient (K) are almost same for the two populations indicating that they attain the asymptotic length at the same rate. Since the asymptotic lengths are also very similar, the growth rates of the two varieties at the two sampling sites appear to be the same.

The K values recorded in the present study are higher than those recorded for exploited food fish populations of *Oreochromis mossambicus* and *Trichogaster pectoralis* in some reservoirs in Sri Lanka (Wijeyaratne and Perera, 2001). Higher K values coupled with low L_{∞} values indicate that the growth rates of those two populations are higher than those of the exploited food fish populations.

The natural mortality coefficient (M) of the Parakaduwa population, which is very close to the total mortality coefficient (Z) indicates that this population is not exploited for the aquarium industry. The M and Z values of the Dehiowita population indicate that this population is subjected to very low fishing mortality. The exploitation ratio of this population was 0.1 where as that of the Parakaduwa population was 0.02. The M values recorded in the present study are close to those recorded for indigenous cyprinids such as *Amblypharyngodon melettinus*, *Puntius filamentosus*, *Rasbora daniconius* and *Esomus thremoicos* in some reservoirs in Sri Lanka (Wijeyaratne and Perera, 2001).

High K values and M values indicate that these two populations have a high turn-over rate. Hence these two populations have a high biological production per biomass ratio. It has been shown that the populations with high turn-over rates can withstand removal of biomass from the population without adversely affecting their existence (Chrestensen and Pauly, 1992). Therefore, it appears that these two populations can also withstand removal of biomass. This indicates that there is potential to exploit these two populations for the aquarium industry.

The optimum size at first capture for both varieties are very close to the mean length at maturity of at least one sex, i.e. the females. Therefore, it appears that harvesting at the optimum size estimated from this analysis would not affect the reproductive success of these populations.

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