

The Natural Spawning Cycle of the Common Carp (*Cyprinus carpio* L.) in the Victoria Reservoir

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Abstract

The common carp (*Cyprinus carpio*) has established a breeding population contributing between 35-40% by weight to the commercial fishery of the Victoria reservoir despite the absence of stocking since 1990. A sample of fifty fish was examined monthly from May 1996 to April 1997 and the mean size at maturity, size frequency distribution and individual fecundities of gravid females were estimated. Seasonal changes in sex ratio, the frequency distribution of female gonadal stages and the gonado-somatic index were also analysed and used for the determination of the spawning cycle.

The overall female to male ratio was 1.14:1.00. The females were single spawners and individuals with a total length of 30.8 to 46.0 cm and a weight of 530.62g to 1,990 kg had a fecundity between 49,070 and 240,100. Ovaries were classified into seven maturity stages. Ovaries in spawning condition were present throughout the year indicative of year round breeding. Seasonal variation in mean monthly gonado-somatic index indicated the presence of four possible breeding seasons coinciding with the end of the monsoon and inter-monsoonal rains.

Introduction

The Common carp (*Cyprinus carpio*) was introduced into Sri Lankan freshwaters in 1915 and again in 1948 (Fernando 1971) and now has become a popular food fish. It has been recently pointed out by Chandrasoma (1996) that more emphasis should be placed on propagating the common carp in large perennial reservoirs in the dry zone. Apart from testing the suitability of various material for collecting eggs during spawning (Edirisinghe *et al.* 1985, 1986, 1990, Edirisinghe & Haturusinghe 1989; Edirisinghe & Jeyabalasingam 1992), the breeding of common carp (Indrasena & Ellepola 1965) and monitoring the growth and survival of common carp fry at different stocking densities (Ariyaratne 1996), there is no available information on the reproductive biology of the common carp in Sri Lankan reservoirs.

Victoria is a large deep hydro-power reservoir constructed under the Accelerated Mahaweli Programme. The reservoir was sealed in 1984 and fishing commenced officially in 1989. During the period 1984 to 1990 a total of 125,250 common carp fingerlings (Edirisinghe 1997) were stocked by the Ministry of Fisheries with a view of augmenting the commercial fishery of the reservoir. This stocking programme came to an abrupt halt with the cessation of state patronage for the development of inland fisheries in Sri Lanka in July 1990. Despite the absence of stocking, personal observations carried out since 1990

indicate that the common carp has established a self-breeding population which now contributes between 35-40% by weight to the commercial fishery

This investigation focusses on the determination of the natural spawning pattern of the common carp in the Victoria reservoir, with a view of encouraging its propagation and management.

Materials and Methods

A sample of fifty fish was obtained each month from gill-net catches (mesh size 7.5-13.75 cm stretched mesh) of the commercial fishery for a one year period (May 1996-April 1997) and the total and standard lengths and the total weights were recorded. The fish were dissected, their sexes were determined and the gonads were removed and weighed to the nearest 0.01g and staged according to the maturity scale of Jhingran & Pullin (1985). The percentage occurrence of different maturity stages was also determined in each month. Seasonal variation in the mean monthly gonado-somatic index which was taken as the mean value of the ratio between the gonadal weight as a percentage of body weight was also determined.

The distribution of maturity stages (stage III and above) of both sexes in each two cm length group was also determined. From the results, the mean total length at maturity was also estimated.

For fecundity studies, twenty ovaries in spawning stage were fixed in Gilson's fluid, shaken well and kept aside in the dark for a minimum period of three weeks. When the eggs were well separated from each other and from the ovarian membrane, the number of ripe eggs was estimated in each individual by sub-sampling gravimetrically. The relationship between fecundity and total length, weight and gonadal weight were also determined by linear regression analysis (Bagenal & Braum 1978).

Results

The results presented in this study refer to fish collected from the commercial fishery. The mean landing size was 37 cm with a minimum size of 18.0 cm and a maximum landing size of 64.0 cm. Samples in the commercial fishery are subject to gill-net selectivity where most of the carps are netted in mesh sizes above 11.25 cm. It is unlikely however, that gear selection would affect the findings of this investigation.

Sex ratio and size distribution

The overall female to male sex ratio was 1.14:1.00 indicating a slightly higher abundance of females in the catch. However, there were monthly fluctuations in dominance between the sexes (Fig. 1) with seasonal variation in the percentage of females ranging from 44.1 to 65.2.

The size distribution for both sexes was typically unimodal with the smaller size groups containing more males and the larger size groups more females (Fig. 2). Small sized individuals ranging between 18-22 cm appeared infrequently in the catches usually during May-June and October-November following periods of heavy rain.

Mean size at maturity

Fig. 3 is an illustration of the mature males and females (stage III and above) in each 2 cm length group. The mean size at maturity was considered to be the length at which

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50% of the population reaches maturity (Burd 1962). The mean size at maturity for males and females were 27.5 cm and 31.5 cm respectively. The smallest mature male observed during this study was 25.5 cm in total length, while the smallest mature female was 30.0 cm.

Fecundity

Females are single spawners (Nathanael et al. in press). Gravid individuals with a total body length of 30.8 to 46.0 cm and a weight of 530.62g to 1.990 kg had a fecundity between 49,070 and 240,100.

The statistical relationships of fecundity to total body length, weight and gonad weight are given in Table 1. Fecundity was significantly correlated to these somatic parameters with the relationship between fecundity and body weight being the most significant. These relationships provide useful indices for estimating the egg-producing capacity of this species. The length-fecundity relationship in particular is critical due to its practical usefulness in the assessment of population fecundity, estimation of the average fecundity of a fish in a given length group, and in determining the influence of spatio-temporal variations on the egg producing capacity of common carp.

Table 1. Relationship between fecundity (F) and somatic parameters of common carp at the Victoria reservoir ($p < 0.01$; r = correlation coefficient).

Parameter	Relationship	r
Total length (L)	$F = 40.83L^{3.84}$	0.69
Body weight (W)	$F = 1916.08 + 60037.73W$	0.84
Gonad weight (G)	$F = 35128.25 + 261.25G$	0.65

Spawning cycle

Fluctuations in mean monthly gonado-somatic index (G.S.I.) and the percentage frequency of ovarian maturity stages were taken as indicators for assessing peak spawning seasons. The mean monthly G.S.I. reaches a maximum immediately prior to the onset of spawning, and is a good indicator for determination of the spawning cycle.

Fig. 4 indicates that seasonal fluctuations in the mean monthly G.S.I. of both sexes follow more or less the same pattern. Combination of peak G.S.I. periods of both sexes indicates that peak breeding occurs during July, October, February and April -May coinciding with the end of the monsoonal and inter-monsoonal rains.

Fig. 5 shows the monthly variation of immature, spawning and spent females in the samples. The presence of spawning individuals throughout the year is indicative of year round breeding. Spent females were most abundant in June, August, October and March coinciding with the steep drop in female G.S.I. immediately after spawning. It is also interesting to note that the proportion of immature individuals in the catches were much lower than mature specimens indicating that most of the smaller, immature carps escape being trapped by the gill nets.

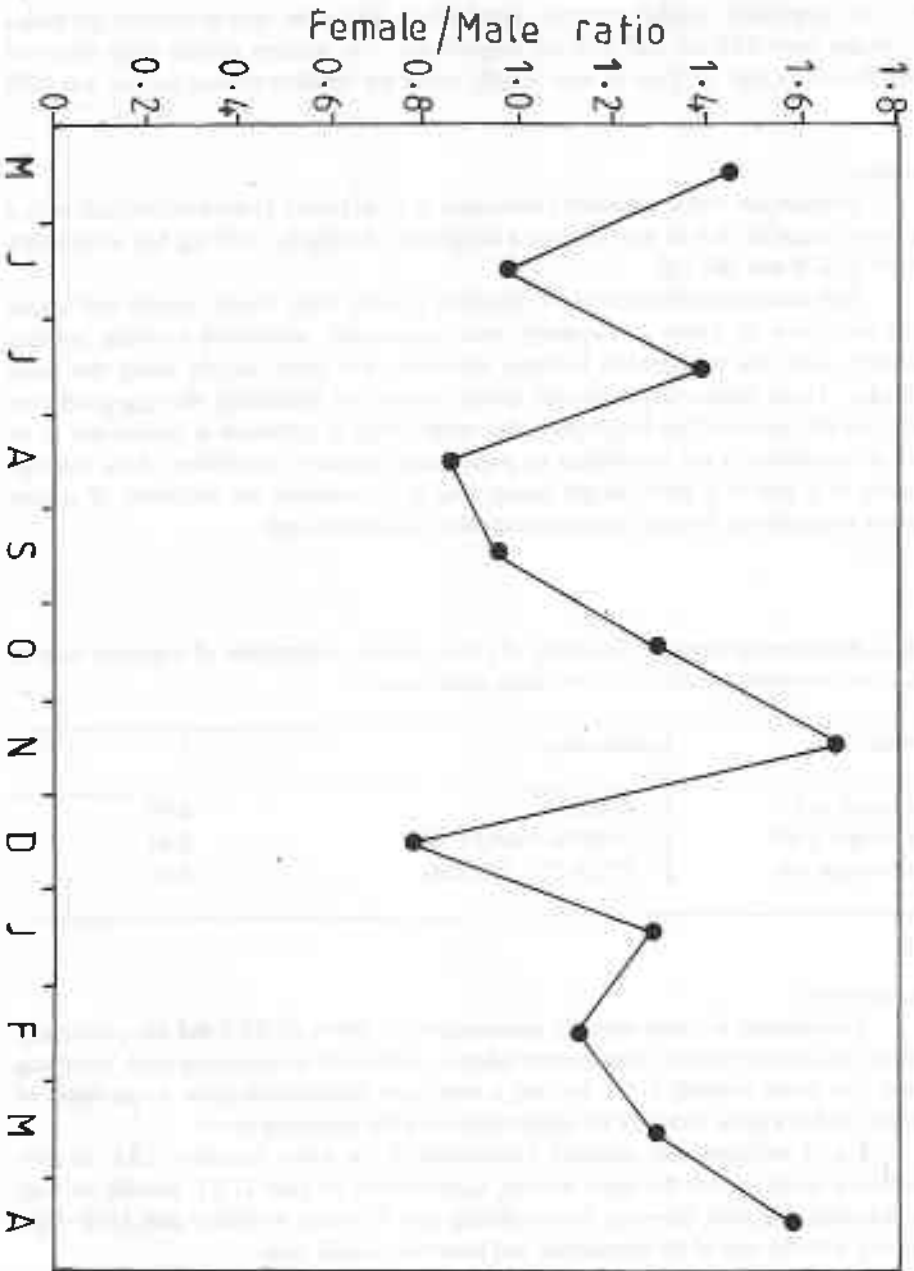


Fig. 1. Seasonal fluctuations in the female:male sex ratio in the commercial fish catch of the Victoria reservoir

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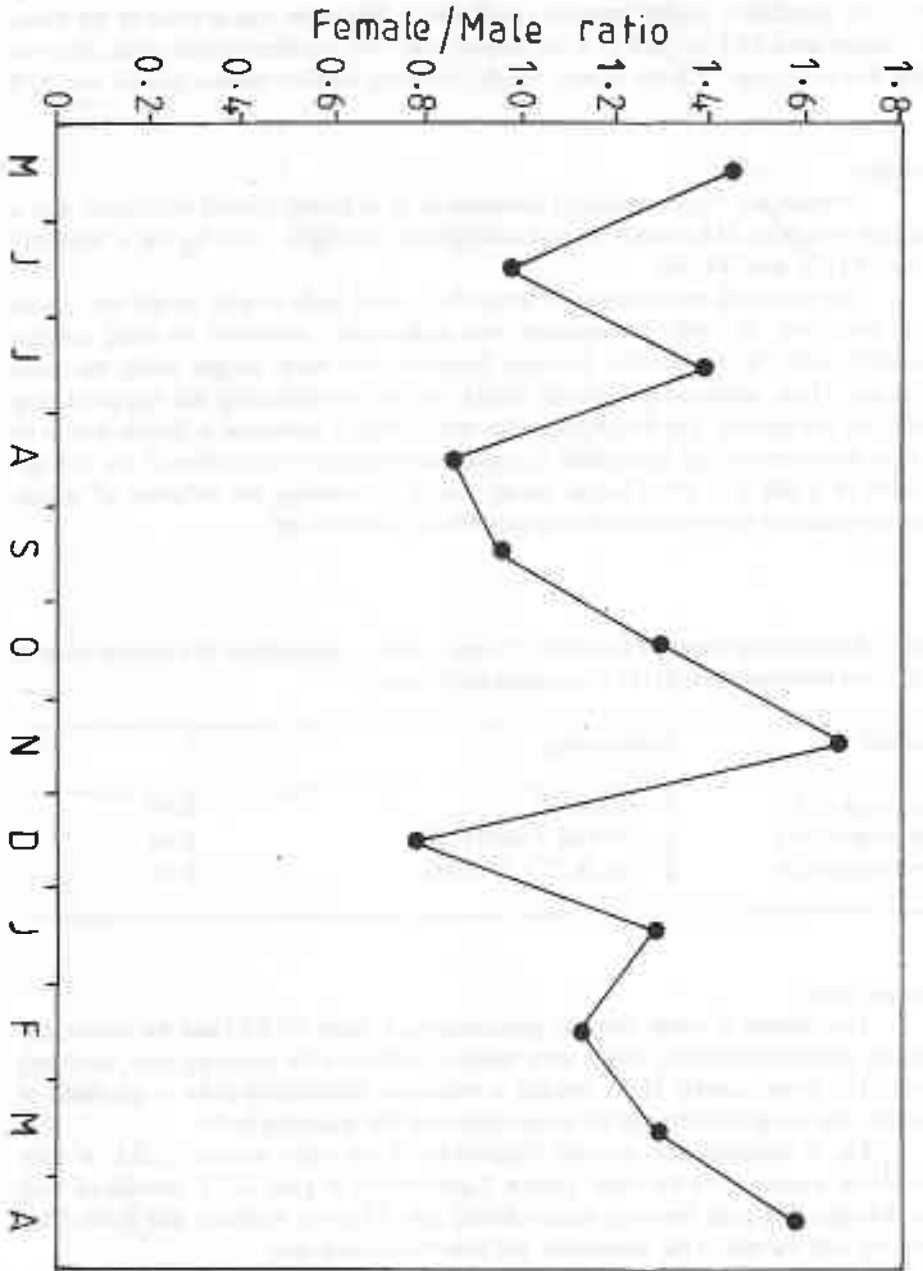


Fig. 1. Seasonal fluctuations in the female:male sex ratio in the commercial fish catch of the Victoria reservoir.

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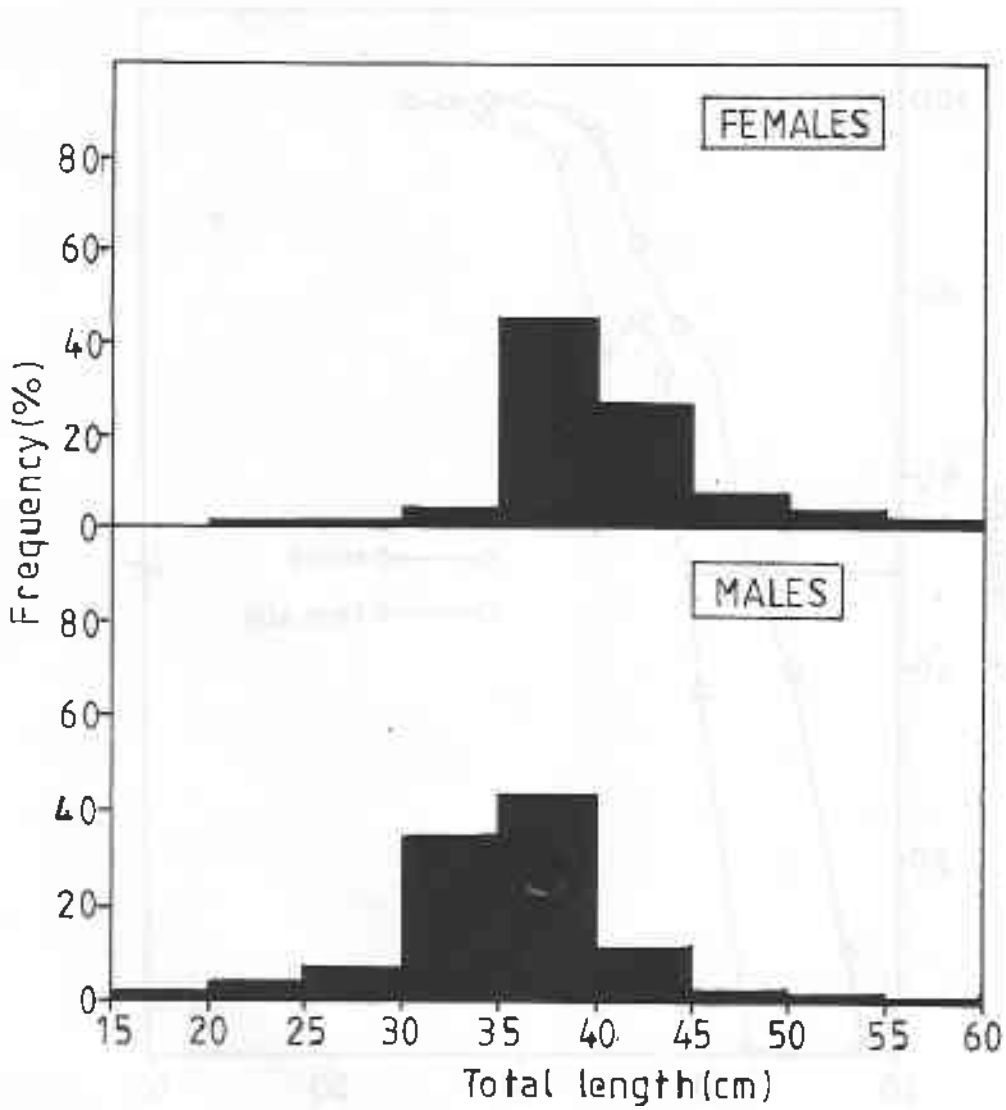


Fig. 2. Size-frequency distribution of male and female common carps in the commercial fish catch of the Victoria reservoir.

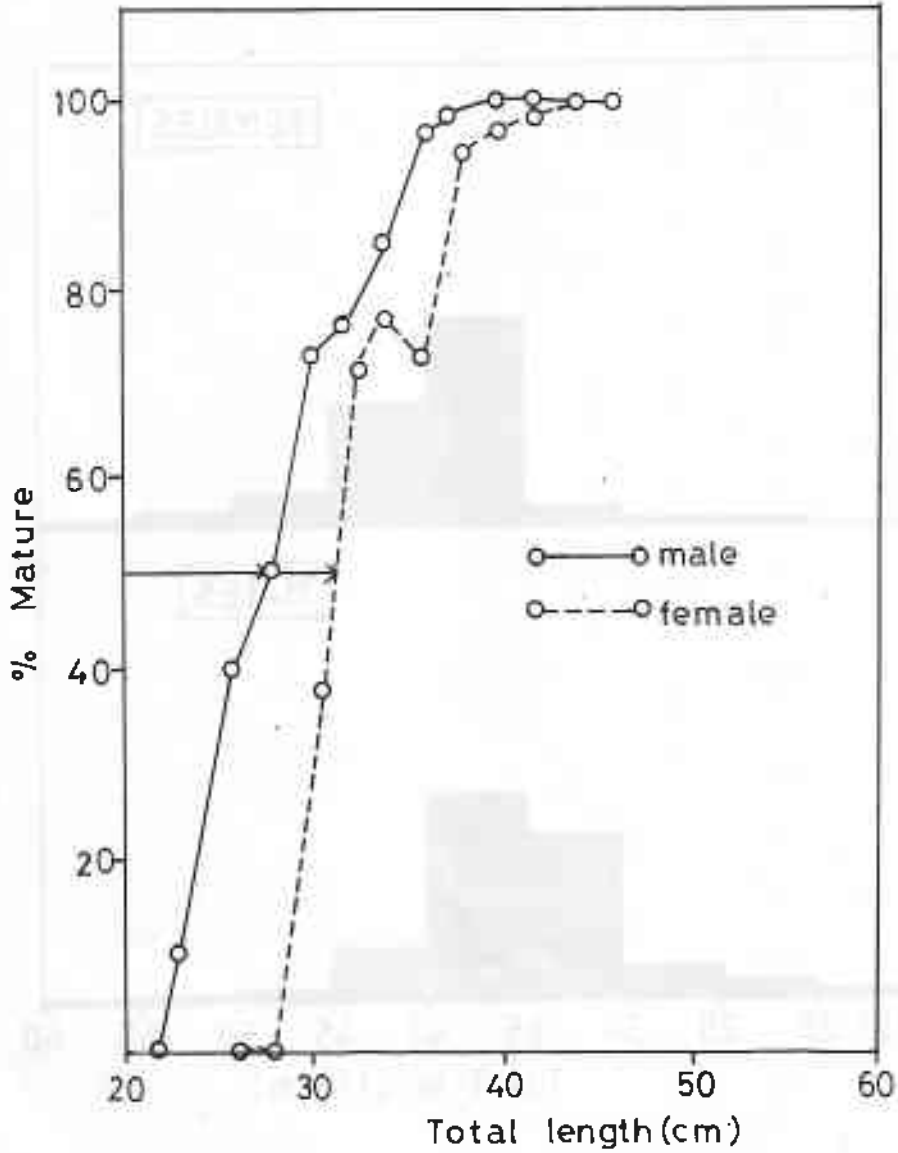


Fig. 3. The mean size at maturity for male and female common carp in the Victoria reservoir.

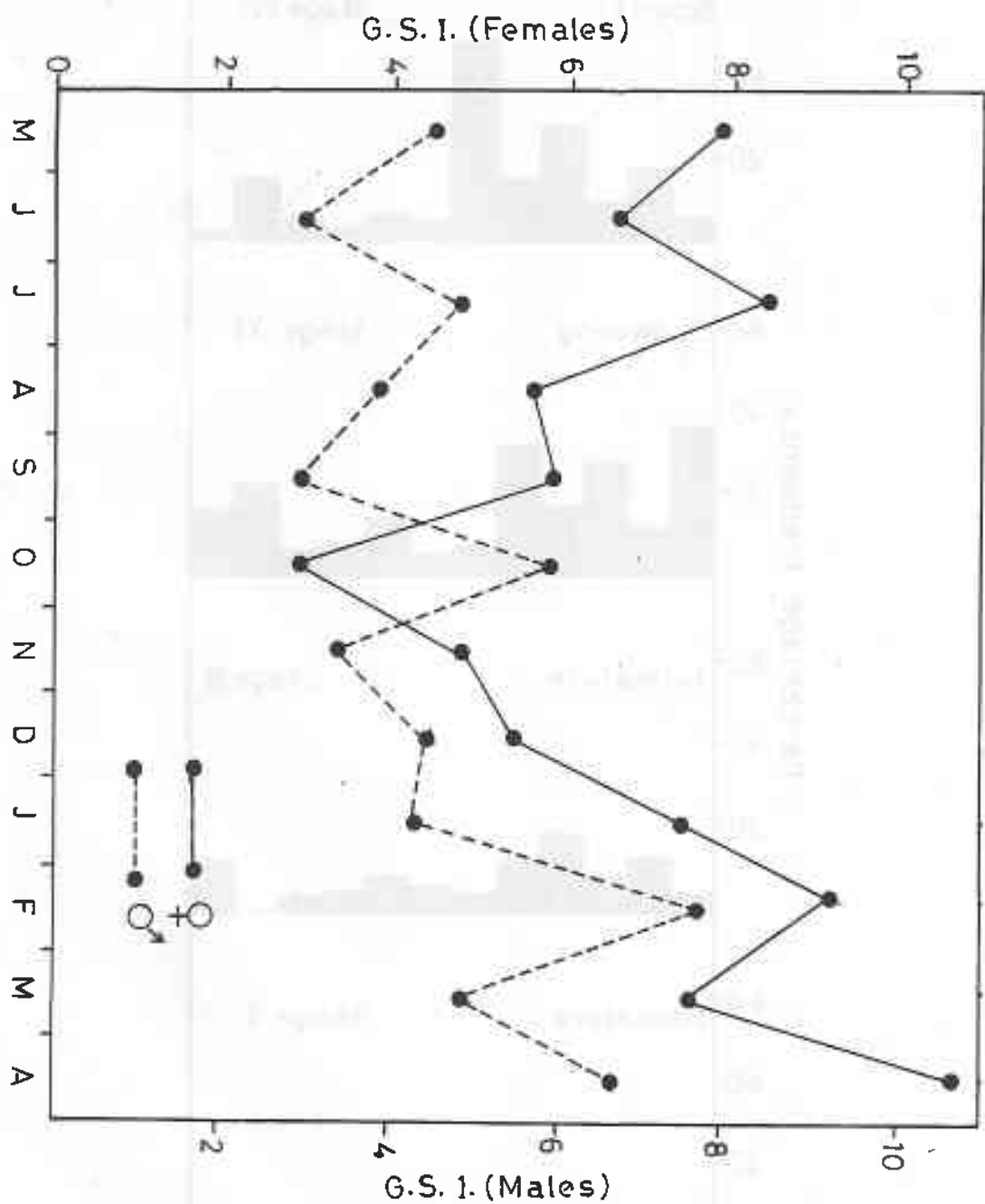


Fig. 4. Variation in mean monthly gonado-somatic index of male and female common carps in the Victoria reservoir.

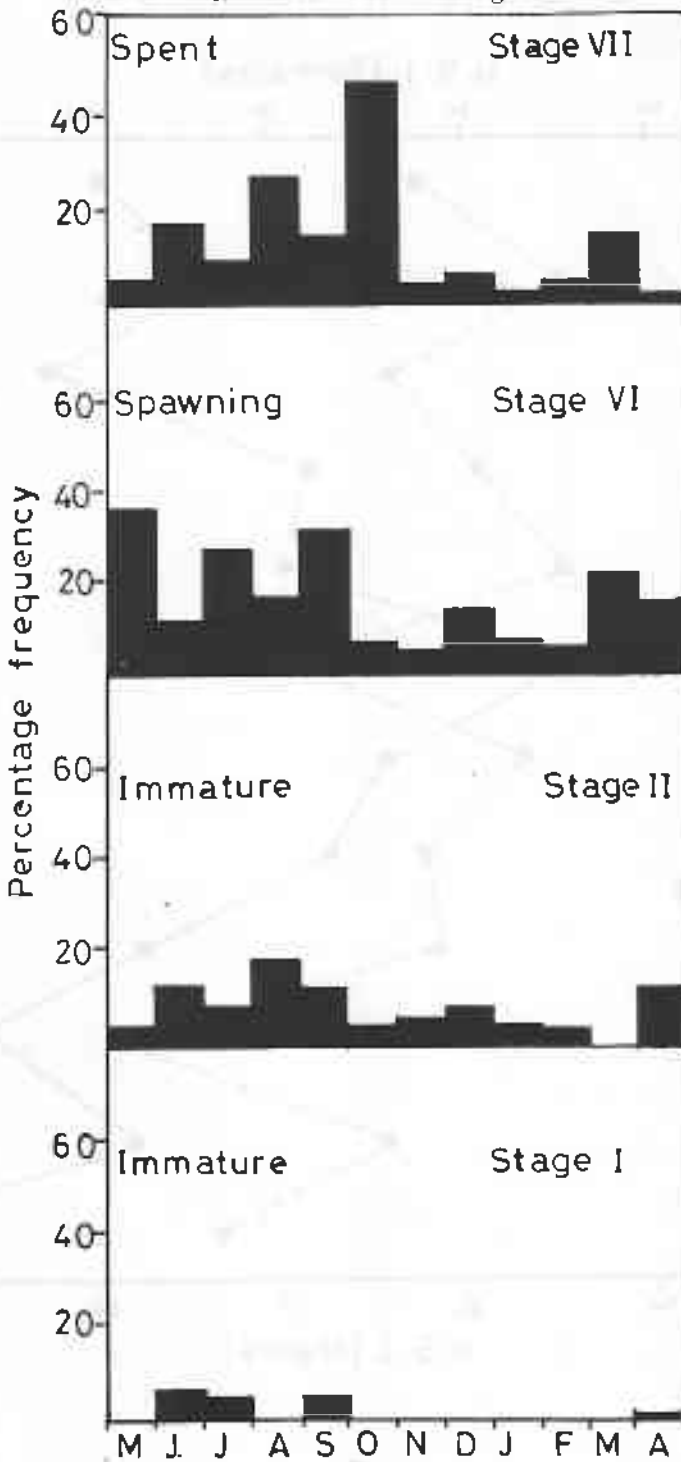


Fig. 5. Monthly variation in immature, spawning and spent females in the commercial catches of the Victoria reservoir.

Discussion

Common carp lay eggs on substrate vegetation and are able to breed under varying natural environmental conditions throughout the world. Unlike in tropical and sub-tropical regions where common carp is known to spawn three or four times a year due to the high water temperature, in temperate regions spawning occurs only once a year during late spring. Again, in tropical and sub-tropical regions, the common carp becomes sexually mature during their first year of life whereas in cooler climates it takes them between three to four years (FAO 1985). These fish are bottom-dwelling omnivores feeding on benthos and detritus and since they are hardier than the major Chinese and Indian carp species, and do not require artificial breeding in Sri Lankan reservoirs they play an important role in commercial exploitation.

Observations carried out at the Victoria reservoir since the cessation of stocking in 1990 shows that the common carp has successfully established itself due to natural recruitment. Catch statistics collected during the present study reveals that it is now an important constituent of the commercial fishery accounting for 35-40% of the total landings and its catchability is second only to the cichlids. Information regarding its reproductive biology is therefore important for successful management of this fishery.

Two possible factors which could contribute to the successful establishment of common carp in Victoria, could be the depth of the reservoir ($D_{\max}=102$ m) and the paucity of carnivorous fish species. Due to its great depth the Victoria reservoir shows thermal stratification with a maximum surface temperature of 32°C and a minimum bottom temperature of 24°C (Piyasiri 1991). The optimum temperature required for growth and reproduction of common carp is 20°C (Horvath 1985). Therefore the ability to tolerate a low temperature combined with its bottom-dwelling omnivorous habit could be a factor promoting its survival in the Victoria reservoir. Monthly catch statistics collected during this study reveal that the carnivorous fish species (*Ompok bimaculatus*, *Anguilla nebulosa*, *Glossogobius giuris* and *Clarias tismanni*) collectively constitute only about 0.5-1.5% of the catch by weight. The common carp provide no parental care, and the young have only a limited chance of survival especially during the early stages (Horvath 1985). The paucity of carnivorous fish species in the reservoir and the very high fecundity of gravid females probably compensate for the loss of eggs and young during development.

Changes in female to male sex ratio with time in *Cyprinus carpio* follows a somewhat similar trend to changes in G.S.I, as in many tropical and sub-tropical fish, where spawning is known to be closely related to rainfall and floods (Lam 1983). However, more studies using larger samples representing the existing population should be carried out to come into definite conclusions on the sex ratio. Peak spawning periods of *Cyprinus carpio* appear to be closely related to the rainy season.

Apart from the necessity of developing this resource to augment the fishery of the Victoria reservoir, the possibility of breeding common carp in other large Sri Lankan reservoirs should also be explored.

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