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Comparison of length-weight relationships and fecundity between pond cultured and reservoir (Victoria) inhabiting common carp (*Cyprinus carpio*)

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ABSTRACT

Comparisons were made on the length-weight relationships, fecundity and egg diameter distribution of yolked ova in mature ovaries of pond cultured female common carp with those collected during the same period from the Victoria reservoir. Irrespective of the location, the condition factor of gravid females was within the range 1.6-2.0. However, the average body condition of ripe females from the reservoir was better than those from the pond. Yolked ova in ripe (stage vi) ovaries had a diameter between 0.85 to 1.70 mm. The single mode indicates that the ova ripen simultaneously and are shed in a single batch. Fecundity is linearly related to body and gonad weight, and curvilinearly to body length. Fecundity of pond cultured females ranged from 15,734 to 65, 642 with length varying from 18.5 to 31.9 cm while in the reservoir, gravid females with a length of 30.8 to 46.0 cm had a fecundity between 49, 070 and 240, 100. Irrespective of the location, the fecundity of females within the same length group were within the same range. The presence of larger sized females with a correspondingly high fecundity and good body condition which produce heavily yolked eggs indicated that under the prevailing conditions, there is potential for the establishment of a common carp based fishery in large, deep reservoirs like the Victoria. Development of pond culture to re-stock heavily depleted reservoirs with fingerlings is therefore feasible.

Key words: Common carp, condition factor, fecundity, egg diameter, pond, reservoir.

INTRODUCTION

The common carp *Cyprinus carpio* is the most adaptable of the cultured fishes since it can be reared successfully from the cold temperate zone to the tropics. It is a benthic omnivore, native to Central Asia.

Two European strains of common carp have been introduced into the inland waters of Sri Lanka in 1915 (Fernando 1971) while the red carp strain was introduced from the Peoples Republic of China in 1976. Catch statistics obtained at Victoria, one of Sri Lanka's largest hydro-power reservoirs (2270 ha) indicate that the common carp has established a self-breeding population despite the absence of stocking, and could play a significant role in enhancing fish production (Edirisinghe 1992).

To derive the most effective and economically viable benefit of its immense reproductive potential, a detailed understanding of the somatic parameters in relation to fecundity and to the habitat is essential. With this objective in view, the present investigation was undertaken to compare length-weight relationships and the fecundity of pond reared gravid females with those inhabiting the Victoria reservoir.

MATERIALS AND METHODS

In this investigation, fecundity is defined as the number of ripe eggs in a gravid (stage vi) ovary that are destined to be shed during spawning. Comparisons of fecundity were made by the estimation of the number of yolked eggs present in fifteen mature ovaries of gravid females (stage vi) collected from the commercial catches of the Victoria reservoir and also from fifteen mature ovaries of gravid females from a large mud pond (0.4 ha in extent with a mean depth of 1.5 m) situated in the Department of Animal Science, University of Peradeniya, Sri-Lanka, at a distance of 18 km from the reservoir. Ovaries obtained during monthly sampling were assigned to seven maturity stages according to Jhingran and Pullin (1985) as given in Table 1.

The total and standard lengths of the fish were measured to the nearest millimeter and the total weights were recorded to the nearest milligram. Gonads were weighed to the nearest 0.01 g. The eggs were freed from ovarian tissue and preserved in Gilson's fluid to separate the ova. Fecundity was estimated by weighing and counting the eggs in three

subsamples of each ovary and estimating the total number of eggs in the bulk. The relationship between fecundity and total length, weight and gonad weight was determined using linear regression.

The length-weight relationships for fifty mature females (stages v,vi) in each location was obtained using ordinary linear regression with the equation $W=aL^b$. The values of the constants a and b were estimated from the log transformed values of length and weight. An estimation was also made of the minimum and maximum fecundities of these fish. The condition factor was calculated using the formula $K=100\ W\ L^{-3}$ where W is the weight in grams and L is the total length of the fish in centimeters. To compare the condition factor twenty gravid females from each location were collected within the period December 1996 and January 1997.

Comparisons of the yolked egg diameter frequency between two ripe ovaries (stage vi) of known fecundity, from each location, was made with three sub samples of approximately 150 eggs per sample using a graduated ocular lens under a stereo microscope.

RESULTS

Length-weight relationships

Comparison of the length weight relationships and condition factor of gravid females at the Victoria reservoir and in the pond are presented in Table 2. These relationships provide a useful index for estimating the weight of carps from each location, given their total length.

Irrespective of the location, the condition factor of gravid females was within the range 1.6 and 2.0. However, the average body condition of ripe females from the reservoir was better than those from the pond (Table2).

Table 1. Ovarian maturity stages of common carp

Maturity stage		Description
I	IMMATURE	Cannot differentiate sex. Gonads are transparent narrow strips.
II	IMMATURE	Unmistakably female. Ovary small, tube-like. Eggs not visible.
III	MATURING	Ovary larger, occupies 1/3 of body cavity. Very small eggs.
IV	MATURING	Ovary dull grey. Occupies 1/2 body cavity. Eggs visible as yellow granules.
V	MATURE	Ovary large. Greenish in colour. Occupies almost entire body cavity.
VI	SPAWNING	Yellow eggs extruded on applying pressure to abdomen.
VII	SPENT	Reddish wrinkled ovary.

Fecundity

Table 3 gives a comparison of the minimum and maximum fecundity of gravid females from the two different sources. The maximum total length and weight of gravid females collected from the reservoir was 46.0 cm and 1990 g respectively, whereas those from the pond had a maximum length of 31.9 cm and a weight of 542.3 g. Gravid females from the reservoir had heavily yolked ova with a maximum fecundity of 240, 100 whereas those from the pond had less energy rich pale yellow ova with a maximum fecundity of 65, 642. Irrespective of the location, the fecundity of females within the same length group fell within the same broad range, and compares well with that recorded by Jhingran and Pullin 1985. Carps below the size of 30 cm are netted only occassionally at the Victoria reservoir.

Table 2. Length - weight relationships of gravid females at the Victoria reservoir and in the pond (r^2=correlation co-efficient, k=condition factor, a=intercept, b=exponent)

Location	a	b	r^2	k
Reservoir	-0.94	2.50	0.93	1.89± 0.12
Pond	0.04	2.74	0.98	1.78± 0.15

The results indicate the presence of larger sized fish with heavily yolked ova at the Victoria reservoir while in the pond females are smaller in size with a reduction in somatic growth and produce less energy rich eggs. Irrespective of the sex or stage of maturity the largest common carp netted in the reservoir weighed between 3 to 5 kg.

Statistical relationships between fecundity and the various somatic parameters are given in Table 4 with the corresponding scatter diagrams and fitted regression lines indicated in Fig.1. Fecundity is linearly related to body weight and gonad weight. A logarithmic fit (log to log plot) gave a higher correlation coefficient compared to a simple linear

Table 3. Comparison of length-weight parameters and fecundity of gravid females from the Victoria reservoir with those from the pond.

Location	Total length, cm		Total weight,g		Fecundity	
	min	max	min	max	min	max
Reservoir	30.8	46.0	530.62	1, 990.00	49,070	240,100
Pond	18.5	31.9	110.05	542.30	15, 734	65,642

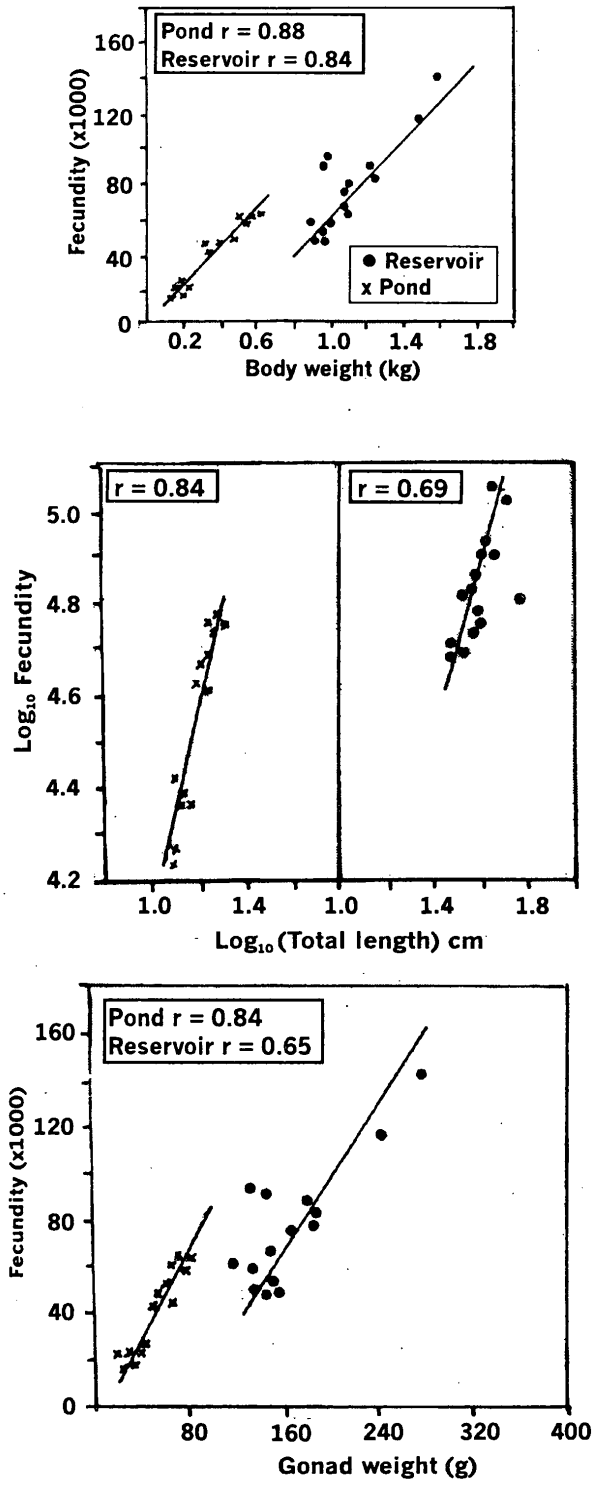

Fig.1. Relationship of fecundity to various somatic parameters of pond cultured females and those collected from the reservoir.

Table 4. Relationship of fecundity to somatic parameters in gravid females at the Victoria reservoir and in the pond (r = correlation co-efficient. $p < 0.01$. W=Body weight, L=Total length, G = Gonad weight).

Location	Body weight, g	r	Body length, cm	r	Gonad weight, g	r
Reservoir	1916.08+60037.73W	0.84	$40.84L^{3.84}$	0.69	35128.25+261.25G	0.65
Pond	-400.19+125.89W	0.88	$9.86L^{2.63}$	0.82	-7868.52+1021.87G	0.84

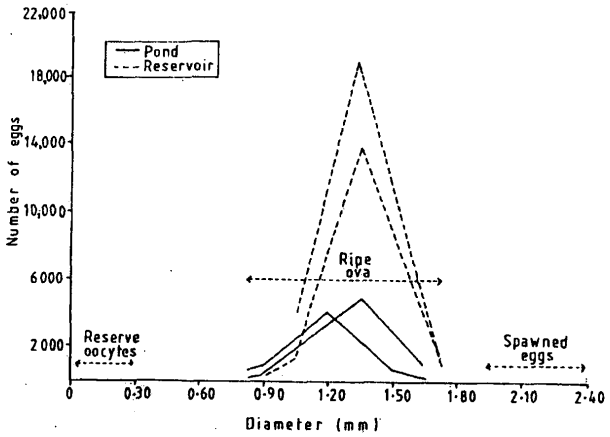

Fig. 2. Egg diameter frequency distribution of yolked ova of stage (vi) females collected from the pond and the reservoir

fit of the data, indicating a curvilinear relationship between fecundity and body length. Fish size and fecundity are positively correlated in both locations, with larger fish having larger gonads with a higher number of eggs.

Figure 2 gives a comparison between the egg diameter and the frequency distribution of yolked ova from randomly selected mature ovaries obtained from the pond and from the reservoir during the same period. The smaller, unyolked reserve oocytes have not been included in the figure.

In spawning (stage vi) ovaries, the yolked ova ranged from 0.85 to 1.70 mm in diameter. Irrespective of the location, the single mode indicates that although the ova develop independently, they ripen simultaneously and are shed in a single batch. Swollen eggs that had been spawned had a diameter between 1.90 - 2.40 mm. Observations in the pond revealed that spawning of these carps generally takes place between dusk and dawn, along the grassy edges of the pond.

DISCUSSION

Assessment of the egg producing capacity or fecundity of fishes is an important factor for understanding their life-history. In addition, fecundity assessments are useful for progeny survival studies, stock evaluation, egg incubation and for induced breeding programmes in different habitats (Baegenal 1978; Alvarez-Lajonchere 1982, Coates 1988). The length fecundity relationship is also a very important parameter with many applications such as the assessment of population fecundity (Baegenal 1978), the estimation of the average fecundity of fish of a given length group and the estimation of its egg producing capacity with growth (Roff 1986). Baegenal (1978) reported that the value of the exponent b in the length-fecundity relationship is between 2.3-5.3 for most fishes. The values obtained during this investigation are well within this range. However, deviations from the expected range have recently been reported by Kock and Kellerman (1991) and King (1997) for different populations of fish.

Irrespective of the location, the fecundity of common carp recorded in this study compares well with those recorded by Alikunhi 1966 (cited by Jhingran and Pullin 1985) for different size classes of common carp in India. Carp provide no parental care, and the high reproductive capacity tends to compensate for the mortality of eggs and young which are exposed to hazards of the environment.

The development of gametes within the gonads of common carp is determined primarily by water temperature and food availability (FAO 1985). To reproduce efficiently the female needs warm water above 17°C and food rich in protein (FAO 1985). Fecundity varies with both genetic and environmental factors (De Silva 1986). Field and experimental studies conducted on the fecundity of many different fish species reveal that changes in fecundity occur in response to food quality as well as quantity. However, there is a maximum permissible level of fecundity above which the population cannot respond (De Silva 1986).

Unlike in multiple or serial spawners where batches of eggs mature and are shed several times during a long spawning season, the common carp is a single spawner where all the mature eggs are shed in one batch. The nature of the substrate on which spawning takes place appears to be particularly important. Fresh growing weeds and short leaved

grasses are suitable, with tactile rubbing on the ventrum stimulating spawning (Horvath 1985).

This investigation indicates that except for differences in size, there were no other observable differences between pond cultured and reservoir nurtured carps. The reduction in growth rate of these fish in pond culture could be attributed to the stocking density, quality and quantity of available food and competition (Jhingran and Pullin 1985). Pond culture could thus be developed to culture fingerlings from small sized females, especially to re-stock some of the heavily depleted reservoirs. The common carp is also known to play an important role in fish polyculture systems, where a combination of fish species, usually in ponds, are used to get a good fish harvest (Chakrabarty 1982). It is an effective and commercially viable system for raising food fish and the results of this investigation would no doubt be beneficial for the development of fish polyculture systems in Sri Lanka.

This could be a profitable future investment since after establishment, the only cost involved would be the need for a cheap supplementary source of artificial feed.

The reservoir, in contrast, has an ample availability of natural food resources, a much greater surface area (2, 270 ha) and depth (D_{max}=102 m) which gives these fish greater freedom of movement. Deposition of a substantial amount of yolk in the eggs combined with its high fecundity and increased growth make this species well suited for commercial exploitation since they are capable of quick recovery from natural or man-induced depletion. The fact that the smaller reproducing size classes (15-30 cm) escape being trapped by the gill nets enable these fish to propagate despite the hazards of overfishing. The common carp has been capable of establishing itself and contributing to around 40 % by weight to the commercial catches of this fishery despite the absence of stocking (Nathanael and Edirisinghe 1997), which is evidence of its adaptability to conditions in the reservoir. One of the most essential conditions for spawning is the presence of a suitable substratum for the attachment of eggs (Horvath 1985). In the reservoir, the main factor that influences the availability of substrates is the wide fluctuation in water level. During high water level a large area around the reservoir is submerged for a sufficiently long period and the lush growth of grasses and macrophytes provide an ideal substrate for spawning. This means that if water level fluctuations could be controlled so as to create conditions conducive for spawning and the fishermen are discouraged from catching gravid females, the common carp could thrive and develop into a self-sustaining, highly profitable commercial resource.

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REFERENCES

Alvarez-Lajonchere L 1982 The fecundity of mullet (Pisces,Mugilidae) from Cuban waters. J.Fish. Biol. 21: 607-613.

Baegenal TB 1978 Aspects of fish fecundity. In: S.D. Gerking (ed.) Ecology of Freshwater Fish production. Blackwell Scientific Publications, Oxford. pp. 75-101.

Chakrabarty RD 1982 Polyculture-principles and practices. J. Inland. Fish. 1: 30-40.

Coates D 1988 Length-dependent changes in egg size and fecundity in females, and brooded embryo size in males, of fork-tailed catfishes (Pisces:Ariidae) from the Sepik River, Papua New Guinea, with some implications for stock assessments. J. Fish. Biol. 33: 455-464.

De Silva SS 1986 Reproductive biology of *Oreochromis mossambicus* populations of man-made lakes in Sri Lanka: A comparative study. Aquacult. Fish Management. 17: 31-47.

Edirisinghe U 1992 Common carp in large Sri Lankan Reservoirs. NAGA 15: (3) 23.

FAO 1985 Common Carp 1. Mass Production of Eggs and Early Fry. Training Series 8. Food and Agriculture Organization of the United Nations. Rome. 87pp.

Fernando CH 1971 The role of introduced fish in fish production in Ceylon's freshwaters. In: Duffey E and Watts AS (eds.) The Scientific Management of Animal and Plant Communities for Conservation. Blackwell Scientific Publishers, Oxford. pp.295-310.

Horvath L 1985 Egg development (oogenesis) in the common carp (*Cyprinus carpio*). In: Muir JF and Roberts RJ (eds.). Recent Advances in Aquaculture, Croom Helm, London. 2:31-76.

Jhingran VG and Pullin RSV 1985 A hatchery manual for the Common, Chinese and Indian carps. ICLARM Studies and Reviews.11 191p. Asian Development Bank, Manila, Philippines. International Centre for Living Aquatic Resources Management, Manila, Philippines.

King RP 1997 Length-fecundity relationships of Nigerian fish populations. NAGA 20 (1): 29-33.

Kock KH and Kellermann A 1991 Reproduction in antarctic notothenioid fish. Antarctic Sci. 3 (2): 125-150.

Nathanael S and Edirisinghe U 1997 The natural spawning cycle of the common carp (*Cyprinus carpio*) in the Victoria reservoir. Proc. Third Ann. Sessions, Sri Lanka Assoc. Fisheries and Aquatic Res. Pg.16 (Abstract).

Roff DA 1986 Predicting body size with life history models. Bioscience 369(5): 316-323.