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The Relationship of Ova Diameter to Fertilization Rates, Hatching Rates, Survival Percentages and Specific Growth Rates in the Common Carp and Indian Major Carps

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Abstract

The effects of different ova diameters on hatching, growth and survival of fry of the common carp (*Cyprinus carpio* var. *communis*, Cyprinidae) and Indian major carps *viz.Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* (Cyprinidae) were examined. The four female brooders of different weight and size of each of *Cyprinus carpio* var. *communis*, *Catla catla*; *Labeo rohita* and *Cirrhinus mrigala* were collected. The highest mean ova diameter was observed in (Cyc 4) 1.235 ± 0.006 mm, (Cc 4) 5.386 ± 0.098 mm, (Lr 4) 4.94 ± 0.167 mm and (Cm 4) 4.95 ± 0.091 mm; highest fertilization rate (Cyc 4) 92.48%, (Cc 4) 85.42%, (Lr 4) 89.64%, (Cm 4) 86.49%; highest hatching percentage (Cyc 4) 82.32%, (Cc 4) 79.67%, (Lr 4) 81.28%, (Cm 4) 80.17% and highest survival (Cyc 4) 75.57%, (Cc 4) 76.36%, (Lr 4) 80.51%, (Cm 4) 68.35% respectively. The specific growth rate was also found highest in *Cyprinus carpio* var. *communis* (Cyc 4) 5.94%, *Catla catla* (Cc 4) 5.62%, *Labeo rohita* (Lr 4) 5.81% and *Cirrhinus mrigala* (Cm 4) 5.86% in fry of brooders having maximum weight. The direct relationship of ova diameter to fertilization rate, hatching, survival percentage and the specific growth rate of *Cyprinus carpio* var. *communis*, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were recorded. However, after the fifth week, the growth rate of spawn reduced in all the groups and was least at the end of the eighth week.

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Introduction

The fresh water pond culture of fishes in Asian countries are composed of *Cyprinus carpio* var. *communis*, Cyprinidae (common carp) and Indian major carps *viz. Catla catla,* Cyprinidae; *Labeo rohita,* Cyprinidae and *Cirrhinus mrigala,* Cyprinidae. These species are characterised by fast growth and well adaptability in confined waters. However, it was observed that some stocks of above fishes do not grow well and have low survival rates in comparison to the progeny of other brooders of same species under uniform environmental, feed and water management. Under the genetic selection programme, the size of the female brooder, its age and weight are the characters that form the basis for selective breeding. It is therefore presumed that the genetic material including ova size may have a role in the survival and growth of said fish.

The influence of ova size on the survival and growth of salmon (*Salmo salar*) have been reported by Fowler (1972). The intra and inter-specific variations in egg size are also reported (Bagenal 1971), despite the fact that an individual fish generally produces eggs of uniform size (Bagenal 1969; Zonova 1973; Larsson and Pickova 1978). The differences in the ova diameter as well as the age and size of the female brooder (Bagenal 1969) are mainly determined by the genotype of parental fish (Springate and Bromage 1985). The availability of food also affects egg size (Springate and Bromage 1984).

In the present study, an attempt was made to investigate the relationship of the ova diameter to fertilization rate, hatching percentage, survival and growth of fry of four different sized brooders each from four species *viz. Cyprinus carpio* var. *communis*, *Catla catla* , *Labeo rohita* and *Cirrhinus mrigala*.

Materials and Methods

The experiments were conducted at government owned fish seed farms in two locations, Mumbai and Khopoli, Maharashtra, India. The data were collected on breeding of four brooders of different weights of each of common carps, *Cyprinus carpio* var. *communis* and Indian major carps, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* for further analysis.

Experiment I. Breeding and growth of spawn of common carp, Cyprinus carpio var. communis

This experiment was conducted in the month of January, 2004 at the government fish seed farm, Mumbai. Four female brooders weighing 730 to 2050 g in weight range and 21.2 to 43.2 cm in length range were selected for breeding purposes. All the brooder specimen were healthy. The brooders were accurately weighed separately and subsequently put into the spawning hapas fixed in the pond for breeding purposes with one female brooder and two male brooders in each hapa. After the spawning was over, fecundity (nos. kg^{-1}) of each brooder was recorded. The average ova diameter, fertilization and hatching percentage were studied in respect of each brooder. One hundred hatchlings of each brooder were reared in a glass aquarium tank of 45 x 22 x 22 cm size in duplicate for eight weeks in the laboratory and survival was recorded. The details are given in table 1.

Experiment II. Breeding and growth of spawn of Indian major carps

This experiment was conducted in the month of August, 2004 at the government fish seed farm, Khopoli, Maharashtra, India. Four healthy female brooders of different sizes of each of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were selected. The female brooders of *Catla catla* were in the weight range of 1900 to 3900 g, *Labeo rohita* 1575 to 3020 g and *Cirrhinus mrigala* 1300 to 2400 g. The breeding was arranged in a separate hapa with one female brooder in each hapa. The fecundity (nos.kg^{-1}), mean ova diameter, fertilization, hatching percentage and survival of spawn at the end of eight weeks rearing in the laboratory were recorded. The details are given in the tables 2, 3 and 4 about *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* respectively.

The male and female brooders were segregated in both experiments and kept separately for about one month before breeding. The induced breeding using synthetic hormone WOVA-FH (Wokhardt- Biostad. Ltd., Mumbai, India; comprised of sGnRH and domperidone) at 0.5 $ml.kg^{-1}$ body weight was done in all above fish species. The polythene sheet strips were placed in the breeding hapas containing *Cyprinus carpio* var.*communis* brooder. The ova diameters (OD) were determined by placing the eggs on 1 cm measuring groove and the average of eggs was recorded. Total thousand

eggs from each female were incubated separately in a glass aquarium tank of 45 x 22 x 22 cm in laboratory for recording the hatching percentage. The hatchlings were fed with phytoplankton for a week and subsequently with white worms (*Enchytraeus* sp) and *Moina* sp. up to satiation till the end of experiment period. Feeding was done twice a day at 10:00 hrs and 16:00 hrs. The spawn were sampled (n = 20 from each female) at weekly intervals to record the length and weight. The survival rate of spawn was determined for each brooder by counting the mortality at the end of the experiment of eight weeks duration. Water exchange of 25% of the total volume of tank was done daily to flush out excreta and unused feed and replenished with fresh water. Water quality parameters i. e. temperature (24 to 26^{o} C), pH (7.1 to 7.2), dissolved oxygen (5.3 to 5.8 mg.l^{-1}) were recorded on alternate days. Analysis of variance (ANOVA) and standard statistical methods were used for analysis of data (Snedecor and Cochran 1967).

Specific growth rate was calculated using the formula below (De Silva and Anderson 1995).

$$\text{Specific growth rate (\%)} = \frac{\text{In } W_{t2} - \text{In } W_{t1}}{(t_2 - t_1)} \times 100$$

where, W_{t1} is initial mean weight at time t_1,

W_{t2} is final mean weight at time t_2

Table 1. Details of *Cyprinus carpio* var. *communis* breeding at Government Fish Seed Farm, Mumbai

Brooder no.	Pre spawning weight of female brooder (kg)	Length of female brooder (cm)	Fecundity (nos.kg^{-1})	Mean ova diameter ± S.E. of mean (mm)	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
Cyc 1	0.730	21.2	68,440	0.834 ± 0.004^{a}	87.01^{a}	74.38^{a}	70.42^{a}	4.90^{a}
Cyc 2	1.020	25.6	74,300	0.878 ± 0.002^{b}	88.79^{b}	73.77^{b}	73.37^{b}	5.19^{b}
Cyc 3	1.470	33.8	83,600	1.097 ± 0.004^{c}	89.42^{c}	78.64^{c}	72.75^{c}	5.42^{c}
Cyc 4	2.050	43.2	84,700	1.235 ± 0.006^{d}	92.48^{d}	82.32^{d}	75.57^{d}	5.94^{d}

± S. E. of mean; values bearing different superscripts (a, b, c, d) in a column differs significantly ($P < 0.05$)

Correlation between mean ova diameter, fertilization, hatching, survival and specific growth rate.

	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
Mean ova diameter (mm)	r = 0.928	r = 0.984	r = 0.766	r = 0.726

Table 2. Details of *Catla catla* breeding at Government Fish Seed Farm , Khopoli.

Brooder no.	Pre spawning weight of female brooder (kg)	Length of female brooder (cm)	Fecundity ($nos.kg^{-1}$)	Mean ova diameter ± S.E.of mean (mm)	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
Cc 1	1.900	47.3	42,600	4.89 ± 0.109^{a}	80.43^{a}	75.69^{a}	70.26^{a}	3.48^{a}
Cc 2	2.700	51.8	59,400	5.029 ± 0.113^{b}	82.37^{b}	76.14^{b}	73.08^{b}	4.16^{b}
Cc 3	3.200	52.3	70,800	5.237 ± 0.103^{c}	84.68^{c}	76.98^{c}	74.14^{c}	5.04^{c}
Cc 4	3.900	54.9	85,850	5.386 ± 0.098^{d}	85.42^{d}	79.67^{d}	76.36^{d}	5.62^{d}

± S.E. of mean; values bearing different superscripts (a, b, c, d) in a column differs significantly ($P < 0.05$)

Correlation between mean ova diameter, fertilization, hatching, survival and specific growth rate.

	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
Mean ova diameter (mm)	r = 0.985	r = 0.919	r = 0.971	r = 0.998

Table 3. Details of *Labeo rohita* breeding at Government Fish Seed Farm, Khopoli.

Brooder no.	Pre spawning weight of female brooder (kg)	Length of female brooder (cm)	Fecundity (nos.kg^{-1})	Mean ova diameter ± S.E.of mean (mm)	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
Lr 1	1.575	43.8	50,879	3.87 ± 0.132^{a}	80.14^{a}	73.16^{a}	71.48^{a}	4.32^{a}
Lr 2	2.500	51.6	53,655	4.28 ± 0.094^{b}	81.43^{b}	75.92^{b}	73.69^{b}	4.49^{b}
Lr 3	2.700	53.4	65,168	4.45 ± 0.062^{c}	86.18^{c}	78.01^{c}	76.33^{c}	5.32^{c}
Lr 4	3.020	57.2	83,571	4.94 ± 0.167^{d}	89.64^{d}	81.28^{d}	80.51^{d}	5.81^{d}

± S.E. of mean; values bearing different superscripts (a, b, c, d) in a column differs significantly ($P < 0.05$).

Correlation between mean ova diameter, fertilization, hatching, survival and specific growth rate.

Mean ova diameter (mm)	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
	r = 0.9498	r = 0.9955	r = 0.9875	r = 0.9365

Table 4. Details of *Cirrhinus mrigala* breeding at Government Fish Seed Farm, Khopoli.

Brooder no.	Pre spawning weight of female brooder (kg)	Length of female brooder (cm)	Fecundity (nos.kg^{-1})	Mean ova diameter ± S.E.of mean (mm)	Fertilization (%)	Hatching (%)	Survival at the end of ex-periment (%)	Specific growth rate (%)
Cm 1	1.300	38.4	52,800	3.84 ± 0.014^{a}	78.14^{a}	74.65^{a}	60.19^{a}	4.67^{a}
Cm 2	1.600	42.8	54,000	4.05 ± 0.006^{b}	83.26^{b}	75.19^{b}	64.48^{b}	5.09^{b}
Cm 3	2.020	53.2	57,400	4.67 ± 0.214^{c}	85.13^{c}	78.64^{c}	65.20^{c}	5.47^{c}
Cm 4	2.400	58.4	62,300	4.95 ± 0.091^{d}	86.49^{d}	80.17^{d}	68.35^{d}	5.86^{d}

± S.E. of mean; values bearing different superscripts (a, b, c, d) in a column differs significantly ($P < 0.05$)

Correlation between mean ova diameter, fertilization, hatching, survival and specific growth rate.

	Fertilization (%)	Hatching (%)	Survival at the end of experiment (%)	Specific growth rate (%)
Mean ova diameter (mm)	r = 0.903	r = 0.996	r = 0.903	r = 0.978

Results

The data on weight of brooder, fecundity, ova diameter, fertilization rate, hatching percentage, survival percentage and specific growth rate of four brooders of *Cyprinus carpio* var. *communis* (Cyc 1 to Cyc 4) are presented in table 1 while similar details of brooders of *Catla catla* (Cc 1 to Cc 4), *Labeo rohita* (Lr 1 to Lr 4), and *Cirrhinus mrigala* (Cm 1 to Cm 4) are given in tables 2, 3 and 4 respectively. It was observed that the large sized brooder of *Cyprinus carpio* var. *communis* (Cyc 4) had the highest fecundity (84,700 nos. kg^{-1}), mean ova diameter (1.23 ± 0.006 mm), fertilization (92.48%), hatching (82.32%) and survival (75.57%). Specific growth rate was also found highest (5.94%) in the case of fry of same female brooder. This was also true to all the three species of Indian major carps *viz. Catla catla* (Cc), *Labeo rohita* (Lr), *Cirrhinus mrigala* (Cm), since the large sized brooder weighing viz 3.900 kg (Cc 4), 3.020 kg (Lr 4), 2.400 kg (Cm 4) yielded the highest fecundity 85,850 nos. kg^{-1} (Cc 4), 83,571 nos. kg^{-1} (Lr 4), 62,300 nos. kg^{-1} (Cm 4), mean ova diameter 5.38 ± 0.098 mm (Cc 4), 4.94 ± 0.17 mm (Lr 4), 4.95 ± 0.091 mm (Cm 4), fertilization 85.42% (Cc 4), 89.64% (Lr 4), 86.49% (Cm 4), hatching 79.67% (Cc 4), 81.28% (Lr 4), 80.17% (Cm 4) and survival 76.36% (Cc 4), 80.51% (Lr 4), 68.35% (Cm 4). Specific growth rate was also found highest 5.62% (Cc 4), 5.81% (Lr 4), 5.86% (Cm 4) in the fry of large brooders.

Discussion

The strong correlation recorded among the mean ova diameter, fertilization rate, hatching percentage, survival percentage and specific growth rate of all the four species of carp as the values of 'r' were nearer to 1 (Snedecor and Cochran 1967). The growth of spawn of *Cyprinus carpio* var. *communis, Catla catla, Labeo rohita, Cirrhinus mrigala* were studied for a period of eight weeks and presented in figures 1, 2, 3, 4, 5, 6, 7, and 8 in respect of each brooder. The analysis of variance (ANOVA) revealed that there is significant ($P < 0.05$) gain in average length and average weight of spawn hatched from eggs of *Cyprinus carpio* var. *communis, Catla catla, Labeo rohita, Cirrhinus mrigala* of different brooders having the highest ova diameter.

The investigation on *Cyprinus carpio* var. *communis, Catla catla, Labeo rohita, Cirrhinus mrigala*, indicated that the fry hatched from larger eggs grow faster at the initial period than those from smaller eggs (Figs. 1 to 8). Similar results have also been reported for the Atlantic salmon (Glebe et al. 1979; Kazakov 1981; Thorpe et al. 1984), Arctic char (Wallace and Aasjord 1984) and rainbow trout (Pitman 1979).

Fig. 1. Increase in length of fry of Cyprinus carpio during the period of 8 weeks

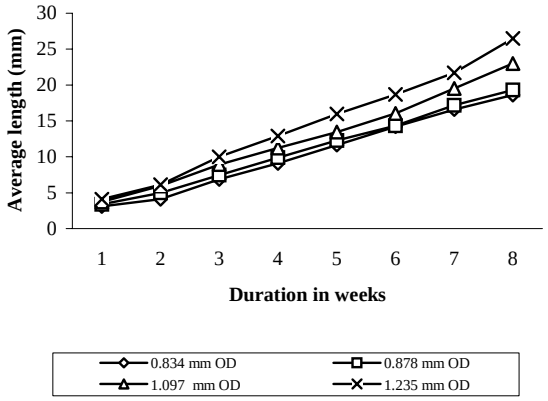


Fig. 2. Increase in weight of fry of *Cyprinus carpio* during the period of 8 weeks

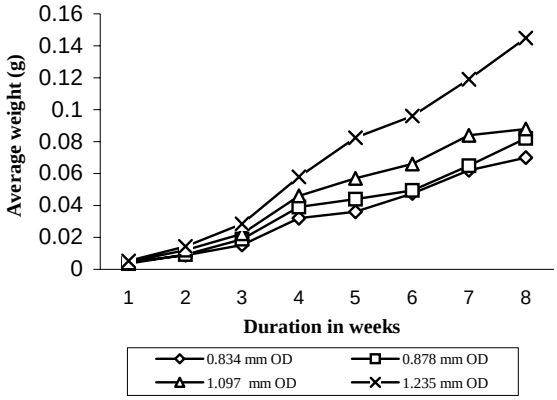


Fig. 3. Increase in length of fry of *Catla catla* during the period of 8 weeks

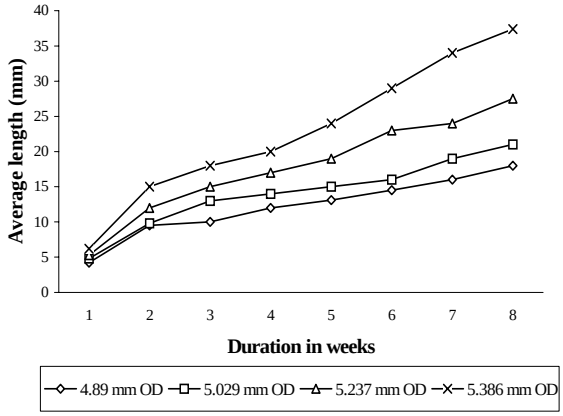


Fig. 4. Increase in weight of fry of *Catla catla* during the period of 8 weeks

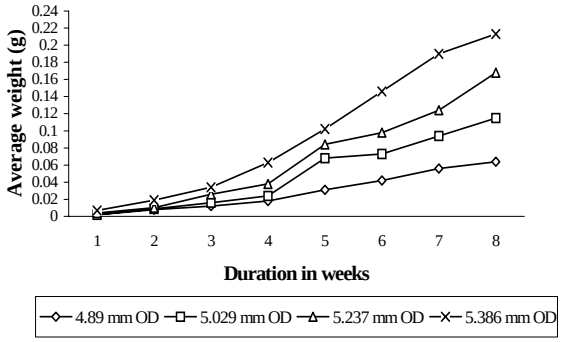


Fig. 5. Increase in length of fry of *Labeo rohita* during the period of 8 weeks

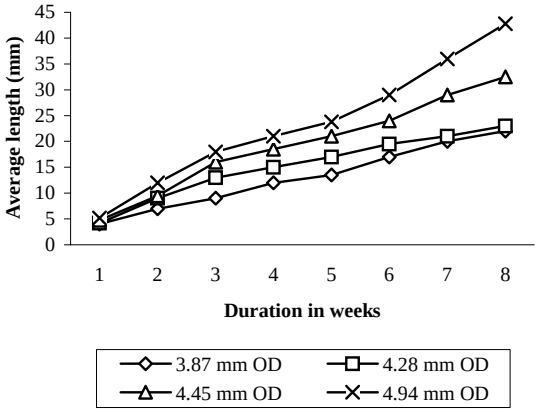


Fig. 6. Increase in weight of fry of *Labeo rohita* during the period of 8 weeks

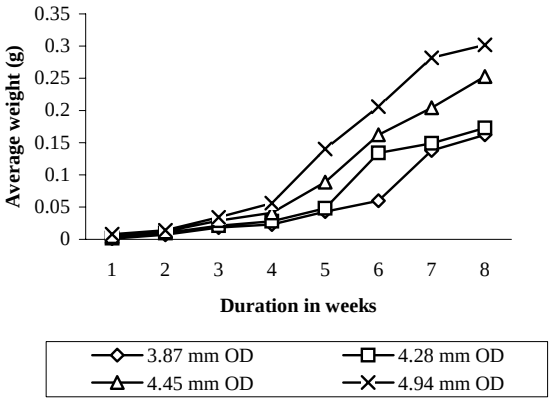


Fig. 7. Increase in length of fry of *Cirrhinus mrigala* during the period of 8 weeks

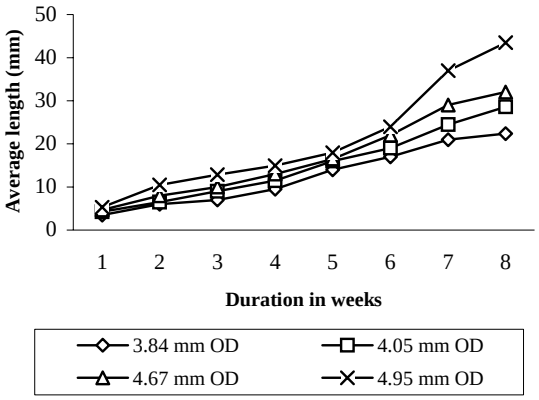
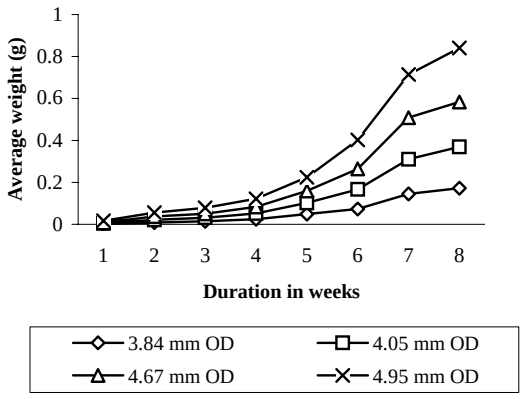


Fig. 8. Increase in weight of fry of *Cirrhinus mrigala* during the period of 8 weeks



The growth rate of the spawn of all the four brooders of each species of *Cyprinus carpio* var. *communis, Catla catla, Labeo rohita, Cirrhinus mrigala* were carefully monitored each week. The highest percentage increase in the weight was at the end of the second week at 175% in respect of *Cyprinus carpio* var. communis (Cyc 4) and remained at 103.5% at the end of the third week. The percentage increase in the weight in subsequent weeks was found decreasing in comparison to the growth in the third and fourth weeks. Similarly, the rate of percentage increase in the weight of spawn of *Catla catla* (Cc 4) was the highest at the end of the second week (171.42%) and to a lesser extent at the end of the fourth week at 85.29%. The decreasing growth was observed from the fourth week onwards. However, the percentage increase in the weight of *Labeo rohita* (Lr 4) was poor at the end of the first week (75%) but increased substantially at the end of the third week at 142.85% in comparison to other brooders in the group. On the contrary, the highest percentage increase in weight (137.5%) was observed at the end of the second week in the spawn of *Cirrhinus mrigala* (Cm 4). The *Labeo rohita* (Lr 4) and *Cirrhinus mrigala* (Cm 4) recorded almost double growth rates at the end of the fifth week in comparison to percentage gain at the end of the fourth week. The percentage increase in the weight at the end of the eighth week was the least in respect of all brooders of all four species. However, no clear cut growth pattern was recorded in any of the brooders of common carp and Indian major carps throughout the rearing period.

Many workers have considered the growth rate of Atlantic salmon as hereditary and that early maturation was associated with high growth rate (Thorpe and Morgan 1980; Thorpe et al. 1984). Svardson (1949) and Springate and Bromage (1985) noted that the largest larvae hatch from the largest eggs, survive and grow better than the smaller ones. Gray (1928) observed that the size of a trout at first feeding was related to the initial quantity of yolk in the egg. Hayes and Armstrong (1942) opined that fry from small salmon eggs were smaller than those from the larger ones but these size differences were lost over the 35 day period. Gall (1974) observed that larger eggs produced by some rainbow trouts lead larger and faster growing fry through the first 75 days of growth. In the present investigation, no growth pattern was clearly maintained in the fry of different ova diameters after the eighth week.

Conclusion

Based on the data available, it may be concluded that the female brooders of *Cyprinus carpio* var. *communis*, *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* having maximum ova diameter have healthier spawn with high fertilization, hatching percentage, fast specific growth and survival rate of the fry. However, after fifth week of rearing of fry the percentage increase in weight reduced substantially and was least at the end of the eighth week in the all groups of fry.

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