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# The Induced Breeding of Common Carps (*Cyprinus carpio*) in Bangladesh

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## Abstract

The study was conducted to know the induced breeding technique of common carp varieties. Scale carp (*C. carpio* var. *communis*), mirror carp (*C. carpio* var. *specularis*) and leather carp (*C. carpio* var. *nudus*) are chosen for the experiment at Ma-Fatema Fish Hatchery in Jessore from January to March, 2016. For induced breeding practice of common carps generally 1<sup>st</sup> dose of PG hormone only injected to the female brood fishes only. After 6 hours of the 1<sup>st</sup> dose, female brood fishes were injected with the 2<sup>nd</sup> dose of hormone at 4 mg PG/kg body weight and male brood fishes were injected at 2 mg PG /kg body weight for scale carp and mirror carp; 4 mg PG/kg body weight for leather carp. After 6-7 hours of injection of 2<sup>nd</sup> dose brood fishes became ready to spawn. The fertilized eggs were hatched after 42-48 hours. The mean ovulation rates were 90.01±2.55, 85.75±4.3 and 78.98±5.85 for scale carp, mirror carp and leather carp, respectively. The mean fertilization rates were 83.06±3.04, 81.54±3.61 and 79.88±5.35 for scale carp, mirror carp and leather carp, respectively. The mean hatching rates were 77.6±3.93, 76.16±2.91 and 74.59±4.65 for scale carp, mirror carp and leather carp, respectively. The mean survival rates were 73.44±4.94, 71.92±1.94 and 69.58±3.79 for scale carp, mirror carp and leather carp, respectively. This is first research work on comparative study of common carps induced breeding in Bangladesh.

**Key Words:** Induced breeding, Pituitary gland, Hatching rate, Fertilization rate, Survival rate

## Introduction

Common carp is a very popular fish item in different country along with Bangladeshi consumer. Generally common carp breeds in natural water bodies. But artificial breeding in commercial community and farm level is too much important for the successful expansion of aquaculture and farmers economic condition. Since 1975, artificial fish breeding techniques and low cost hatchery designs have been successfully adapted in Bangladesh. There are 882 (790 are private and 92 are government) fish hatcheries produced carp hatchlings and 10802 fish nurseries are operating in Bangladesh. The production of hatchlings in the year 2014 is 478993 kg in private hatcheries and 10338 kg in government hatcheries (DoF, 2014).

Common carp was first introduced in Bangladesh by the Department of fisheries in 1960 from China and then second batch in 1995 from Vietnam (Rahman, 1985; Hussain, 1997). Now found all over Bangladesh especially all culture ponds and baors (Talwar and Jhingran, 2001). In tropical condition it attains sexual maturity within 1 year (Alikunhi, 1966). It spawns throughout the year in pond environment with two periods, one from January to March and the other during July to August. Spawning occurs in shallow marginal weed infested areas. Three varieties of common carp, scale carp (*C. carpio* var. *communis*), mirror carp (*C. carpio* var. *specularis*) and leather carp (*C. carpio* var. *nudus*) are mostly confined to the cold upland waters and do not generally breed in plains (Alikunhi, 1957). For successful induced breeding it is necessary to select ripe brood fish (Penman and McAndrew, 1998). Scale carp is a bottom dweller and detritivorous fish. Its whole body covered with moderate size scales. Seeds can be produced by induced breeding technique. Now found all over Bangladesh especially all culture ponds and baors (Talwar and Jhingran, 2001). Mirror carp breeds in confined water of the pond and almost throughout the year, with the peak period from December to April (Karim, 1975). Leather carp has a large body in size and apparently greater disease resistance. This carp is an omnivore in nature and in cultured ponds, feed on a wide variety of plant and animal matters (Pillay, 1993). The common carp was found to attain maturity when six to eight months old, the males about two months earlier than the females and at a smaller size. Mature specimens of both sexes occur throughout the year, being maximum during late January to March and July to August. The females held in optimum conditions become ready for breeding in 42 to 60 days after the previous spawning (Parameswaran *et al.*, 1972). All three varieties are being cultured in Bangladesh and are employed in the breeding to produce fry for stocking. Over the last two decades, Jessore district has experienced an intense growth of fish breeding hatcheries than any other parts of Bangladesh (Samad *et al.*, 2013). Thus it is important to get an idea about the present status of induced breeding of common carps from Jessore. Thus an attempt has been taken to investigate the fry production method of the species as a whole three varieties of common carp viz. scale carp (*C. carpio* var. *communis*), mirror carp (*C. carpio* var. *specularis*) and leather carp (*C. carpio* var. *nudus*) at Ma-Fatema fish hatchery in Jessore. The present study was conducted to know the induced breeding techniques of common carps.

## Materials and Methods

### Study area and duration

The experiment was conducted at a private hatchery named as “Ma-Fatema Fish Hatchery” Chanchra, Jessore from January, 2016 to March, 2016. The study area are shown in Figure 1.



Figure 1. Study area.

### Experimental fish

Three varieties of common carp viz. scale carp (*C. carpio* var. *communis*), mirror carp (*C. carpio* var. *specularis*) and leather carp (*C. carpio* var. *nudus*) were used in the present study.

### Selection of brood fish

Table 2. Selection criteria of the mature brood fish of common carps.

Male	Female
(a) Small in size.	(a) Relatively large in size.
(b) Abdomen normal; not bulky like female.	(b) Abdomen bulging, elastic and soft.
(c) Pectoral fins were rough.	(c) Pectoral fins were slimy.
(d) Slightly protruding reddish vent seemed best criteria for male.	(d) Small amount of eggs from the ovary with a small pressure were observed for maturity.

### Conditioning of brood fish

Mature males and females from the brood rearing ponds were selected and immediately carried to the hatchery and kept in rectangular water tanks for about 24 hours for conditioning under water showering. No feed was supplied during the period of conditioning.

### **Collection and preparation of pituitary glands (PG)**

Locally available dry carp pituitary glands (PG) were used as inducing agent who was collected from market in preserved condition in airtight vials. At first, the pituitary glands were gently removed from the vial with a pair of forceps and dried by using the filter paper for 2-3 minutes and then weighted by an analytical electronic balance (College B204-S, Switzerland). The amount to be weight out was calculated using the following formula:

$$\text{Weighth of PG (mg)} = \frac{\text{Wt} \times \text{Pt}}{1000}$$

Where, Wt represents total body weight (g) of all the fishes to be injected and Pt, represent the rate in mg PG to be injected/kg body weight under a particular treatment. The weighed PG was transferred to a tissue homogenizer for thoroughly crushing. The crushed PG then diluted with distilled water to dissolve it and was centrifuged with a hand centrifuge for precipitations.

### **Hormone administration**

The freshly prepared supernatant solution of hormone was then taken slowly in a 1 ml syringe for injection. Brood fish was caught carefully by net and kept in sponge were covered by soft cloth. PG was then injected near the pectoral fin base. The amount of PG solution for each fish was determined according to the body weight of the brood fish.

### **Age and weight of brood fish**

Each single brood fishes were weighed before injecting 1<sup>st</sup> dose of hormone. The lowest weight was taken from each variety of common carp.

### **Observation of ovulation success**

After 6 hours of 2<sup>nd</sup> hormone dose female's ovulation were happened. The rate of ovulation was estimated by using the following formula-

$$\text{Ovulation rate (\%)} = \frac{\text{Number of females ovulated}}{\text{Total number of females injected}} \times 100$$

### **Eggs and milts collection**

After 6 hours of 2<sup>nd</sup> dose, eggs and milt were collected from the ovulated females and males by stripping the abdomen of the fishes with a gentle pressure. Eggs were collected first into a dish (Figure 2). Then males were stripped over the same dish.



Figure 2. Eggs and milts collection.

### **Determination of fertilization**

The eggs and milts in the dish were mixed together with a soft feather for 2 minutes or by shaking the bowl for five minutes and then a solution containing 0.3% urea and 0.4% sodium chloride in distilled water was added to the mixture. This solution temporarily reduced the stickiness of the eggs and prolonged the fertilizing capacity of the milt. After well mixing the eggs were poured in the circular tank in the hatchery.

### **Estimation of fertilization rate**

The fertilized eggs were differentiated from the unfertilized ones after 15-20 minutes of stripping by the presence of "eye spot" and the swelling of the fertilized egg. The unfertilized eggs were white and opaque while the fertilized eggs were transparent. The rate of fertilization was estimated by using the following formulas-

$$\text{Fertilization rate (\%)} = \frac{\text{Number of fertilized eggs in sample}}{\text{Total number of eggs in sample}} \times 100$$

### **Estimation of hatching rate**

The fertilized eggs were placed in funnel-type incubators for hatching. A continuous water flow through the inlets of the incubators was maintained. Hatching started after 42-48 hours of fertilization. When hatching was completed, the hatchlings were collected in a pot (dish) and counted by visual observation using magnifying glass and recorded. Then hatching rate was determined by the following formula-

$$\text{Hatching rate (\%)} = \frac{\text{Number of hatchlings in sample}}{\text{Total number of fertilized eggs in sample}} \times 100$$

### Estimation of survival rate

After hatching the fry do not take any external food within 70-72 hours. At this time they use the yolk to survive. After 72 hours the fry were feed with boiled egg yolk grounded in a homogenizer. Feeding was done 4 times a day. After 96 hours of hatching the number of live fry was observed by taking sample in a pot (dish) (Figure 3). Then survival rate was determined by the following formula-

$$\text{Survival rate (\%)} = \frac{\text{Number of survived fry in sample}}{\text{Total number of hatchlings in sample}} \times 10$$



Figure 3. Hatchling.

### Results

#### Age and weight of brood fishes

The brood of common carp are selected by some age and weight criteria. The age and weight criteria of brood selection is given below (Table 1).

Table 1. Selection criteria like age and weight of brood fish.

Species	Sex	Minimum age (years)	Minimum weight (Kg) (Mean $\pm$ SD )
Scale carp	Male	1.0	1.17 $\pm$ 0.3
	Female	1.5	1.27 $\pm$ 0.18
Mirror carp	Male	1.0	1.21 $\pm$ 0.36
	Female	1.5	1.44 $\pm$ 0.21
Leather carp	Male	1.5	1.28 $\pm$ 0.28
	Female	2.0	1.72 $\pm$ 0.3

### **PG dose used in induced breeding**

The 1<sup>st</sup> dose of PG hormone given only to the females at the rate of 2.0 mg/kg body weight. After 6 hours, the 2<sup>nd</sup> dose of PG hormone injected to the male and female both at different rate. After 6-7 hours of 2<sup>nd</sup> dose the eggs and milts were collected and the fertilized eggs were transferred into incubation jars in which hatching occurs after 42-48 hours (Table 2).

Table 2. Doses of pituitary glands (PG) hormone for female and male broods.

<b>Species</b>	<b>Sex</b>	<b>1<sup>st</sup> PG Dose (mg/kg body weight)</b>	<b>Interval (hrs)</b>	<b>2<sup>nd</sup> PG Dose (mg/kg body weight)</b>	<b>Ovulation time (hrs)</b>	<b>Hatching time (hrs)</b>
Scale carp	Male	-	6	2.0	6	42-46
	Female	2.0		4.0		
Mirror carp	Male	-	6	2.0	6	42-46
	Female	2.0		4.0		
Leather carp	Male	-	6	4.0	7	44-48
	Female	2.0		4.0		

### **Induced breeding of common carp**

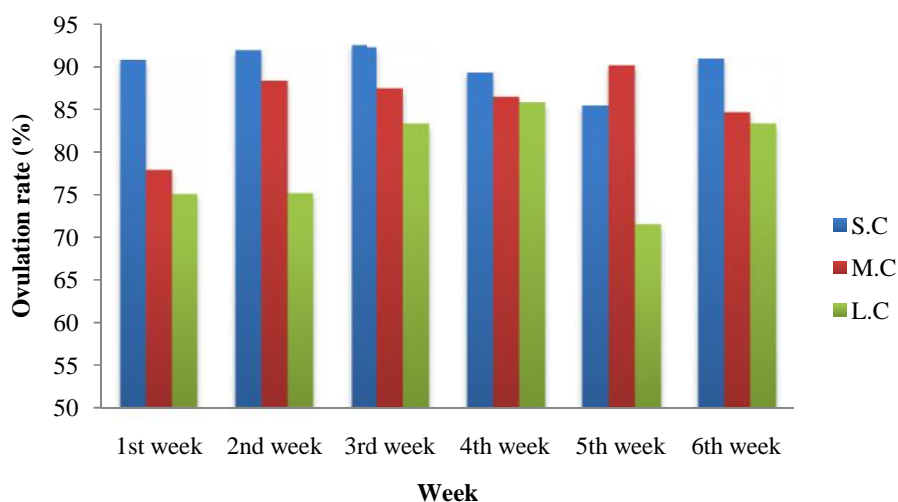
Brood fish were kept sex-separated in rectangular tanks with falling oxygenated water. To induce ovulation and spermiation by hormonal stimulants, brood fish were injected with pituitary gland (PG). After 6 to 7 hours of injecting 2<sup>nd</sup> dose of hormone the eggs were collected through hand stripping method and kept on bowl. For proper handling of common carp eggs, it is necessary to remove the adhesive substance which makes the eggs sticky. For this, a solution was made with water, to which 0.3% of urea and 0.4% of sodium chloride were added. Then milts were mixed with egg by a bird's feather for 2 minutes then transferred to the incubation jars. The fertilized eggs were hatched after 42-48 hours. After 72 hrs larvae were transferred in several hapa set in the rectangular tanks and the larvae were fed with homogenized boiled egg yolk. Then the larvae were ready for sale.

### **Ovulation, fertilization, hatching and survival rate**

Variations of ovulation rate (%), fertilization rate (%), hatching rate (%) and survival rate (%) of scale carp, mirror carp and leather carp in different weeks from January to March 2016.

### Ovulation Rate (%)

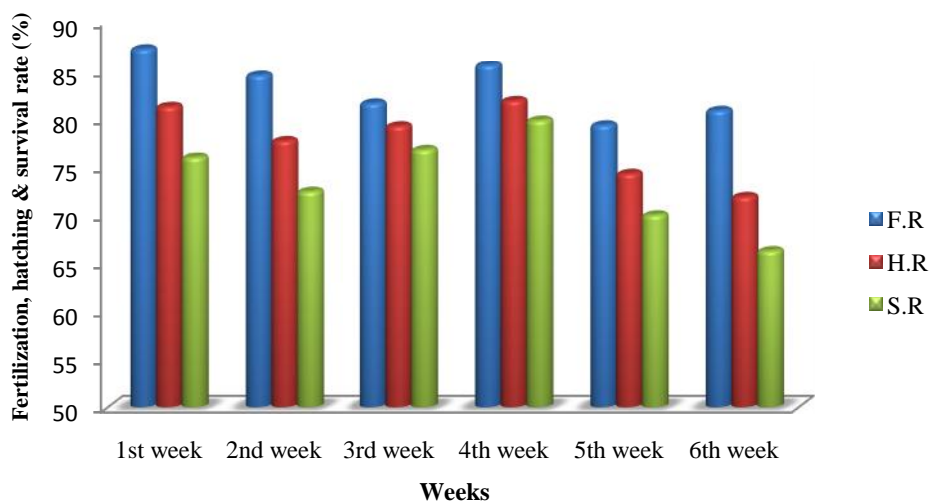
The highest ovulation rate (91.8 %) of scale carp was found in 2<sup>nd</sup> week and lowest (85.29%) in 5<sup>th</sup> week. The highest ovulation rate (90 %) of mirror carp was found in 5<sup>th</sup> week and lowest (77.78 %) in 1<sup>st</sup> week. The highest ovulation rate (85.71 %) of leather carp was found in 4<sup>th</sup> week and lowest (71.42 %) in 5<sup>th</sup> week (Figure 4).



**Figure 4. Variation of ovulation rate of scale carp (S.C), mirror carp (M.C) and leather carp (L.C) in different weeks.**

### Scale carp

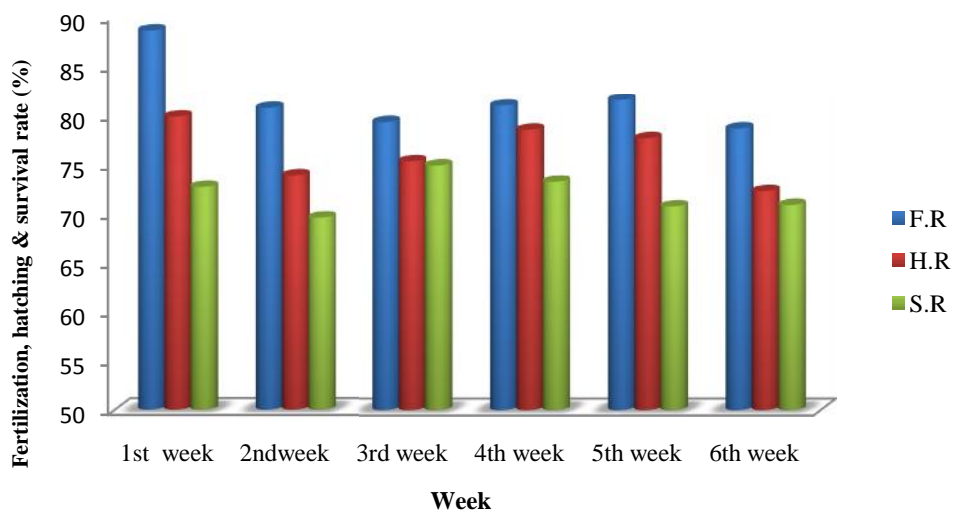
The highest fertilization rate (87.09%) of scale carp was found in 1<sup>st</sup> week and lowest (79.22%) in 5<sup>th</sup> week. The highest hatching rate (81.75%) of scale carp was found in 4<sup>th</sup> week and lowest (71.81%) in 6<sup>th</sup> week. The highest survival rate (79.71%) of scale carp was found in 4<sup>th</sup> week and lowest (66.19%) in 6<sup>th</sup> week (Figure 5).



**Figure 5. Variation of fertilization rate (F.R), hatching rate (H.R) and survival rate (S.R) of scale carp in different weeks.**

### **Mirror carp**

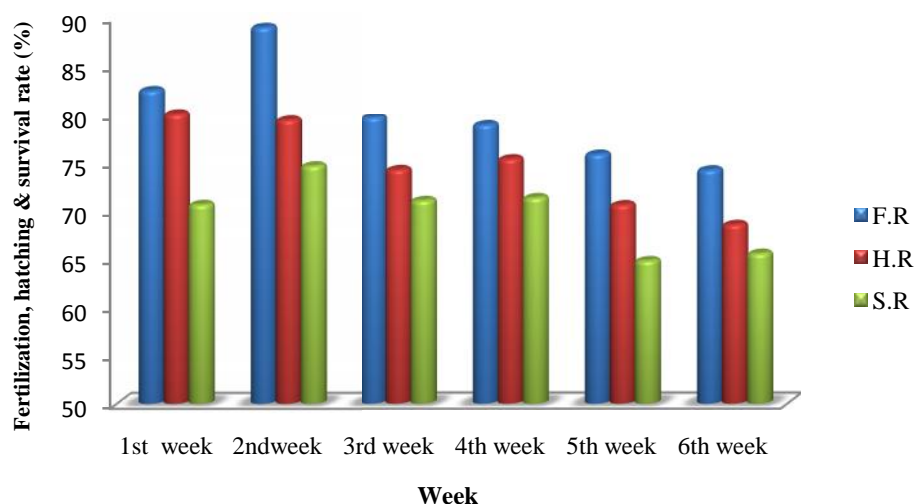
The highest fertilization rate (88.57%) of mirror carp was found in 1<sup>st</sup> week and lowest (78.52 %) in 6<sup>th</sup> week. The highest hatching rate (79.82%) of mirror carp was found in 1<sup>st</sup> week and lowest (72.18%) in 6<sup>th</sup> week. The highest survival rate (74.18%) of mirror carp was found in 3<sup>rd</sup> week and lowest (69.53%) in 2<sup>nd</sup> week (figure 6).



**Figure 6. Variation of fertilization rate (F.R), hatching rate (H.R) and survival rate (S.R) of mirror carp in different weeks.**

### Leather carp

The highest fertilization rate (89%) of Leather carp was found in 2<sup>nd</sup> week and lowest (74.04%) in 6<sup>th</sup> week. The highest hatching rate (80%) of Leather carp was found in 1<sup>st</sup> week and lowest (68.42%) in 6<sup>th</sup> week. the highest survival rate (74.64%) of leather carp was found in 2<sup>nd</sup> week and lowest (64.7%) in 5<sup>th</sup> week (Figure 7).



**Figure 7. Variation of fertilization rate (F.R), hatching rate (H.R) and survival rate (S.R) of leather carp in different weeks.**

Table 5. Mean ( $\pm$  SD) ovulation rate (%), fertilization rate (%), hatching rate (%) and survival rate (%) of three common carp varieties during the study period (January to March, 2016).

Species	Ovulation rate (%)	Fertilization rate (%)	Hatching rate (%)	Survival rate (%)
	(Mean $\pm$ SD )	(Mean $\pm$ SD )	(Mean $\pm$ SD )	(Mean $\pm$ SD )
Scale Carp	90.01 $\pm$ 2.55	83.06 $\pm$ 3.04	77.6 $\pm$ 3.93	73.44 $\pm$ 4.94
Mirror Carp	85.75 $\pm$ 4.3	81.54 $\pm$ 3.61	76.16 $\pm$ 2.91	71.92 $\pm$ 1.94
Leather Carp	78.98 $\pm$ 5.85	79.88 $\pm$ 5.35	74.59 $\pm$ 4.65	69.58 $\pm$ 3.79

## Discussion

The common carp was found to attain maturity when six to eight months old, the males about two months earlier than the females and at a smaller size (Parameswaran *et al.*, 1972). In the present study the researchers found that common carp like Scale, Mirror and leather carp are get maturity and fit for breeding with in one year to one year and half. This research findings is more or less similar to previous research work.

In the present experiment it required more PG hormone for responding to the breeding in early breeding season. On the other hand, in the peak breeding season it required normal amount of PG hormone. In January and February normally common carps started to spawn after 6 hrs of injection while in March it started to spawn after 7 hrs of injection as observed during the present study which was similar to Yeasmin (2015) who stated that after 6-7 hrs of injection ovulation occurred naturally.

The induced breeding and fry production techniques of common carps viz. scale carp (*C. carpio* var. *communis*), mirror carp (*C. carpio* var. *specularis*) and leather carp (*C. carpio* var. *nudus*) were observed at Ma-Fatema fish hatchery in Jessore district. During the present study, the ovulation rate, fertilization rate, hatching rate and survival rate of common carps were investigated. Water quality parameters were considered as growth promoting factors within the optimum standard values. Brood pond management relating to fertilization and feeding was the prime consideration for producing quality broods and that in turn would allow the availability of good seed for successful aquaculture in the country. It is widely known that a complete brood stock diet is necessary to improve spawning quality and consistency. A high quality seed production demands in particular nutrition of brood stock which significantly affects fecundity and survival (Bromage *et al.*, 1992). The mean ovulation rates were  $90.01 \pm 2.55\%$ ,  $85.75 \pm 4.3\%$  and  $78.98 \pm 5.85\%$  for scale carp, mirror carp and leather carp, respectively; the mean fertilization rates were  $83.06 \pm 3.04\%$ ,  $81.54 \pm 3.61\%$  and  $79.88 \pm 5.35\%$  for scale carp, mirror carp and leather carp, respectively; the mean hatching rates were  $77.6 \pm 3.93\%$ ,  $76.16 \pm 2.91\%$  and  $74.59 \pm 4.65\%$  for scale carp, mirror carp and leather carp, respectively; the mean survival rates were  $73.44 \pm 4.94\%$ ,  $71.92 \pm 1.94\%$  and  $69.58 \pm 3.79\%$  for scale carp, mirror carp and leather carp, respectively during the study period. Yeasmin (2015) studied on induced breeding of common carp and reported that the ovulation rate was 93.34%, fertilization rate was  $84 \pm 5.29\%$ , hatching rate was  $87.33 \pm 2.51\%$  and larval deformity rate was  $11 \pm 2\%$ . Ali *et al.*, (2016) worked on dose optimization with

synthetic hormone flash for induced spawning of Shing. In their research the best result in terms of fertilization rate (80.33%), hatching rate (71.67%) and survival rate (61.56%).

The results of the present study were closely related to those of the above authors. Yeasmin (2015) found that hatching occurred within 46 to 48 hrs after fertilization which depended on the ambient temperature. The findings of the above authors more or less agreed with that of the present study.

### **Conclusion**

The study was conducted at Ma-Fatema Fish Hatchery in Jessore from January to March, 2016. The main objectives of this research were to estimate the ovulation, fertilization, hatching and survival rate of selected common carp species. The mean ovulation rates were  $90.01 \pm 2.55$ ,  $85.75 \pm 4.3$  and  $78.98 \pm 5.85$  for scale carp, mirror carp and leather carp, respectively. The mean fertilization rates were  $83.06 \pm 3.04$ ,  $81.54 \pm 3.61$  and  $79.88 \pm 5.35$  for scale carp, mirror carp and leather carp, respectively. The mean hatching rates were  $77.6 \pm 3.93$ ,  $76.16 \pm 2.91$  and  $74.59 \pm 4.65$  for scale carp, mirror carp and leather carp, respectively. The mean survival rates were  $73.44 \pm 4.94$ ,  $71.92 \pm 1.94$  and  $69.58 \pm 3.79$  for scale carp, mirror carp and leather carp, respectively. So the survival and growth rate of hatchery produced spawn was satisfactory.

### **References**

- Ali, M.M.; Asif, A.A.; Shabuj, M.A.I.; Faruq, O.; Vaumik, S.; Zafar, M.A.; Sharif, B.M.N. Dose optimization with synthetic hormone flash for induced spawning of *Shing* (*Heteropneustes fossilis*). International Journal of Fauna and Biological Studies, 2016, 3(1), 39-45.
- Alikunhi, K.H. 1957: *Fish Culture in India*: Indian Council of Agricultural Research, New Delhi, Farm Bull, 1957, 20, 144 pp.
- Alikunhi, K.H. Synopsis of biological data on common carp (*Cyprinus carpio* Linn, 1758), Asia and Far East, FAO Fish Synopsis, 1966, 31 (1), 1-77.
- Bromage, N.; Jones, J.; Randall, C.; Thrush, M.; Davies, B.; Springate, J.; Duston, J.; Barker, G. Broodstock management, fecundity, egg quality and timing of egg production in the rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 1992, 100, 141-166.

DoF. Department of Fisheries, Ministry of Fisheries and Livestock, Annual Report 2014-2015, 2014. Bangladesh, 111pp.

Hussain, M.G. 1997: *Current status of carp genetic research and breeding practices in Bangladesh*. In: M.V. Gupta, M.M. Dey, R. Dunham and G. Bimbao (Editors), Proceedings of the Collaborative Research and Training on Genetic Improvement of carp species in Asia. Central Institute of Freshwater Aquaculture, Bhubaneshwar, India, ICLARM Work Documents 1 (Unpublished). 12 pp.

Karim, M.A. An Introduction to Fish Culture in Bangladesh. Ruby Press, Mymensingh, Bangladesh. 1975, 164 pp.

Parameswaran, S.S.; Alikunhi, K.H.; Sukumaran, K.K. Observation on the maturation, fecundity, and breeding of the common carp, (*Cyprinus carpio*, Linnaeus). Indian Journal of Fisheries, 1972, 19 (1-2), 110-124.

Penman, D.J.; McAndrew, B.W. Practical aspects of selection and fitness of stocked fish. Food and Agricultural Organization, Technical Paper, 1998, 374, 223-233.

Pillay, T.V.R. Aquaculture Principles and Practices, 3<sup>rd</sup> edition, Cambridge, University press, 1993, 283-286 pp.

Rahman, A.K.M. Study on the exotic fishes in Bangladesh. Paper presented at a seminar on the culture need of exotic species in Bangladesh, organized by the Zoological Society of Bangladesh, Dhaka, 1985, 13 pp.

Samad, M.A.; Hossain, M.T.; Rahman, B.M.S. Present Status of Broodstock Management at Carp Hatcheries in Jessore. Journal of Bangladesh Agricultural University, 2013, 11 (2), 349–358.

Talwar, P.K.; Jhingran, A.G. Inland Fishes of India and Adjacent Countries. Oxford & IBH Publishing Company Private Limited, New Delhi, 2001, 18 pp.

Yeasmin, S.M. (2015). Broodstock management and induced breeding of common carp (*Cyprinus carpio* var. Linnaeus, 1758) among three hatcheries at Jessore, MS thesis, Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology, Jessore.