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PERFORMANCE EFFICIENCY OF ARTIFICIAL PROPAGATION AND BREEDING OF CARPS

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ABSTRACT: Sound knowledge of the reproductive traits of brood fish is essential to maximize the propagation efficiency of fishes. This study was undertaken to understand and document the efficiency of artificial propagation and breeding performances of exotic carps at the National Research & Development Centre for Aquaculture (NR&DCA), Gelephu between February and June 2021. The reproductive performances of six carp species (Silver carp, Grass carp, Common carp, Catla, Rohu, and Mrigal; n = 414) were investigated. Two propagation methods: semi-natural for common carp and artificial propagation method for Indian Major Carp and Chinese Major Carp were studied to understand their breeding performance. The brooders and larvae were fed @ 2 % and @ 4 -8 times the initial body weight and fry and fingerlings @ 50 -100 % of their initial weight respectively. ANOVA results revealed that there are significant differences ($F_{5, 413}$ = 69.701, $p < 0.05$) in the mean body weights of brooders used for propagation. However, regression coefficients depict a non-significant ($p > 0.05$) effect of mean body weight (MBW) on relative fecundity (RF). The association and degree of relationship observed between MBW and RF were negative and moderate correlations (r = -0.661) which could be accounted for due to the low fecundity of heavy brooders relative to age factors. The overall mean body weight recorded was 3383.44 ± 1847.50 g (Mean ± SD) with a range of 2023.45 ± 690.35 g to 5483.57 ± 1502.49 g. Mrigal exhibited the highest absolute fecundity of 405,749 numbers, whereas Rohu had demonstrated the highest relative fecundity of 171,642 numbers. Overall fertilization rate, hatching rate, and fingerling survival rates recorded were 53%, 56%, and 71% irrespective of fish species. These species-specific findings will provide a scientific basis to improve the current hatchery protocols to enhance fingerling production for Carp species in the country.

Keywords: Artificial propagation; carp; efficiency; fecundity; the survival rate

1. INTRODUCTION

Fish farming was introduced during the early 1980s with the establishment of the Fish Seed Production Centre at Gelephu under the Sarpang district with an objective to promote Carp farming in Bhutan. Thereafter, the center served as a fish seed production and demonstration center that enabled the development of the fisheries sector through capacity development and provision of extension services to the interested local fish farmers, particularly in the southern foothills of the country.

Since then, warm water-based Carp farming is promoted in the field and currently, about 500 farmers across twelve districts - Chhukha, Dagana, Mongar, Pemagatshel, Punakha, Samdrup Jongkhar, Samtse, Sarpang, Trashigang, Tsirang, Wangdue Phodrang, and Zhemgang of Bhutan have adopted Carp farming (National Research & Development Centre for Aquaculture [NR&DCA] 2017).

Fish is one of the important sources of animal protein in the diet of Bhutanese (Thinley et al. 2018). The consumption pattern of fish has been increasing over the years, and the growing requirements are met through major imports resulting in an outflow of millions of Ngultrums. The domestic fresh fish production was 181.65 MT (Renewable Natural Resources Statistical Division [RNR-SD] 2020) against the import of 1109.23 MT (Bhutan Trade Statistics 2020) in 2020. This demand-supply deficit provides an opportunity to increase domestic fish production.

Currently, fish farming is by and large undertaken at the subsistence level as commercialization is mainly constrained by the limited and small land holding of Bhutanese farmers.

In absence of private hatcheries, artificial propagation of Carps in two government-owned farms (i.e., NR&DCA, Gelephu and RCA, Phuntshothang) plays an important role in ensuring a consistent and adequate supply of fingerlings to Bhutanese fish farmers. However, a comprehensive study to understand the efficiency and breeding performance of Carps on government-owned farms has not been undertaken, so far. Therefore, this study was conducted to understand and document the performances of artificial propagation of Carp, and the breeding performance of different Carps promoted in Bhutan, which will enable the establishment of a benchmark for further improvement of Carp farming in the country.

2. MATERIALS AND METHODS

2.1 Artificial propagation

The empirical investigation started from February 2021 until June 2021. Out of six species, the breeding season for common Carp starts first from February to March followed by Grass Carp, and Silver Carp in the month of March to May. Similarly, Catla, Rohu, and Mrigal responded to induced breeding during the month of June to August. Data were collected from 414 sets of brooders (828 males, 1:2 ratio female to male brood proportion for the propagation), in total, 414*3 = 1,242 numbers of brooders).

The artificial propagation of Chinese Major Carps (CMCs) and Indian Major Carps (IMCs) was carried out within the Carp hatchery using the synthetic hormone i.e., Salmon Gonadotropin-Releasing Hormone (Ovatide manufactured by Capital Nets, Ganeshpeth Colony, Nagpur, Maharashtra, India) to induce spawning and then data were recorded on daily basis using the standard format. After spawning, the ova were collected and transferred to incubators @ 35-90 liters of ova per incubator. The ova hatched within 12-24 hours of incubation. After absorption of the yolk sac, the larvae were fed with poultry egg yolk @ 4-8 times their initial body weight. After seven days of larval rearing in the incubators, they were transferred to nursery ponds and fed with soya bean and poultry egg mixed juice for 25 days. From 26-120 days, the fries received fry feed @ 50-100% of the initial body weight.

2.2 Semi-natural propagation

Common Carp has different breeding nature which is a semi-natural type. During the breeding season, matured female to male brood ratio of 1:2 in numbers by body weight was selected and set for propagation in an earthen pond. The brood spawned after three days to five days and eggs were automatically collected on underlying kakabans (a type of egg collector, egg collectors are joined together in a sort of raft which can be fixed slightly off the pond bottom by using two long poles tied in place with cord and stakes). The ova hatched within 12-24 hours. After absorption of the yolk sac, the larvae were fed with poultry egg yolk @ 4-8 times their initial body weight. After seven days of larval rearing in the incubators, they were transferred to nursery ponds and fed with soya bean and poultry egg mixed juice for 25 days. From 26 - 120 days, the fries received fry feed @ 50-100% of the initial body weight.

2.3 Fecundity

Fecundity is the indication of fertility, such as the sperm or egg count of an organism. Fecundity is important to assess the reproductive potential and to evaluate the commercial potential of fish stock. Following the onset of spawning after 12-18 hours of the induced breeding, the ova were measured using the volumetric method to determine the gross quantity of ova being spawned by the respective sets of brooders. Measured and counted ova were transferred from hapa (a cage enclosure) into incubators for hatching. From each set, a one-liter ova was taken as a sub-sample with calibrated beakers to determine the fecundity. For Common Carp, fecundity estimation was determined through weighing and counting ova from the three broods. Body weight and gross weight of the ovaries were taken to determine the relative and absolute fecundity. The samples were randomly collected from the cases that exhibited egg clog. With minimal exposure to the stressors, the sampled eggs were set in within the incubators for hatching. Absolute Fecundity (AF) is the reproductive power of a female fish, i.e., the total number of ova present in the ovary or eggs released by a female fish during spawning. A formula to measure AF is adopted from (Bandpei et al 2011);

$$\textit{Absolute Fecundity} = nV/v$$

Where n = number of eggs in the subsample,

V = volume to which the total number of eggs is made up and

v = volume of the subsample

Whereas, Relative Fecundity (RF) refers to the number of eggs produced/present expressed in terms of the number of eggs per gram ovary or body weight (per g or kg).

2.4 Fertilization, Hatching, and Survival Rate

The fertilization, hatching, and survival rate were determined using the following formula adopted from (Naeem et al. 2011);

$$\text{Fertilization Rate} = \frac{\text{Nos. of fertilized eggs}}{\text{Total number of eggs}} \times 100$$

$$\text{Hatching Rate} = \frac{\text{Nos. of hatchlings}}{\text{Total no. of fertilized eggs}} \times 100$$

$$\text{Survival Rate (Fry to fingerling)} = \frac{\text{Total no. of remaining seed}}{\text{Initial no. of seed}} \times 100$$

2.5 Data analysis

Both descriptive and inferential statistics test like Analysis of Variance (ANOVA) was used to compare the mean of breeding parameters. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0.

3. RESULTS & DISCUSSION

The alternate hypothesis tests for the study are Mean Body Weight (MBW) has a positive correlation to Relative Fecundity (RF). The dependent variable RF was regressed on predicting variable MBW to test hypothesis H_1. MBW non-significantly predicted RF, F (1, 4) = 3.097, $p > 0.05$, which indicates that the MBW can play a non-significant role in shaping RF (b = -26.124, $p > 0.05$). These results clearly direct the negative effect of the MBW. Moreover, the $R^2 = 0.436$ depicts that the model explains 43.6% of the variance in RF.

The finding indicated a significant difference in the MBW and Body Length (BL) of brooders of six species, F (5, 413) = 69.701, p < 0.05) (**Table 1**). Grass Carp broods were the heaviest in terms of body weight and longest in its length. However, Rohu was recorded as the slimmest and Catla the shortest.

Table 1: Morphometric information indicating mean body weight (g) and mean body length (cm)

Species	Mean BW ± SD	Mean BL ± SD
Common carp	3590.48 ± 1924.48^{a}	54.86 ± 10.89^{a}
Grass carp	5483.57 ± 1502.49^{b}	72.25 ± 6.88^{b}
Silver carp	$2529.23 \pm 1722.10^{acd}$	57.85 ± 10.67^{ae}
Rohu	2023.45 ± 690.35^{ce}	49.53 ± 5.11^{cd}
Catla	2330.29 ± 846.41^{de}	49.20 ± 3.79^{d}
Mrigal	3285.74 ± 1049.53^{a}	59.70 ± 7.07^{e}

**Means with the same superscript within the columns are not significantly different at (p = 0.05).*

Pareto dot chart summarizes the overall species-wise absolute fecundity and relative fecundity of total numbers of brood sets (n = 414) used for propagation during the empirical trial (Figure 1).

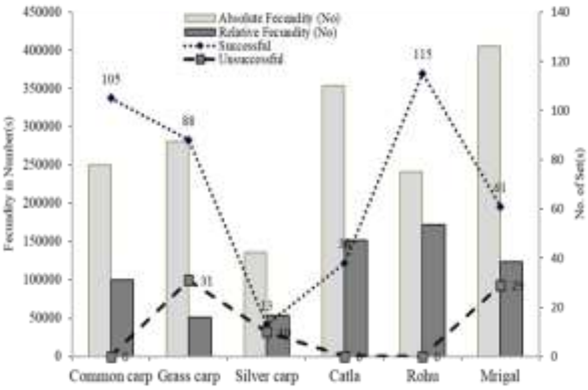

Figure 1: Pareto dot chart showing reproductive traits of six carps.

The same chart also reveals the proportion of successful and unsuccessful sets of brooders used for propagation. Notably, 84.49% (n = 414) of the brood sets responded successfully whereas unsuccessful sets recorded was only 15.51% (n = 76). The overall absolute fecundity ranged from 135,629 to 405,749 numbers for six species with a relative fecundity range of 51,178 to 171,642 numbers. The highest absolute fecundity recorded was 405,749 numbers for Rohu followed by 353,734 numbers in Mrigal and 341,269 numbers in Catla.

3.1 Fertilization, Hatching, and Survival Rate

The overall species-wise fertilization, hatching and survival rates are reflected in Figure 2. It is evident that CMCs (68.5%) and IMCs (75%)

have relatively higher survival rates than the Common Carp (65%). Overall fertilization rate ranged from 45% to 60% wherein Grass Carp, Silver Carp, and Mrigal had the least fertilization rate of 45%. Hatching rates varied from 52% to 65%, in which this study recorded the highest hatching success of 65% for Common Carp.

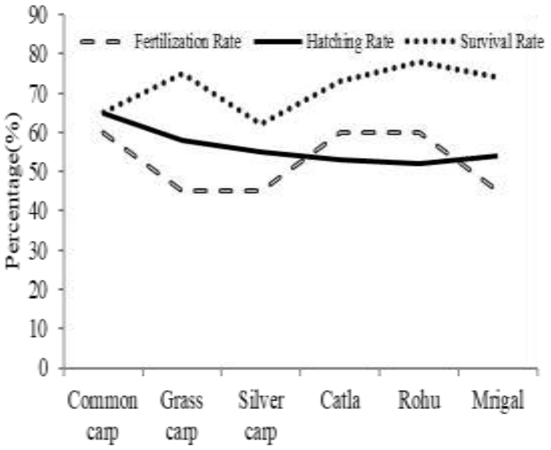

Figure 2: Reproductive traits of carps in terms of fertilization, hatching, and survival rates.

3.2 Reproductive Traits of IMCs

The mean body weight of the IMCs broods differed significantly ($p<0.05$) between Rohu (2023.45 ± 690.35) and Mrigal (3285.74 ± 1049.53) and also between Mrigal (3285.74 ± 1049.53) and Catla (2330.29 ± 846.41). The findings from the study indicate 366,917 and 446,928 numbers of absolute fecundity and relative fecundity respectively for IMCs. The consolidated fertilization rate for IMCs was 55%, wherein Rohu and Catla showed the highest hatching rates of 60%. Rahman et al. (2013) reported that the Rohu *Labeo rohita* has induced breeding performance of 80.76% and 70.96% of fertilization and hatchability rate respectively which is comparatively higher than the current finding. The low reproductive traits in this study could be due to low water temperatures, probable inbreeding, age factors, feeds and feeding, health-related, and also due to the management aspects compared to the study undertaken by Rahman et al. 2013.

3.3 Reproductive Traits of CMCs

The mean absolute fecundity of CMCs was noted as 208,135 numbers which ranged from 135,629 numbers for Silver Carp and 280,641 numbers for Grass Carp. Similarly, the mean relative fecundity was recorded as 52,402 numbers with a minimum of 51,178 numbers for Grass Carp and a maximum of 53,628 numbers for Silver Carp. On contrary, Basavaraja (2007) reported high fecundity of 100,000 & 150,000 numbers per kg body weight in Silver Carp *Hypophthalmichthys molitrix* and Grass Carp *Ctenopharyngodon idella*. This study recorded a fertilization rate of 53%, a hatching rate of 56%, and a survival rate of 73% which is almost similar to the findings of Venugopal et al. (2000) who reported mean fertilization, hatching, and larval survival rate of 75%, 70%, and 60% respectively. This comparable finding of the reproductive traits in CMCs indicates their reproductive suitability within the wet sub-tropical agro-ecological zone.

3.4 Fecundity of EC - *Cyprinus carpio*

The absolute fecundity recorded was 250,000 numbers while the relative fecundity was recorded as 100,000 numbers. The fecundity, fertility, and hatching rates range from 99,450 to 125,700 numbers, 79,560 to 103,074 numbers, and 63,648 to 82,459 numbers (Malik et al. 2017). Fertilization, hatching, and survival rate recorded for Common Carp were 60%, 65%, and 65% respectively. Similarly, 7.8-82% of fertilization rate, 32-80% of hatchability rate, and 32-80% of survival rate in the semi-natural environment were reported by Malik et al. (2017). Linhart et al. (1999) also obtained a mean relative fecundity of 100,000 to 300,000 eggs through a review report on Common Carp breeding in the USSR and European countries. Similarly, Thien et al. (2001) reported 65.5-85.9%, 10-66.8%, and 64.3-96.0% range survival rates in larva, fry, and fingerlings respectively.

4. CONCLUSIONS & RECOMMENDATION

By and large, fish farming in the country is at the subsistence level as commercialization is mainly constrained by the limited and small land holding of Bhutanese farmers. In order to meet the current requirement of fingerlings to enhance table fish production, two government farms are ensuring a consistent and adequate supply of fingerlings to Bhutanese fish farmers. The artificial propagation and breeding performance of different Carps in Government farms is crucial for upscaling Carps farming in the country. The finding from the current study indicated that IMCs has higher survival rates than CMCs and the Common Carps. However, CMCs have a better fertilization rate than IMCs. On the other hand, Common Carp has higher hatching rates than IMCs and CMCs. The body weight of IMCs brood was found higher when compared to CMCs and Common Carp.

It is also indicative that Silver carp is found to be the low-performing species in terms of fecundity, hatching rate, and overall larvae to fingerlings survival. Thus, based on the current findings on fingerlings' fecundity and survival rate, IMCs are recommended to be the better species for propagation in the Government farms at NR&DCA and at RCA as these centers have similar climatic and agro-ecological conditions. It is suggested that an in-depth study with the same age and weight of brooders of all Carp species considering the same variables needs to be investigated to further understand and establish sound scientific knowledge on their reproductive performances.

REFERENCES

Akinwande AA, Fagbenro OA and Adebayo OT. (2012). Fertilization, hatchability, survival and larval biometry in interspecific and intergeneric hybridization in Heterobranchus longifilis, Clarias gariepinus and Clarias anguillaris under controlled hatchery conditions.

Almeida DB, Da CMAP, Bassini LN, Calabuig CLP, Moreira CGA, Rodrigues MDN, Pe'rez, HJ, Tavares RA, Barela JAS and Moreira HLM. (2013). Reproductive performance in female strains of Nile tilapia, Oreochromis niloticus. Aquaculture International, 21, 1291-1300.

Bajer, PG and Sorensen PW. (2015). Effects of common carp on phosphorus concentrations, water clarity and vegetation density: a thermally stratified lake. Hydrobiologia, 746: 303-311.

Bandpei A, Mashhor MAM, Abdolmaleki SH, Najafpour SH, Bani A, Pourgholam R, Fazli H, Nasrolahzadeh H and Janbaz AA. (2011). The Environmental Effect on Spawning Time, Length at Maturity and Fecundity of Kutum (Rutilus frisii kutum, Kamensky, 1901) in Southern Part of Caspian Sea, Iran. Iranica Journal of Energy & Environment 2(4):374-381.
DOI: 10.5829/idosi/ijee.2011.02.04.3097.

Basavaraja N. (2007). Freshwater fish seed resources in India. In Assessment of freshwater fish seed resources for sustainable aquaculture. FAO Fisheries Technical Paper, M.G. Bondad-Reantaso (editor): 267-327. FAO, Rome.

Bazlur RSM, Mahmud Z, Ahmed F, Ghosh AK and Sabbir W. (2011). Induced breeding, embryonic and larval development of comet goldfish (*Carassius auratus*). Electronic Journal of Biology, 7(2): 32-39.

Das SM. (1964). A study on the fecundity on some freshwater fishes in India with a note on a new concept of comparative fecundity. Ichthyologic, 3: 33-36.

Department of Revenue and Customs. (2020). Bhutan Trade Statistics 2020. Department of Revenue and Customs, Ministry of Finance, Royal Government of Bhutan, Thimphu.

Hanumantharao L. (1971). Studies on the Biology of Cirrhinus mrigala (Hamilton) of the River Godavari. Indian Journal Fish, 21(2): 303-322.

Linhart O, Kudo S, Billard R, Slechta V and Mikodina EV. (1999). Morphology, composition and fertilization of carp eggs: a review. Aquaculture, 129(1-4).
https://doi.org/10.1016/0044-8486 (94)00230-L

Malik A, Abbas G, Jabbar A, Sajjad SS and Ali MA. (2017). Effect of different salinity level on spawning, fertilization, hatching and survival of common carp, Cyprinus carpio (Linnaeus, 1758) in semi-artificial environment. Iranian Journal of Fisheries Sciences, 17(4): 790-804.

More PR, Bhandare RY, Shinde SE, Pathan TS and Sonawane DL. (2010). Comparative study of synthetic hormones Ovaprim and carp pituitary extract used in induced breeding of Indian major carps. Libyan Agriculture Research Central Journal International, 1(5): 288-295.

Naeem M, Zuberi A, Salam A, Ashraf M, Elahi N, Ali M, Ishtiaq A, Malik T, Khan MJ, Ayaz MM, Iqbal MJ and Ahmad B. (2011). Induced spawning, fecundity, fertilization rate and hatching rate of grass carp (Ctenopharyngodon idella) by using a single intramuscular injection of ovaprim C at a fish hatchery Faisalabad, Pakistan. African Journal of Biotechnology. 10(53): 11048-11053.

National Research & Development Centre for Aquaculture [NR&DCA]. (2020).
Introduction.

http://www.nca.gov.bt/introduction/ (Accessed on 19th January, 2020).

Pathani SS. (1981). Fecundity of Mahseer, Tor putitora (Hamilton). Proc Indian Academic Science, 9: 253-260.

Rahman MH, Rahman MA, Hossain MMM, Haq M, Islam MS and Yeasmin SM. (2013). Comparative study on the induced breeding performance of Rohu (Labeo rohita) obtained from hatchery and natural sources. Eco-friendly Agriculture Journal, 6(9): 205-210.

RNR-SD (2020). Annual Livestock Statistics 2020. Royal Government of Bhutan. Renewable Natural Resources, Statistical Division, Directorate Services. Thimphu, Bhutan.

Thien TM, Dan NC and Tuan PA. (2001). Review of fish genetics and breeding research in Vietnam. In Gupta MV and Acosta BO (Editors). Fish genetics research in member countries and institutions of the International Network on Genetics in Aquaculture. ICLARM Conference Proceedings, 91-96.

Thinley P, Drukpola and Dorji N. [2018]. Effect of Stocking Density on Performance of Cultivable Carps in Southern Bhutan. Bhutan Journal of Animal Science [BJAS] , 25-30.

Venugopa G, Prasad JK, Reddy KR and Patnaik RRS. (2000). A new model magur hatchery of CIFE Kakinada Centre’s Design. Fishing Chime, 19(10 &11): 19-20.