Reproductive characteristics of wild and captive Scale carp, *Cyprinus carpio* var. *communis* in Kashmir, India


Faculty of Fisheries, Rangil, Ganderbal, J&K, India
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, 190 006, India

(Received 10 February, 2023; Accepted 4 April, 2023)

**ABSTRACT**

*Cyprinus carpio* var. *communis* is a widely distributed fish throughout the world. The fish has also got well adapted in various water bodies of Kashmir and constituted a major fishery here. The demand of the seed of Common carp has been increasing over the years. Domestication of fish seems to be an effective tool to meet the seed demand. However, domestication represents the challenges for aquaculture causing reproductive dysfunctions as per the earlier studies. In this background, current study was undertaken to evaluate the reproductive characteristics of both male and female Common carp, *Cyprinus carpio* var. *communis* in farmed and wild environment of Kashmir. Gonad somatic index (GSI) in both the sexes was found higher in wild fishes (female GSI=13.7±3.605; male GSI=7.403±2.01) compared to farmed fishes (female GSI=8.6±3.52; male GSI=6.37±1.5). Significant difference were found in the male GSI (p<0.05) and female GSI (p<0.05) between the two groups (wild and farmed). The average values of absolute and relative fecundity of fish in wild environment were recorded as 68864±35950.29 and 185.96±45.7 respectively. Whereas, in farmed environment, the absolute and relative fecundity was 44533±28572.59 and 115.98±49.25 respectively. Both absolute and relative fecundity significantly varied between the two environments (p<0.01). The results showed that cultured brooders produced more dense milt than wild individuals. In contrast, the milt volume was found higher in wild brooders than in cultured individuals.

**Key words:** Common carp, Wild, Farmed, Gonadosomatic index, Sperm density

**Introduction**

Normal gonad growth and effective reproduction require a favourable environment. Temperature and photoperiod influence fish reproduction in the majority of teleosts, including cyprinids (Lam, 1983). The majority of research found that gonad cyclical variations are influenced by environmental factors like as temperature, photoperiod, rainfall, and spawning substrate. A fish’s natural environment is never completely replicated in captivity. Some fishes ecobiology is unknown, therefore simulating the essential environmental factors for natural reproductive performance is difficult, if not impossible (i.e., spawning migration, depth, riverine hydraulics, etc.). Stress on captive fish can have a negative impact on reproductive function and gamete quality (Schreck et al., 2010). Fish confinement and overstocking in captivity may have an impact on egg quality. Chronic confinement throughout the final
stages of reproductive development, along with periods of acute stress, have been shown to disturb the endocrinology that underpins normal ovary growth and development in trout, potentially leading to significantly reduced progeny survival rates (Campbell et al., 1994). Humans handle reproduction in captivity, and there is no mate selection as there is in the wild world. Concerns regarding the impact of domestication on fish have arisen in response to the significant increase in worldwide aquaculture production (Naylor et al., 2005). The aquaculture setting provides a very different environment for fish compared to the wild, resulting in changes in the selective pressures that can lead to fundamental genetic changes at the population level (Skaala et al., 2004; Jonsson and Jonsson, 2006). Farming practices often result in a reduction in genetic diversity due to genetic bottlenecks, as well as the divergence of farmed stocks from wild populations as a result of novel selective pressures associated with domestication (Einum and Fleming 1997; Norris et al., 1999; Skaala et al., 2004).

The demand of the seed of common carp has been increasing over the years. Domestication of fish seems to be an effective tool to meet the seed demand. However, domestication represents the challenges for aquaculture causing reproductive dysfunctions as per the earlier studies. In this background, current study was undertaken to evaluate the reproductive characteristics of scale carp, *Cyprinus carpio* var. *communis* in farmed and wild environment. Studies on the influence of wild and farmed environments on reproduction characters is meagure so it is absolutely necessary to evaluate the reproductive parameters of fish. Understanding the difference in reproductive characteristics of both sexes in farmed and wild conditions will help in an identification of good quality males and females in particular environment that would significantly improve brood stock management, discarding non-productive individuals.

**Materials and Methods**

The investigation was carried on 240 samples of common carp from the wild (120; Dal lake) and the farmed environment (120; Pandach fish farm) during 2020. The fishes were dissected and sex was determined. Gonads of both the sexes were collected and weighed to nearest gm and Gonadosomatic index (GSI) were calculated using the gonad weight body weight ratio given by Desai (1970). Fecundity was estimated by Gravimetric method (Polder and Zystra, 1959) by placing the ovaries in 10% formaldehyde for at least 24 hours to bring hardness of eggs, so as to make easy and accurate calculation of sticky eggs. This was followed by drying of eggs on blotting paper for 1-2 hours, three subsamples of one gram each from anterior, middle and posterior region were weighed and then eggs were counted carefully by gravimetric method. The mean numbers of eggs were multiplied by gonad parts of ovary weighed on a sensitive mono-pan weighing balance and the total number of eggs per gonad was obtained, i.e. fecundity of fish. The absolute fecundity and relative fecundity was calculated as per the formula given by (Bagenal, 1978):

\[
\text{Absolute fecundity} = \frac{\text{No. of ova in the subsample} \times \text{total ovary weight}}{\text{Weight of subsample}}
\]

\[
\text{Relative fecundity} = \frac{\text{Absolute fecundity}}{\text{Weight of fish}}
\]

To determine the milt volume in fishes, each male was stripped once only and the total amount of expressible milt was collected individually by gently pressing the abdomen. The semen was collected directly into clean 15 ml graduated centrifuge tubes. The tubes were covered and immediately transported on ice (4 °C) to the laboratory for analyses. The sperm density was estimated by haemocytometer counting chamber. Milt was diluted at ratio of 1:1000 with Hayem solution (5g

**Fig. 1.** Reproductive system of *Cyprinus carpio* var. *communis* (A) Ovary (B) Testis
Na₂SO₄, 1g NaCl, 0.5g HgCl₂ and 200ml double distilled water) and mean spermatozoa count was calculated from three replicate samples for each fish at magnification of 40X. A haemocytometer counting chamber (Gem Industrial Corporation, Noida, India) was used to determine the spermatozoa density. A droplet of the diluted milt was placed on a haemocytometer slide (depth 0.1 mm) with a cover slip and counted using light microscopy. After 3-5 min (to allow sperm sedimentation), the number of spermatozoa was counted (Rainis et al., 2003) Fig. 2.

reported by Kouril et al. (1997a) they reported superior development of gonads in wild perch under natural conditions. Fontaine et al. (2008) has also reported the lower quality of reproduction under controlled conditions in farmed perch. Kristen et al. (2012) observed the GSI of wild fish of both the sexes higher than the farmed one while comparing the GSI of wild and farmed perch. This differences between farmed and wild Common carp may be mainly by unsuitable feed for the farmed fish as suggested by Izquierdo et al. (2001); Bell et al. (1997); Henrotte et al. (2010); Kestemont et al. (1999); Kestemont et al. (2008b). The significant difference in GSI between wild and farmed conditions during the present study indicated that culture system has an influence on GSI.

**Statistical analysis**

Results were presented as mean±SD. Statistical significant differences were determined by T-test using, Microsoft excel, PAST 3 software, Spss Window (Version 16).

**Results and Discussion**

The results of reproductive biology of fishes is presented in Table 1. The mean GSI of the female fishes in wild and farmed conditions was 13.7±3.605 and 8.6±3.52 respectively (Fig. 3). The Gonadosomatic index in wild fish of both the sexes (Fig. 3 and 4) during the present study was found significantly higher than the farmed one. Similar findings were

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Wild (Mean±SD)</th>
<th>Farmed (Mean±SD)</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>435.1±364.889</td>
<td>375.2±261.32</td>
<td>0.731</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Length</td>
<td>301.43±76.32</td>
<td>280.77±74.51</td>
<td>1.0612</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Ovary weight</td>
<td>48.96±22.745</td>
<td>33.68±21.65</td>
<td>2.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>No. of ova</td>
<td>135.2±106.18</td>
<td>133.9±148.28</td>
<td>0.707</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Absolute fecundity</td>
<td>68864±35950.29</td>
<td>44533±28572.59</td>
<td>2.85</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Relative fecundity</td>
<td>185.96±45.7</td>
<td>115.98±49.25</td>
<td>5.7</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Female GSI</td>
<td>13.7±3.605</td>
<td>8.6±3.52</td>
<td>5.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Sperm volume (ml)</td>
<td>2.39±1.64</td>
<td>1.46±0.88</td>
<td>2.62</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Sperm density (×10⁹/ml)</td>
<td>3.53±0.272</td>
<td>3.84±0.181</td>
<td>-5.148</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Kristen et al. (2012) who reported the fecundity in wild condition was significantly higher than the farmed conditions. However, Kjesbu et al. (1991) reported captive Cod had higher potential fecundity than wild cod. Thorpe et al. (1984) observed that cultured salmon had smaller but higher numbers of eggs per unit weight than wild sh. Contreas Sanchez et al. (1998) reported that when the fishes were subjected to stress in the form of confinement, significant differences in relative fecundity were found but absolute fecundity were not significantly affected. Randak et al. (2006) while studying the effect of captive conditions on reproductive traits of brown trout Salmo trutta reported no difference in the fecundity (absolute, relative) between the farmed and wild fish. The reason for such a difference in the results from the above work may be there is the difference in species, age, size and environment conditions between the present study and the study done earlier. According to Simpson (1951) the fecundity of an female fish varies in relation to many factors including size, age, species and environmental conditions, such as water temperature, food availability, and salinity. It may be believed that the lower fecundity in farm conditions during the present study might be due to the improper and underfeeding of fish or genetic makeup of fish stock or overstocking in pond which affected the growth of fish and indirectly the gonadal development which are similar to the findings with Billard (1995) who reported that the fish in pond show low fecundity and fail to spawn due to the stress of confinement, insufficient food and over stocking density.

In the present study mean sperm volume was higher in wild brooder (2.393±1.64ml) than in farmed individual (1.486±0.88 ml). Comparison of wild scale carp with farmed fishes revealed a significant difference in sperm volume (p<0.05) Fig. 5. Mean sperm volume in farmed and wild fish was found similar with the finding of Belova (1981) that indicated sperm volume in the range of 1-9 ml for scale carp. Mean seminal volume was also similar with the results reported by Nahiduzzman et al. (2014), who reported the sperm volume of Scale carp as 2 ml during the spawning season. Bozkurt (2006) also reported the volume of milt in scaly carp as 2.75 ml. Thamizh selvi and Thirumathal (2016) also reported the range of volume of milt in the Cyprinus carpio from 1.83 to 1.98 ml.

Higher sperm volume of wild fish than farmed has also been reported by Hajirezae et al. (2011). Morisawa et al. (1979) reported that the cultured fish spent their entire life (fry to adult) in a hypotonic medium contrary to wild males of Caspian brown trout. The hypotonicity of freshwater environment establishes the hydration of testis, possibly causing the dilution of milt and leading to a higher milt volume which is contrary to the results reported by Hajirezae et al. (2011). It is likely that cultured males of Scale carp with the application of an effecient osmoregulation, excrete the excess water of the body in response to hypotonicity of freshwater environment as reported by Hajirezae et al. (2011) in Caspian brown trout while studying the milt quality in the cultured and wild stocks on comparative basis. It is essential to say that the weight of wild males was higher than cultured individuals during the present study. Suquet et al. (1994; 1998) have reported that milt volume increases with increase of weight in turbot (Scophthalmus maximus). Thus the higher weight of wild fish seems one of the reasons for the higher milt volume of wild males than cul-

![Fig. 4. Box plot depicting GSI of wild (A) and farmed (B) Cyprinus carpio var. communis (male)](image)

![Fig. 5. Relative sperm volume (mean) of Cyprinus carpio var. communis in wild (B) and farmed (C) conditions](image)
tured fishes. The sperm volume has also been found higher in wild European flounder (0.7ml; Sahin et al., 2012) than in cultured ones (0.2 ml; Aydýn et al., 2011). Cabrita et al. (2006) has found a low sperm quality and volume of stocked animals.

In the present study, the average sperm density of 3.534±0.27 x10⁹ mL⁻¹ in wild and 3.8415 x10⁹ ± 0.18ml⁻¹ in farm (Fig.6) was recorded for the fish which are in conformity with the results sof Bozkurt et al. (2009) for grass carp (2.87-33.914 x10⁹ mL⁻¹). Chutia et al. (1998) have reported the sperm density of 6.6x10⁹ sperm cells/ml in C. carpio. Thamizh selvi and Thirumathal (2016) recorded the average sperm density of 2.25x10⁹ sperm cells/ml in C. carpio from January to March, 2013. Lahnsteiner et al. (2000) found that the sperm density of C. carpio as 0.5 to 1.0x10¹¹ cells per mL of milt. Comparison of farmed fish with wild revealed that sperm density of farmed fish was higher than wild individual. Similar results have been reported by Hajirezaee et al. (2011).

Relationship between fish body weight, body length, ovary weight, absolute fecundity and relative fecundity

Table 2 shows the relationship between body weight, body length, ovary weight, absolute fecundity and relative fecundity in case of wild condition. The data reveals that significant positive correlation was found between fish weight and fish length (r=0.878, p<0.01), fish weight and ovary weight (r=0.888, p<0.01), fish weight and absolute fecundity. (r=0.907, p<0.01). Furthermore significant positive correlation was formed between fish length and ovary weight (r=0.981, p<0.01), fish length and absolute fecundity (r=0.976, p<0.01), Ovary weight and absolute fecundity (r=0.998, p<0.01). Relative fecundity showed a significant negative correlation with weight, length and absolute fecundity(r=-0.747, p<0.01; r=-0.419, p<0.05 and r=-0.460, p<0.05 respectively).

**Table 2.** Pearson correlation between fish body weight, body length, ovary weight, absolute fecundity and relative fecundity in wild Scale carp

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Weight</th>
<th>Length</th>
<th>Ovary weight</th>
<th>Absolute fecundity</th>
<th>Relative fecundity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>1</td>
<td>0.878&quot;</td>
<td>0.888&quot;</td>
<td>0.907&quot;</td>
<td>-0.747&quot;</td>
</tr>
<tr>
<td>Length</td>
<td>1</td>
<td>.981&quot;</td>
<td>.976&quot;</td>
<td>0.976&quot;</td>
<td>-0.419&quot;</td>
</tr>
<tr>
<td>Ovary weight</td>
<td>1</td>
<td>0.998&quot;</td>
<td>1</td>
<td>1</td>
<td>-0.460&quot;</td>
</tr>
<tr>
<td>Absolute fecundity</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative fecundity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**"**correlation is significant at 0.01 level (2 –tailed).  
* correlation is significant at 0.01 level (2 –tailed)
Absolute fecundity has been usually related to fish or gonad length and weight (Bagenal, 1966). A relationship has been found to exist between fish length and fecundity in different species of fishes. Length has an advantage over other factors in that the fish does not shrink significantly although it can lose weight during the spawning season (Bagenal, 1967). Clark (1934) suggested that the fecundity of a fish increases in proportion to the square of its length. Simpson (1951) pointed out that the fecundity of plaice was related to the cube of its length. The close relationship between absolute fecundity and fish length demonstrated here is supported by the works of Treasurer (1990); Joshi and Khanna (1980) and Dobriyal (1988) and many others. Fecundity generally increased with total length in several fishes. A direct proportional increase in the fecundity with the increase in fish weight has been reported by Dobriyal (1988) and Lehman (1953). During the present study an increase in the number of ova was found with the increase in body weight in both the groups (wild and cultured). Absolute fecundity of Cyprinus carpio var. communis under both wild and farmed condition had a strong correlation with ovary weight than body weight and Total length. These results are in conformity with the results obtained by Khan et al. (1992) for Mystus tengra and Nabi et al. (2007) for Glossogobius giuris. According to Smith (1947), the fecundity has been more related to the fish weight than to the length in Salvelinus fontinalis. Same has been reported for Liza parsia by Rheman et al. (2002). However, the ‘r’ value, the correlation between fecundity and total weight was higher than that of fecundity and total length, suggesting that total weight is a better predictor of fecundity in the present study than total length. Similar finding have been reported by Ikomi and Odum (1998) in Chrysichthys auratus. Varghese (1961) has found a reduction in the rate of egg production with the increase in ovary weight in Coilia ramcarati. But in present study a corresponding increase in the number of eggs with the increase in the weight of ovary has been found, as in Tilapia nilotica (Soliman et al., 1986), Labeo gonius (Joshi and Khanna, 1980), Esox lucius (Treasurer, 1990) and Chinese silver carp (Dobriyal, 1988).

**Conclusion**

The fish showed better reproductive characteristics in wild than farmed environments terms of GSI, fecundity and sperm volume. The finding of the present study indicated that the type of environment (wild and farmed) has significant impact on the reproductive characteristics of both the sexes of fish.

**Acknowledgement**

Authors are highly thankful to the faculty of fisheries Rangil Ganderbal and Fisheries department for proper assistance during this experiment.

**References**

Aydin, I., Sahin, T., Polat, H. and Kucuk, E. 2011. A study on the spermatological characteristics of hatchery-reared flounder (Platichthys flesus luscus Pallas,


Kouril, J. and Hamackova, J. 2000. The semi artificial and artificial hormonally induced propagation of Euro-


