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Studies on the fecundity (F), gonadosomatic index (GSI) and hepatosomatic index (HSI) of *Salmo trutta fario* (Brown trout) at Kokernag trout fish farm, Anantnag, Jammu and Kashmir

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Abstract
Fecundity (F), Gonadosomatic index (GSI) and Hepatosomatic index (HSI) of *Salmo trutta fario* (Brown trout) at Kokernag trout fish farm, Anantnag, Jammu and Kashmir was estimated for a period of six months (October, 2008- March, 2009). During the present study the fish samples was within the range of 30cm to 45.8cm in length and 250g to 750g in weight. The fecundity per kg body weight of the fish ranged between 891-1570 eggs. The maximum mean value of fecundity was 1570 for fish with a mean total length of 45.8 cm and mean body weight of 750g. The minimum fecundity 891 was recorded with fish of mean total length 30cm and mean body weight 250g.The mean GSI of female fish fluctuated between minimum 8.4 to 17.5 with minimum of 8.4 in March and 17.5 in November. Similarly the mean (HSI) of female also fluctuated between 1.2 to 1.96 with its minimum value in November and maximum in March.

Keywords: *Salmo trutta fario*, fecundity, gonadosomatic index, hepatosomatic index

1. Introduction
The brown trout is a native of European waters and now it has become extensively distributed throughout many of the fresh waters of the world. Brown trout (*Salmo trutta fario*) and Rainbow trout (*Oncorhynchus mykiss*) constitute the trout fishery in the streams, Lakes and reservoirs in the Indian uplands (Vass, 2000) [24]. Trout is highly nutritious and it contains omega-3 poly unsaturated fatty acid that is needed for the development of brain and retina in infants (Ackman, 1989) [1]. In the inland waters the natural seed propagation and production of trout is significantly low. Therefore to this fishery artificial propagation is the only source by which seed could be raised in hatchery or farm for stocking in streams, lakes etc. (Vass, 2000) [24]. Thorough knowledge on the fecundity of the fish is essential for evaluating the commercial potentialities, stock study, life history, particular culture and the management of fishery (Lagler *et al*., 1956, Zin *et al*., 2011) [14, 26]. Fecundity is an important parameter in fishes for determining the reproductive potential of fish species (Zin *et al*., 2011) [26]. Fecundity along with other indices such as gonadosomatic index (GSI) and hepatosomatic index (HSI) are used to access the reproductive condition of a fish. Changes in the gonadosomatic index (GSI) helps to determine the reproductive season of the fish (Arruda *et al*., 1993) [5]. GSI value has been considered by many workers in different fishes for determining spawning season and spawning frequency (Islam *et al*. 2008., Ghaffari *et al.* 2011., Kingdom and Allison, 2008., Sadekarpawar and Parikh, 2013 and Jan *et al*, 2014) [10, 9, 12, 20, 11]. Liver produces vitellogenin which is a yolk precussor thus plays an important role for the development of eggs. Hence the study of HSI is also considered important by many workers, because it describes the status of energy stored in fish and is considered as good indicator of recent feeding activity of the fish (Tyler and Dunns, 1976) [22]. Lot of work has been done in India, abroad and also by our local workers in the past on Rainbow trout but not much is known about *Salmo trutta fario*. This fish prefers wild type of environment and accepts less amount of artificial feed which is a big challenge for its culture practice. Kokernag trout hatchery is doing lot of efforts for artificial propagation of this fish. The present study would be helpful to know the exact breeding season of the fish so that maximum number of eggs could be extracted from the brood fishes for

raising this fish artificially in a hatchery and then stocking them in their natural habitats as well as in raceways of the Kokernag trout fish farm.

2. Material and methods

2.1 Study sites

Kokernag is located within geographical coordinates of 33.584721°N and 75.308601°E and is famous for its trout stream and trout hatchery where trout is reared. The study site was selected at Department of Fisheries Kokernag trout fish farm, Anantnag, Jammu and Kashmir. The species of trout fish which are bred as well as propagated are Rainbow trout (*Oncorhynchus mykiss*) and Brown trout *Salmo trutta fario*.

2.2 Collection and identification of specimens

The present study is based on the data collected from sixty specimens over a period of six months. The method for identification of fish was used as described earlier by Day 1876 and Kullander *et al*., 1999 [13, 8].

2.3 Measurements

The fishes were collected from the tanks or raceways and the total length of the fishes was measured to the nearest 0.01cm and weight was taken on digital balance (Shimadzu UX320G) with 0.01g accuracy. It was properly washed, cleaned and prepared for dissection. Its abdominal region was dissected with the help of a sterile blade. The gonads and liver was taken out in intact form and weighed. The ovary was then fixed in 5% formalin and the procedure for estimation of fecundity was followed as given below.

2.4 Fecundity (F)

In the present study the sub sample method was applied to estimate the fecundity. Three different sections, each of 1 g in weight was taken from the anterior, middle and posterior regions of ovary, respectively. Sections were weighed on digital balance. Ova from these three small sections of ovary were separated and counted. As it was over, the individual number of these sections was added and made a sum total of it. Then the fecundity of the collected specimen was calculated according to (Yelden and Avsar, 2000) [25].

$$F_1 = \frac{\text{Ovary weight} \times \text{number of eggs in the sub sample}}{\text{Sub sample weight}}$$

Later, by taking the mean number of three sub sample fecundities (F_1, F_2 and F_3), the individual fecundity for each female fish was calculated by the following equation:

$$F = \frac{F_1 + F_2 + F_3}{3}$$

2.5 Gonadosomatic Index (GSI)

A live ripe female specimen was collected from the source. The weight and total body length was recorded. It was dissected and finally the ripe ovaries were exposed and were taken out carefully in intact form. Weight of gonads was taken and finally GSI value of female specimen was calculated. The GSI was calculated to know the maturity in order to determine the breeding cycle of the fish. This was done as percentage of the gonad weight (GW) in terms of body weight (BW) of the fish (Afonso-Dias *et al*., 2005) [2].

$$GSI = \frac{GW}{BW} \times 100$$

Where, GW and BW are gonad weight and total weight of the fish, respectively.

2.6 Hepatosomatic index (HSI)

Hepatosomatic index (HSI) was calculated to examine monthly variations in feeding intensity and to correlate these variations with breeding cycles. The HSI was calculated according to the method of Rajaguru, 1992 [17] by determining the weight of hepatopancreas as a percentage of the total live weight of the fish.

$$HSI = \frac{LW}{BW} \times 100$$

Where, LW and BW are liver weight and total weight of the fish, respectively.

3. Results

3.1 Fecundity (F)

In the present study the fecundity was found maximum 1570 with fishes having mean total length of 45.8cm and mean weight 750g. While the minimum fecundity 891 was recorded with fishes of mean total length 30cm and mean body weight 250g as shown in table 1. This suggests that large sized fishes contain more eggs as compared to small sized fishes. So egg production is related to the size of the fish. Similar results were shown by Vass *et al*, 1981[23].

3.2 Gonadosomatic Index (GSI)

The mean GSI of female fish varied from minimum 8.4 in March to maximum 17.5 in November as shown in table 2. This suggests that in the month of November *Salmo trutta fario* reached its peak breeding period.

3.3 Hepatosomatic Index (HSI)

In the present study the mean HSI of female fish fluctuated from minimum 1.2 in the month of November to maximum 1.96 in the month of March as shown in table 2. The variations in HSI have been observed on monthly basis as well as seasonal basis depending upon the breeding season as well as the availability of food. The present study shows a high hepatic activity during March and low hepatic activity during spawning season November.

Table 1: Month wise estimation of fecundity (F) of *Salmo trutta fario*

Month	Mean total length (TL)cm	Mean body weight (BW)g	Mean fecundity (F)
October	30	250	891
November	40	380	1150
December	45.8	700	1570
January	45.5	546	1480
February	45.6	554	1520
March	45.6	548	1500

Table 2: Monthly Gonadosomatic index (GSI) and Hepatosomatic index (HSI) of *Salmo trutta fario.*

Month	GSI	HSI
October	15.5	1.4
November	17.5	1.2
December	16.2	1.3
January	14.2	1.3
February	10.8	1.8
March	8.4	1.96

4. Discussion

Fecundity is the estimation of ova content in the ovary of a matured female specimen. In fisheries science, several methods have been applied to estimate fecundity (Arnold *et al.*, 1997) [4]. The present study reveals that the maximum fecundity was 1570 for fish measuring 45.8cm in mean total length and 750g in mean weight and minimum fecundity 891 was observed in fish having mean total length of 30cm and mean weight of 250g. This study revealed that larger fish were more fecund than smaller fish. Similar results were also reported in the past (Dan, 1977, Alam and Pathak, 2010, Rheman *et al*., 2002 and Ratnalka *et al.*, 2013) [7, 3, 19, 18] also observed same findings. Variation in the fecundity among the fishes of the same as well as different species is very common depending upon the various factors such as size of the fish, age and condition of the fish, and also depends upon the space and food intake by the fish. Bagenal (1967) [6] reported that length and weight are reliable indicators of the capacity of egg production; hence the fecundity increases with the increase of the fish in size and weight. This condition is also found in the present work, in which the number of eggs increases with an increase of length and weight of fish.

In *Salmo trutta fario* the GSI was observed to vary with season. A gradual and distinct development of gonad was seen reaching its peaks during November. Thereafter, GSI decline abruptly. GSI indicates gonadal development and maturity of fish which increases with the maturation of the fish and declines abruptly thereafter (Parameswarn *et al*., 1974) [16]. Yeldan and Avsar (2000) [25] also reported that GSI is widely used especially for the bony fishes in order to examine the spawning period because its value is directly related to the development of the gonad. In the present study, GSI showed higher value during the period from November - December with the highest value of 17.5 noticed in November and declined gradually from January. The higher GSI values recorded during the present study were in the month of November which shows peak breeding season with lower values of HSI in the same month. It was observed that when the HSI values were at its minimal, the GSI values were highest and this condition suggests the point that the liver has a weight loss during reproduction which may indicate the mobilization of hepatic reserve for gonads maturation (Zin *et al*., 2011) [26] and therefore the same period might be the pre - spawning period of this fish. HSI is associated with liver energetic reserves and metabolic activity (Lenhardt *et al.*, 2009) [15]. The mean HSI of fish fluctuated from minimum 1.2 in the month of November to maximum 1.96 in March.

5. Conclusion

Fecundity along with gonadosomatic index (GSI) and hepatosomatic index (HSI) are used to assess the reproductive condition of the fish. Study of HSI is also important because it describes the status of energy stored in fish and is thus considered as good indicator of recent feeding activity, metabolic activity. GSI is a most vital parameter which provides significant information about the cyclic changes taking place during different seasons. The seasonal timing of reproduction and spawning time can easily be identified by the changes in the GSI, which determines reproductive season. Therefore, the study of these indices will not only provide useful information about the effect of season on the reproductive activity of the fish, but information about these parameters is also useful for rational exploitation of the fish. The present study can be further expanded and the results/findings can be used as baseline information by researchers. It was found that the fecundity of trouts is very low as compared to the carps so the findings of the present work could be used by the Fisheries Department for obtaining eggs at right time so as to ensure 100% fertilization and maximum production for stocking in raceways and also in their natural habitats so as to cater the public demand of this most preferred fish.

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