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Study on the fecundity of *Salmo trutta fario* (Brown trout) in Kashmir

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Abstract

The study has been carried in the year 2004 and describes fecundity, spawning season and sex ratio of brown trout, *Salmo trutta fario*. A total of 121 brown trout (67 males and 54 females) were captured by angling. Gonad somatic index (GSI) confirmed that spawning lasted from October to December. The left ovary, with some exceptions, was found to be longer and heavier producing more eggs than the right one. The absolute fecundity of sampled population varied from 527 to 2445 and the relative fecundity had a mean value of 2.56. Fecundity was positively co-related with the total fish length (r=0.865), fish weight (r=0.9426) ovary weight (r=0.952) and ovary length (r=0.845).

Keywords: Gonadsomatic index, ovaries, fecundity, reproduction, *Salmo trutta fario*.

1. Introduction

Salmo trutta fario (known as Mediterranean trout, mountain trout, stream trout, coral trout,

and big spotted trout) is a salmonid species occurring in inland water habitats in northern Africa, southern Europe, western Asia and Anatolia (Tortonese, 1954).

The introduction of trout in Kashmir was made in 1900 (Mitcheil, 1918). At present brown trout is doing well in the cool water streams of the Kashmir valley and is the most famous fresh water species found in the streams of Sindh, Bringi, Lidder, Ferozpur, Erin etc.

The size at which fish attain sexual maturity and the number of eggs they produce are important considerations in the management of sport and commercial species. Studies pertaining to the fecundity reveal useful information about the reproductive potential of a fish species. Fecundity is an adaptation to varying environmental conditions which work through the food supply; hence is basic means of regulating the rate of reproduction to changing conditions (Nikolskii, 1969).

The fecundity aspect of reproduction is deeply associated with the studies of population dynamics and fishery management practices.

Several investigators have contributed to this aspect of fishery biology (Khan, 1945, Pillay, 1954; Bagenal, 1957, 71, 78; Dass, 1964; Wootton, 1973; Singh et al, 1982; Dobriyal, 1988; Victor et al, (2004); Naeem et al (2005); Jacobson et al (2009); Mekkawy and Hassan (2011 and 2012); Shinkafi et al (2011). A review of the literature reveals that information on fecundity of salmonids is limited. Thus, the aim of the study was to report on the fecundity, spawning season and sex ratio of *Salmo trutta fario*.

The current investigation was carried out in the Sindh stream and Ferozpur stream situated at two different districts of Kashmir valley at an average altitude of 2100m with 75.12˚ E longitude and 34.17˚ N latitude and 2400m with74.56˚ E longitude and 34.07˚ N latitude above sea level respectively. During the study, three sites were selected for collection of fish: middle, uphill and downhill parts of the stream.

2. Materials and methods

The anglers used fishing rods with various types of artificial flies to catch the trout. A total of 121 brown trout were captured by angling. Estimation of fecundity was based on 15 mature female brown trout specimens which were procured from Laribal trout fish farm. The gravid females were identified by their swollen abdomens.

After various body measurements, the fishes were dissected and both the ovaries were taken out carefully. The moisture was thoroughly wiped out from the ovaries with a blotting paper. The length and weight of ovaries was noted with complete care. The collected ovaries were then placed in 4% 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 sub samples of one gram each were taken from anterior, middle and posterior parts of ovary and were weighed on a sensitive mono-pan balance and then eggs were counted carefully in each sub-sample.

The number of eggs (F1) for the sub sample was estimated using the equation

$$F1 = \frac{\text{Gonad weight x No. of eggs in the sub sample}}{\text{Sub sample weight}}$$

(Yeldan and Avsar, 2000). #

Later, by taking the mean number of three sub-sample fecundities (F1, F2 and F3) the individual fecundity for each female fish was calculated.

$$F = \frac{(F1 + F2 + F3)}{3}$$

Fecundity relationships with various body parameters were established by applying the method of least square, i.e.

$$Y = a + b\,X$$

or in logarithmic form

$$\log Y = \log a + b \log X$$

where Y = fecundity; X = body measurements, such as fish length (L), fish weight (W), ovary weight (OW) and ovary length (OL); a (intercept) and b (slope) are the constants.

In order to assess the gonadal development and spawning season of fish, the gonadsomatic index (GSI) of the fish was calculated as per formula:

$$GSI = \frac{\text{Weight of gonad}}{\text{Total weight of fish}} \times 100$$

3. Results

3.1 The Ovary Features

The ovary of *Salmo trutta fario* was bilobed. The shape and size of ovary did not remain same throughout the year but it was found to be dependent on the different stages of sexual maturity of the female. Usually the two lobes of the ovary were not of the same size, so a comparison was made between the right and left ovaries of six individuals as to their length, weight and number of eggs (Table 1).

Table 1. Ovary Features of *Salmo Trutta fario.*

S.No	Total Fish Weight (gms)	Total Fish Length (mm)	Standard Fish Length (mm)	Right Ovary			Left Ovary		
				Weight (gms)	Length (mm)	No. of Eggs	Weight (gms)	Length (mm)	No. of Eggs
1.	270	280	255	9.62	140	404	13.18	160	553
2.	760	375	345	16.7	105	434	40	167	1013
3.	425	321	292	37	144	717	41	163	763

4.	350	305	276	24	135	480	36	160	750
5.	425	354	301	26	150	494	31	196	568
6.	640	402	355	55	158	843	64	192	917

As shown in Table 1, the left ovary is generally longer and heavier than the right and usually contains more eggs. This difference is primarily due to the anatomical arrangement of the organs in the coelomic cavity. In the brown trout, the posterior portion of the intestine usually bends strongly to the right, thus crowding the right ovary at its caudal end. The length of the ovary is inversely proportional to the degree of crowding. However, the left ovary is not always the longer. One fish was observed to have a longer right ovary and it was interesting to note that the specimen had an intestine which bent to the left instead of the right. In one or two fishes the ovaries were of approximately equal length, with the intestine bending neither to the right nor to the left.

Table 2. Relationship between Fecundity and various body and ovary parameters of *Salmo trutta fario* (Brown Trout), year 2004.

S.No	Total Fish Weight (gm)	Total Fish Length (mm)	Standard Fish Length (mm)	Ovary weight (gm)	%age of Ovary wt. in Total wt. of Fish	Ovary Length (mm)	Fecundity	Relative Fecundity
1.	270	280	255	22.8	8.4	150	957	3.54
2.	760	375	345	56.7	7.46	136	1447	1.90
3.	220	256	235	27.8	12.6	112	527	2.39
4.	425	321	292	78.9	18.56	153.5	1480	3.48
5.	330	323	287	50	15.15	137.5	808	2.44
6.	310	322	286	47.11	15.19	134.5	693	2.23
7.	288	285	252	38.15	13.24	130	688	2.38
8.	288	289	267	39	13.54	132.5	597	2.07
9.	1130	431	397	196	17.34	219	2335	2.06
10.	1000	430	385	168	16.8	215	2338	2.33
11.	950	425	375	188	19.7	217	2445	2.57
12.	350	305	276	60	17.14	147.5	1230	3.51
13.	425	354	301	57	13.41	173	1062	2.49
14.	370	377	286	38	10.27	115	844	2.28
15.	640	407	355	119	18.59	175	1765	2.75
Av.	517.06	350	306.26	79.09	14.55	156.5	1281	2.56

3.2 Fecundity

The fecundity of *Salmo trutta fario* was studied in relation to fish length, fish weight, ovary length and ovary weight. The fecundity, relative fecundity and other associated parameters studied are given in Table 2.

3.2.1 Relationship between Fecundity and Fish Length (L)

The scatter diagram revealed a linear relationship between fecundity and fish length (Figure1) and the coefficient of correlation was significant (P = 0.00). The relationship between fecundity (F) and total fish length (L) is expressed by the equation

$$F = -2077 + 9.724\ L;\ (R^2 = 0.8647)$$

A logarithmic transformation gives the straight-line regression of log fecundity on log length

$$\log F = -3.376 + 2.54 \log L;\ (R^2 = 0.719)$$

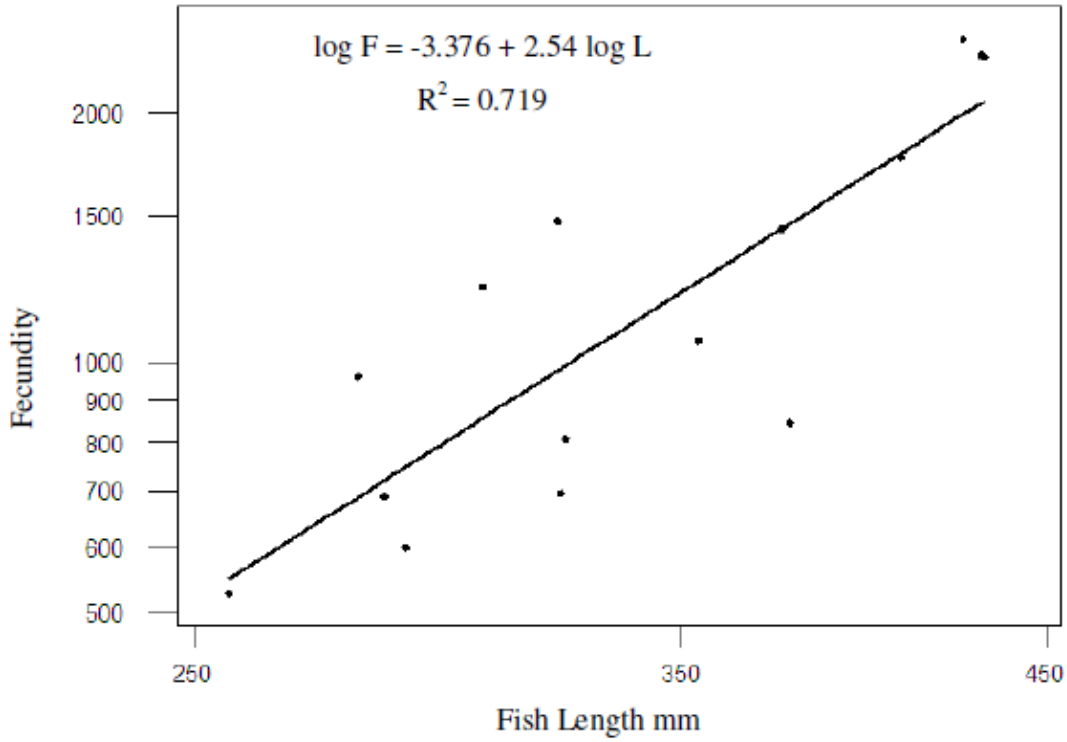

Figure 1

3.2.2 Relationship between Fecundity and Fish Weight (W)

The data pertaining to fish weight (somatic + gonadal) and absolute fecundity revealed a linear relation (Figure 2) between the two parameters which was expressed mathematically as:

$$F = 204.75+2.082\ W;\ (R^2 = 0.9\ 426)$$

$$\text{or } \log F = 0.668 + 0.90 \log W;\ (R^2 = 0.867;\ P = 0.00)$$

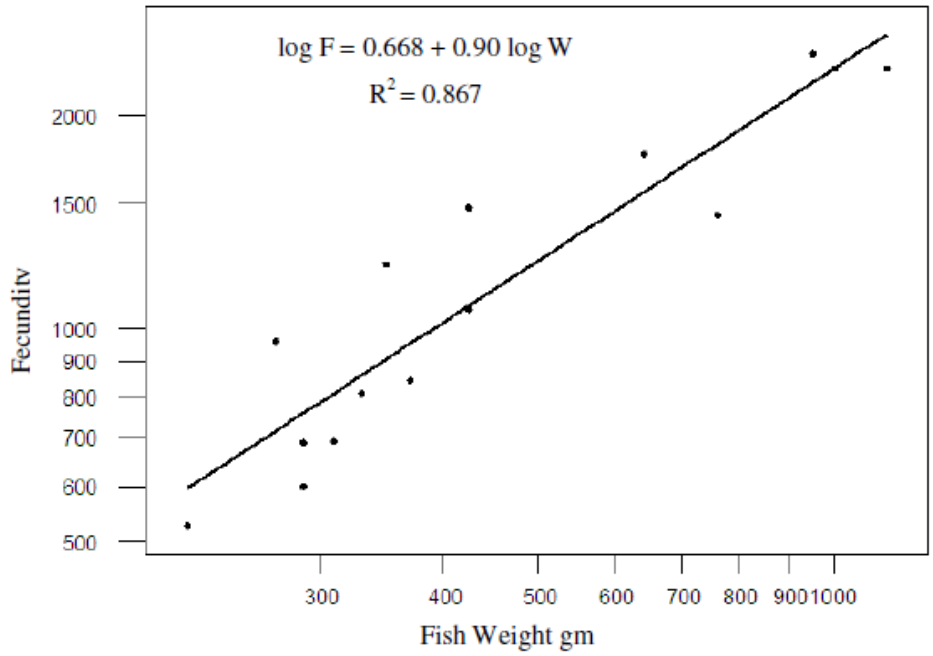

Figure 2

3.2.3 Relationship between Fecundity and Ovary Length (OL):

Fecundity showed increase with an increase in the length of ovaries (OL). A significant linear relationship was observed (Figure 3) which was expressed by the equation:

$$F = -989.97 + 14.798\ OL\ (R^2 = 0.845)$$

$$\text{or } \log F = -1.497 + 2.083 \log OL;\ (R^2 = 0.786;\ P = 0.00)$$

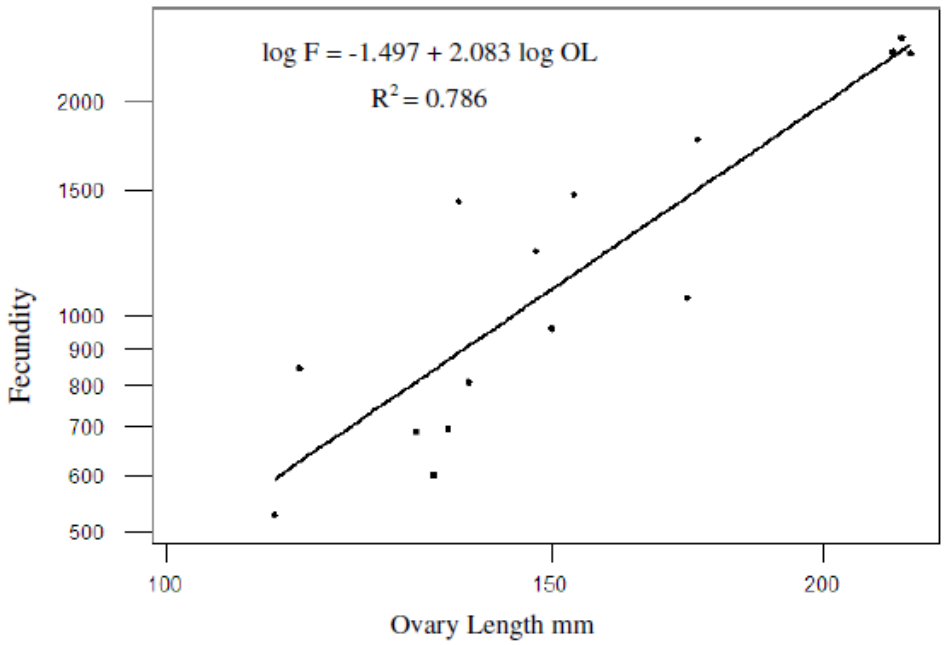

Figure 3

3.2.4 Relationship between Fecundity and Ovary Weight (OW):

A highly significant linear relationship was found between the two parameters (Figure 4) which was expressed by the equation:

$$F = 434.8 + 10.699\ OW;\ (R^2 = 0.952)$$

$$\text{or } \log F = 1.832 + 0.68 \log OW;\ (R^2 = 0.812, P = 0.00)$$

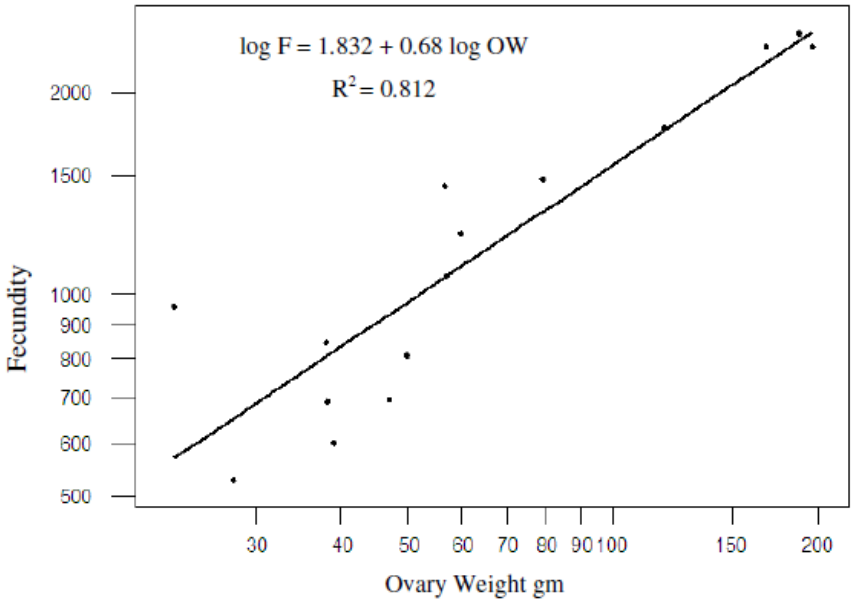

Figure 4

3.2.5 Relationship between Ovary Weight (OW) and Fish Weight (W):

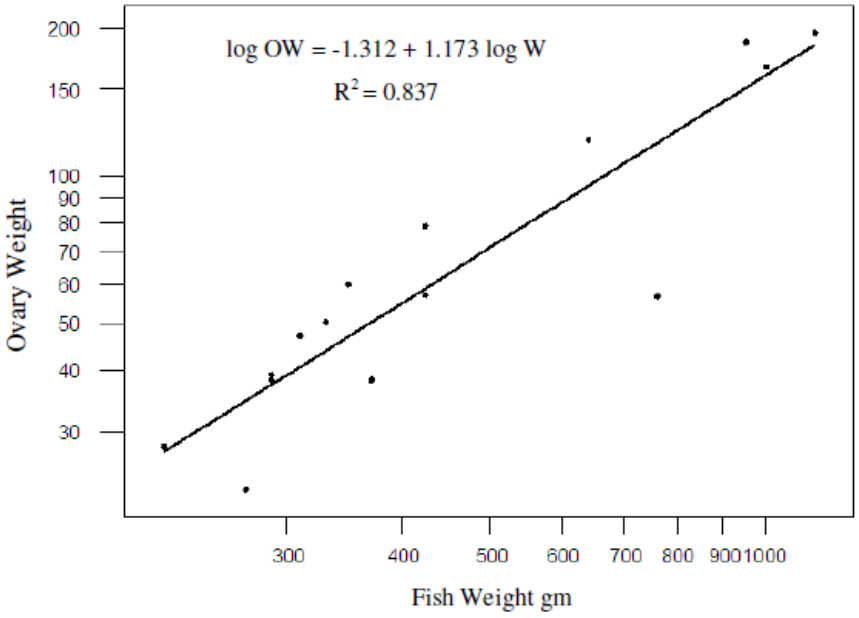

Figure 5

A highly significant relationship was found between the two variables (Figure 5), the

obtained equation was as:

$$OW = -15.537 + 0.183\ W;\ (R^2 = 0.9312)$$

$$\text{or } \log OW = -1.312 + 1.173 \log W;\ (R^2 = 0.837;\ P = 0.00)$$

3.2.6 Relationship between Ovary Weight (OW) and Fish Length (L):

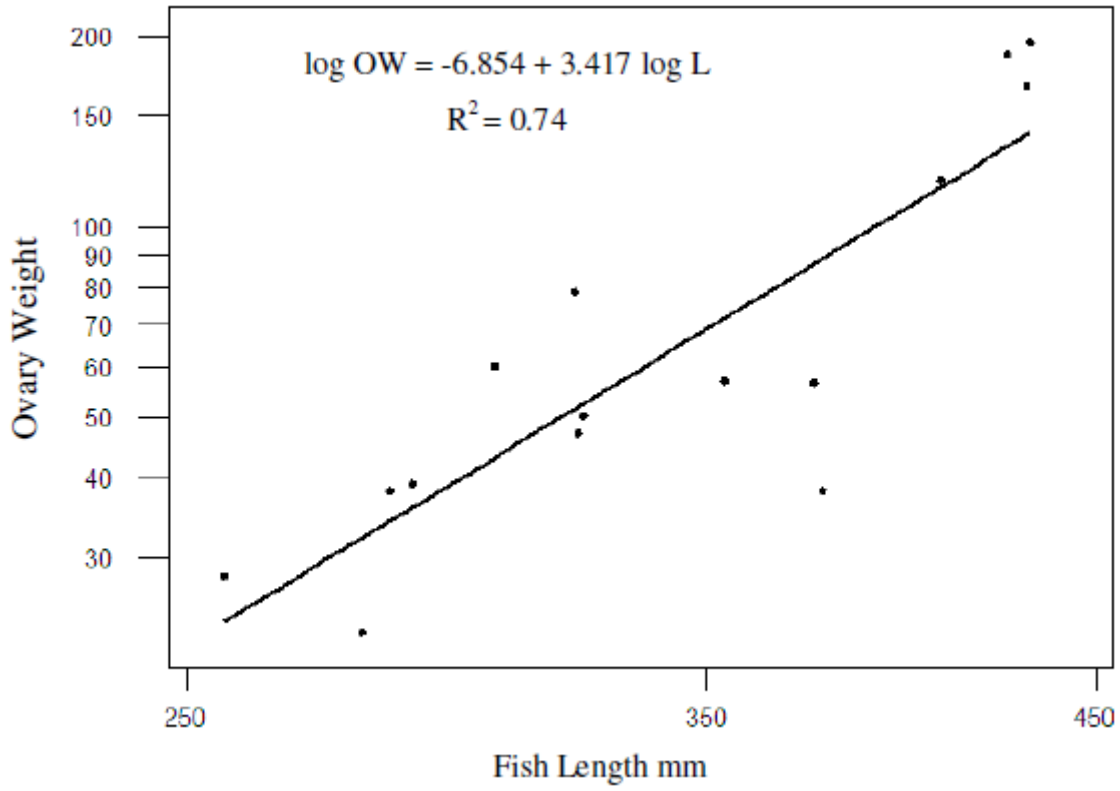

Figure 6

The weight of ovary in a fish is influenced by its size. A significant positive correlation was found between the two variables (Figure 6), expressed by the equation.

$$OW = -215.03 + 0.852\ L;\ (R^2 = 0.851)$$

$$\text{or } \log OW = -6.854 + 3.417 \log L;\ (R^2 = 0.74;\ P = 0.00)$$

3.3 Relative Fecundity

To compare the fecundity of *Salmo trutta fario* from other fishes, the production of eggs per unit weight of fish was calculated and it was observed to be 3.54 for a fish weighing 270gms and decreased upto 1.90 for a fish weight of 760gms.

3.4 Gonadsomatic Index

The reproductive period for brown trout was determined by GSI. Gonad somatic index exhibited variations in different months of the year (Figure 7). The lowest GSI among female fish was 0.3065 in February and highest was 15.419 in the month of October. Similarly, in

males the GSI fluctuated from 0.257 in February to a highest value of 8.785 in October. These values indicated that spawning period lasted from October to December.

3.5 Sex Ratio

A total of 121 brown trout were examined, out of which 67 were males (55.4%) and 54 were females (44.6%). The sex ratio was found to be 124: 1 indicating that males slightly outnumber the females in the population.

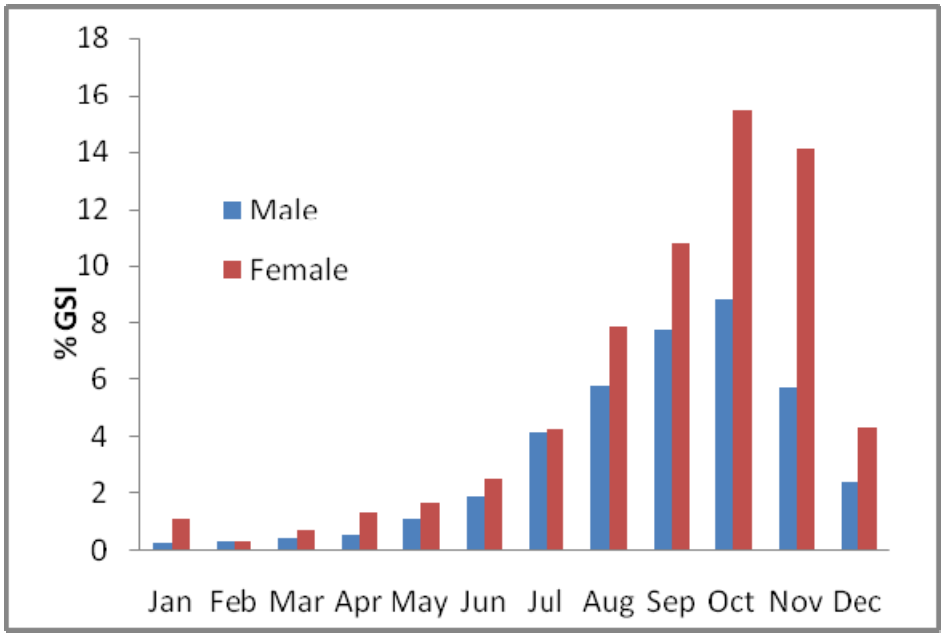

Figure 7. Seasonal fluctuations in the mean GSI of male and female Brown Trout (*Salmo trutta fario*).

4. Discussion

As the spectrum of reproductive patterns in teleosts is quite large, the exact definition of fecundity acceptable to all circumstances has neither been put forth nor is it easy as such. In general, fecundity is defined as the number of ripening eggs found in the female just prior to spawning and termed as individual or absolute fecundity (Bagenal, 1978). In teleosts, fecundity estimations fluctuate from a few hundred to several lakhs.

Fishes inhabiting cold water streams and lakes have comparatively low fecundity. Das and Subla (1969) recorded the fecundity of *Crossocheilus diplocheilus* from 6424 to 21432 in the fish length group of 95mm to 128mm. Fecundity estimates of *Tor putitora* from Kumaon lakes revealed that the fish measuring 339 to 517mm in length possessed 7076 to 18525 eggs (Pathani, 1981).

The fecundity estimates of brown trout (*Salmo trutta fario*) have been described by several workers. Absolute fecundity of brown trout ranged from 160 to 761 eggs per female (Garcia and Brana, 1988). Brown and Kamp (1941) found that the average number of eggs produced was 1,285 in brown trout which had an average total length of 388.6mm (15.3 inches). Taube

(1975) found that in the length range of 202-354mm (8-14 inches), the average number of eggs produced per female trout by inch group ranged from 241 to 936. When present results are compared with these fecundity estimates, brown trout appears to be equally productive having an average fecundity of 1281 in an average total fish length of 345mm.

The fecundity in fishes is often correlated with length, weight and age of fish and also with the length, weight and volume of the ovary. Several workers reported a straight line relationship between the fish weight and fecundity (Bagenal, 1957; Singh et al, 1982; Nautiyal, 1985; Pokhriyal, 1986). As far as *Salmo trutta fario* is concerned various workers including Allen (1951), Hardy (1967), Nicholls (1958), Bagenal (1969a) and Alp (2003) correlated the fish weight and fecundity Allen (1951) found this relationship to be linear. Mc Fadden, Cooper and Anderson (1965) found a direct relationship between egg weight and fish weight. In *Salmo trutta fario* this relationship is also found to be linear. Linear relationships of fecundity with body measurements were also reported by Swarup (1962); Jhingran (1968); Varghese (1973), (1976); Rao et al (1979) and Pathani, (1981); Bhuiyan et al (2006). The findings of the present work are in agreement with these observations.

According to Nikolskiie (1961) the quality and quantity of food consumed by the present population determined not only the fecundity but also the quality of sexual products and the viability of offspring. Scott (1962) reported that the lowering of fecundity is intensified by poor food intake as also stated by Wootton (1973) in the stickleback. Mc Fadden et al (1965) observed that trout from infertile streams had lower egg production. The relatively poor reproductive potential of *Salmo trutta fario* revealed from the present investigation may also be due to low water temperature and fast water current which appear to regulate the egg production capacity upto some extent. However, the low reproductive potential of brown trout when compared with other fish species is probably due to genetic difference.

In the present study the sex ratio of brown trout indicated that the males slightly outnumber females. Maitland and Campbell (1992) mentioned that the number of males in migrating trout populations were more abundant then females.

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