E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2017; 5(1): 167-172

www.fisheriesjournal.com
Received: 26-11-2016
Accepted: 27-12-2016

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Study on the fecundity of brown trout (*Salmo trutta fario* L.) in River Asiganga, Uttarkashi (Uttarakhand), India

MS Rawat, Babita Bantwan and Dhyal Singh

Abstract
A total of 253 brown trout (*Salmo trutta fario* L.) (130 males and 123 females) were examined for the study of fecundity, spawning season and sex ratio. The length ranged in between 26.15 to 44.15 cm, while, weight from 235 to 1140 gms. The fecundity of brown trout (*S. trutta fario* L.) was in between 454 to 1052 eggs per female. It was positively co-related with the total fish length (r=0.859), fish weight (r=0.653), ovary length (r=0.828) and ovary weight (r=0.996). Gonadosomatic index (GSI) confirmed that spawning lasted from October to January. The sex ratio of male and female was 1: 0.95.

Keywords: Brown trout, fecundity, ovaries, gonadosomatic index

1. Introduction

The term fecundity refers to the number of eggs present in the ovary of a fish [38]. Fecundity is an important index of the biology of fishes and is used to evaluate the reproductive potential of particular fish species that must be understood to explain the variations in the level of fish population, as well as to make efforts to increase the aquaculture harvest and production. Further the knowledge about fecundity of a fish is essential for evaluating the commercial potentialities of its stock, life history, practical culture and actual management of the fishery [17]. Fecundity varies from one species to another, depending on the environmental conditions, length, age, *etc*. Fecundity of a species is also known to vary with location [20, 32]. Many factors can affect fecundity and differences in fecundity among brown trout populations have been variously attributed to variations in genetic stock, growth rates, food availability, stream fertility, metal concentrations and other environmental factors such climate (McFadden [33], Bagenal [9], Lobon-Cervia [31], Jonsson [25], Pender [43]).

The breeding biology of brown trout was studied in different part of the world by Hobbs [23], Brown [12], Vladykov [55], McFadden [33], Bagenal [7, 8], Taube [53], Kaya [28], Avery [5], Aoyama [3], Pender [43], Nicola [39], Alp [1], Olsen [41, 42], Chad [14], Gortazar [19], Korner [30], Schubert [51], Hao [22], Demir [16], Kara [26] and Kocabas [29]. Breeding biology of brown trout in India was carried by Jhingran [24], Raina [46], Vass [54], and Rasool [47]. In Garhwal Himalaya some work on morphometry, status, length-weight relationship and eco-biology of brown trout of were made by Rawat [48, 49] and Bantwan [6]. Therefore the present study was undertaken to know the fecundity of brown trout inhabiting in River Asiganga for its conservation and management.

2. Materials and Methods

To study the fecundity of brown trout length and weight was measured then the body cavity was opened and sexes were identified. The size, shape and colour of the gonads were also recorded in each case. The ovaries were then removed from the body cavity of the fish, preserved in 5% formalin and allowed to harden and further studies were performed after the ovary became quite hard. The estimation of fecundity was made by the gravimetric methods. The preserved and washed eggs were kept on a filter paper to remove the excess moisture and they were left to air dry. To calculate fecundities, the ovaries were weighed; three sub samples were taken from the anterior, middle and posterior of each ovary and weighed. The total number of eggs in each sub sample was determined. This value was proportional to the total ovary weight; the number of eggs (F_1) for the subsample was estimated using the equation by Yeldan [57].

$$F_1 = \frac{\text{Gonad weight} \times \text{number of eggs in the subsample}}{\text{Subsample weight}}$$

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

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

The relationship of fecundity with total fish length, total fish weight, ovary length and ovary weight were established by applying the least square method.
$Y = a + bX$
Or in logarithmic form $\text{Log } F = \text{Log } a + b \log X$
Where Y = Fecundity, X = body measurements such as body length, body weight, ovary length, ovary weight. a (intercept) and b (slope) are constant.
In order to assess the gonadal development and spawning season of fish, the gonadosomatic index (GSI) of the fish was calculated as per formula:

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

3. Results

The ovaries of brown trout (*Salmo trutta fario* L.) are paired and elongated structures. Anteriorly both the ovaries (left and right) are free while their posterior portions join each other to form a thick walled oviduct, which opens to the exterior through an urinogeniatal aperture. Ovaries attain their maximum weight during spawning season (October to January) and thereafter it declines occupying to the release of ripe ova**.** For the estimation of fecundity of brown trout the ovaries of the 4^{th} and 5^{th} stages of maturity was taken into consideration. During this phase the ovary becomes broad, yellow in colour, presence of ripe ova heavily loaded with yolk and absent in oviduct. Both left and right ovaries are unequal in length. A thin transparent vascular membrane enveloped the ova of each lobe. The relationship of the fecundity with various body measurements are shown in Table 1.

Table 1: Relationship between the fish (length, weight) ovary (length, weight) and fecundity in Brown trout (*Salmo trutta fario* L.).

Size group	Fish length	Fish weight	Ovary length	Ovary weight	Fecundity
	Average± SD	Average± SD	Average± SD	Average± SD	Average± SD
25-26	26.150 ± 0.265	235.000 ± 28.868	11.950 ± 0.191	33.796 ± 2.547	454.250 ± 34.238
28-30	29.809 ± 0.869	387.823 ± 60.072	13.278 ± 0.336	51.782 ± 5.635	696.000 ± 75.740
31-33	32.057 ± 1.011	438.571 ± 42.201	14.471 ± 0.618	65.791 ± 3.196	871.429 ± 58.574
34-36	34.067 ± 0.058	403.333 ± 5.774	15.333 ± 0.058	70.978 ± 0.515	954.000 ± 6.928
37-39	-	-	-	-	-
40-42	-	-	-	-	-
43-45	44.150 ± 0.212	1140.000 ± 7.071	20.300 ± 0.424	78.269 ± 6.523	1052.000 ± 87.681

(1) Fecundity and total length: For a fish measuring 25.9 cm. the minimum number of ova estimated was 417, while the maximum was 1114 for a fish of 44.3 cm. in total length. The average fecundity values of different length groups were recorded to range from 454 to 1052 in the mean total length of 26.15 to 44.15 cm. The fecundity values have been plotted against the respective total length as a scatter diagram (Fig 1). The relationship between fecundity and fish length can be expressed as:
$\text{Log } F = 0.1872 + 1.7966 \log TL$
Where, F = fecundity
and TL = total length of fish
The coefficient of correlation 'r' showed a relationship between the fecundity and fish length ($r = 0.859$, $P<0.01$).

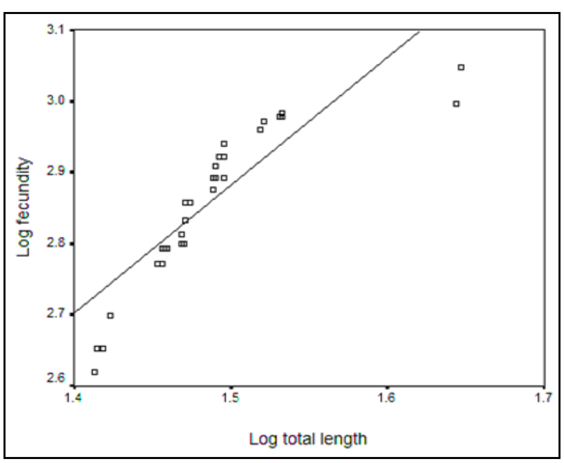

Fig 1: Relationship between total length and fecundity.

(2) Fecundity and fish weight: It was observed that fecundity ranges from 417 to 1114 in fish weight range of 260 to 1140 gm. The number of ova varied from 454 at mean weight 235 gm. and 1052 at the weight of 1140 gm. The data plotted between fish weight and fecundity (Fig 2) may be expressed as:
$\text{Log } F = 1.5478 + 0.5049 \log FW$
Where, F = fecundity
and FW = fish weight
The coefficient of correlation ($r = 0.653$, $P<0.01$) showed a relationship between the fecundity and fish weight.

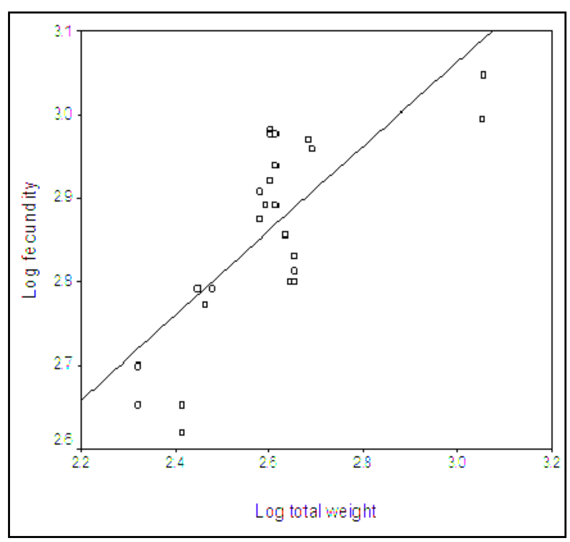

Fig 2: Relationship between total weight and fecundity.

(3) Fecundity and ovary length: For evaluating this relationship the ovary length and fecundity were studied. It was observed that ovary length ranged from 11.7 to 20.6 cm. while total length of fish ranges from 25.9 to 44.3 cm. The average ovary length value of difference length groups were recorded to range from 11.95 to 20.3 cm in the mean total length of 26.15 to 44.15 cm. The fecundity and ovary length relationship was expressed as:

Log F = 0.9717 + 1.6567 log OL

Where, F = fecundity

and OL = ovary length

The coefficient of correlation (r = 0.828, *P*<0.01) showed a relationship between the fecundity and ovary length (Fig 3).

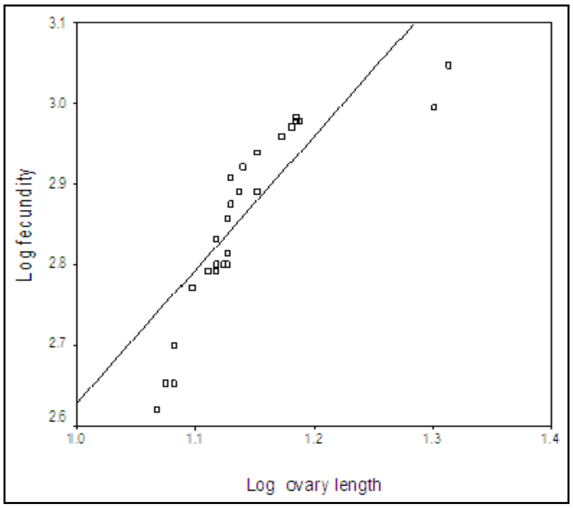

Fig 3: Relationship between ovary length and fecundity.

(4) Fecundity and ovary weight: In order to study this relationship the fecundity values were plotted against the respective weight of ovaries (Fig 4). The egg production ranged from 417 in an ovary of 31.025 gm to 1114 in an ovary of 82.882 gm. The average fecundity values of different ovary weight group were recorded to ranges from 454.25 to 1052 in the mean total ovary weight of 33.796 to 78.269 gm. The relationship between the two variables was expressed as:

Log F = 1.1444 + 0.9901 log OW

Where, F = fecundity

and OW = ovary weight

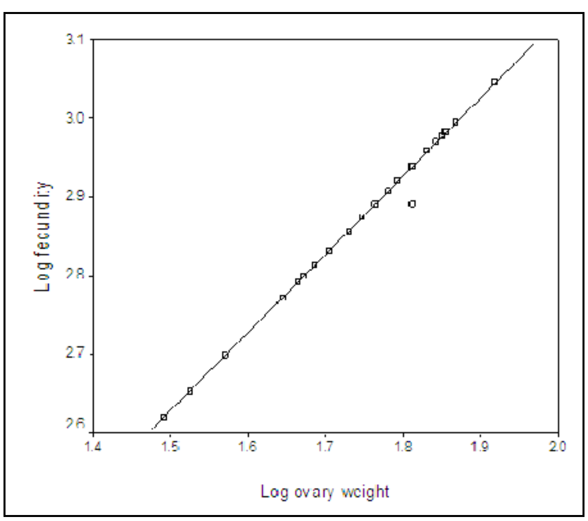

Fig 4: Relationship between ovary weight and fecundity.

Linear regression: The analysis of variance proved the linearity of regression (Table 2). A significant difference between fecundity and fish length (F = 104.45, P = 0.0001, df = 1, 37), fish weight (F = 27.54, P = 0.0001, df = 1,37), ovary length (F = 81.36, P = 0.0001, df = 1,37) and ovary weight (F = 4545.25, P = 0.0001, df = 1,37) were recorded.

Sex ratio: A total number of 253 specimens were examined for fecundity study, out of which 130 (51.38%) were males and 123 (48.62%) were females. The number of males and females differ no significantly difference with their mean ratio 1: 0.95.

Gonadosomatic Index (GSI): Gonadosomatic index was calculated for male and female fish separately and monthly averages were plotted in Fig 5. High values were observed during October to January in both the sexes due to the increase in gonad weight during breeding season. Rapid fall in GSI in February shows the reduction in weight of ovary and testes due to releasing of ova and sperms, gonads lose their weight and value of GSI is reduced. GSI indicates that the spawning season of fish extends from October to January. The maximum GSI values for male and female fish were observed as 2.894±1.475 and 12.747±5.499, respectively, in the month of January. The minimum values observed in February were 0.147±0.133 for male and 0.323±0.463 for female.

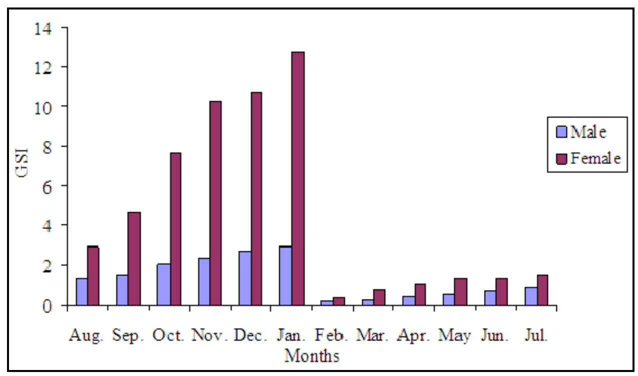

Fig 5: Gonadosomatic Index during different months.

Table 2: Test of linearity of regression (analysis of variance) of Brown trout (*Salmo trutta fario* L.).

	df	F	P	Sig.
Fish length and Fecundity	1,37	104.45	0.0001	S
Fish weight and Fecundity	1,37	27.54	0.0001	S
Ovary length and Fecundity	1,37	81.36	0.0001	S
Ovary weight and Fecundity	1,37	4645.3	0.0001	S

4. Discussion

Fecundity is the most common measure of reproductive potential in fishes. In order to maintain the position of any species in an environment, it is required to reproduce to such an extent that would enable it to counteract all physical and biological hazards such as predation, critical stages of its life history, food supply, etc. [45]. There is a large variation in the estimated value of fecundity of brown trout reported by different workers in different part of the world. Centinkaya [13] calculated the fecundity as 2340 per individual in Catak stream, egg number was determined as 2810 in the Tifi stream [27], as 3099 in Firniz stream [1]. Demir [16] reported the egg productivity ranged from 1840 to 3200/ Kg of fish during spawning season. The mean fecundity of brown trout were

876 in the Watauga River, 1365 in the South Fork of the Holston River, as 2276 in the Clinch River and as 2821 in the Caney Fork stream [14]. Alp [1] reported the fecundity of age groups II, III, IV, V and IX were 360, 452, 693, 1283 and 3232 egg per female with the mean fecundity ± SD of the population was estimated as 554 ± 534 eggs per fish. Mean fecundity in age groups III, IV and V were 120, 195 and 281 eggs per female in northern England stream [15]. Arslan [4] also reported fecundity were 308±27 and 392±46 per individual in the Anuari and Cenker streams, respectively. The fecundity in per fish was 960 to 1430 in the reservoir, Central Norway [25]. Kocabas [29] reported the mean value of absolute fecundity of *Salmo trutta macrostigma* was 312.23±254.71 eggs/ female. Female brown trout reportedly lay 77 to 103 eggs/ inch (30 to 40 egg/ cm) of their fork length [34]. Rasool [47] reported fecundity of brown trout from Kashmir 527 to 2445. Fecundity varies greatly among life-history forms of brown trout. Elliott [18] reported that while a 15 cm long stream resident female may only produce 100 eggs; a 50 cm long sea run female brown trout may produce 2,000 eggs.

In the present study the mean fecundity of brown trout (*S. trutta fario* L.) ranged in between 454 to 1052 eggs per female. Fecundity of *S. trutta fario* L. in the Asiganga River was low as compared to other study. The fecundity was similar to the fecundities of other slow growing self-sustaining brown trout population in Watauga River [14], Ceyhan River [1], Northern England stream [15], reservoir Central Norway [25] and Anuari and Cenker streams [4]. Many factors are responsible for large variations in fecundity data. These are fertility, the frequency of spawning, parental care, egg size, population density and most importantly environmental factor such as temperature, salinity and availability of food [10]. These factors directly or indirectly act on growth, metabolism and wellbeing of the fish.

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 [7, 52, 36, 44]. As far as *Salmo trutta fario* is concerned various workers including [2, 21, 37, 8] correlated the fish weight and fecundity. Allen [2] found this relationship to be linear. McFadden [33] found a direct relationship between egg weight and fish weight. In present study on *Salmo trutta fario* L. this relationship is also found to be linear. The findings of the present work are in agreement with these observations.

According to Nikolskiie [38] 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 [50] reported that the lowering of fecundity is intensified by poor food intake in the stickleback [56]. McFadden [33] observed that trout from infertile streams had lower egg production. The relatively poor reproductive potential of *Salmo trutta fario* L. 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 fecundity increases at the growth rate of 1.7966 of the fish length, 1.6567 of the ovary length, 0.9901 of the ovary weight and 0.5049 of the fish weight. These observations are similar to the findings of Alp [1], Arslan [4], Nicola [39], Moyle [35] and Kocabas [29], fecundity increase with fish size. Lobon-Cervia [31] indicated that trout length was the major determinant of fecundity. Bagenal [8] also stated that fecundity of brown trout is usually positively related to their growth rate. The fecundity of *S. trutta fario* L. increased with the fish size and weight in River Asiganga and show significant correlationship. The fecundity increase with the increase the body measurement in all the cases, a liner relationship was observed between the fecundity and the body parameters. The value of the coefficient of correlation indicated that fecundity was more directly related to ovary weight (r = 0.996) and fish length (r = 0.859) then the ovary length (r = 0.828) and the fish weight (r = 0.653). The sex ratio of males and females of brown trout was 0.94:1 and 0.97:1 in the Anuri and the Cenker streams, respectively [4], indicating no significant differences in the number of males and females in both stream, while, the sex ratio of *Salmo trutta fario* L. in the Yadong stream was 1: 0.78 Tibet [22]. In the present study a sex ratio was observed 1: 0.95 in the fish brown trout, indicating no significant differences in the numbers of male and female. The sex ratio of the fish populations changes in the spawning season, life stage of the fish, spawning ground and migration but in the majority of species it is close to one Nikolsky [40].

5. Acknowledgement

Authors are thankful to UGC, New Delhi for financial assistance in the form of major research project F. No. 34-434/2008(SR).

6. References

1. Alp A, Kara C, Buyukcapar HM. Reproductive biology of brown trout, S*almo trutta macrostigma* Dumeril 1858, in a tributary of the Ceyhan River flows into the Eastern Mediterranean Sea. J Appl Ichth. 2003; 19:346-351.
2. Allen KR. The Horokiwi stream, a study of a trout population. New Zealand Marine Department, Fisheries Bulletin, 1951; 10:238.
3. Aoyama T, Takami T, Shimoda K, Koyama T. Age, growth and sexual maturity of brown *trout, Salmo trutta*, *in Hokkaido*, Japan. Scientific report of the Hokkaido fish hatchery. 2002; 56:115-123.
4. Arslan M, Aras NM. Structure and reproductive characteristics of two brown trout (*Salmo trutta*) populations in the Coruh River basin, North-Eastern Anatolia, Turkey. Turk. J Zool. 2007; 31:185-192.
5. Avery EL. Factors Influencing Reproduction of Brown Trout above and Below a Flood Water Detention Dam on Trout Creek, Wisconsin. Wisconsin Department of Natural Resources, Research Report 106, Madison. 1980.
6. Bantwan B. A study of eco-biology of brown trout (*Salmo trutta fario* L.) in River Asiganga, Garhwal Himalaya. D. Phil. Thesis submitted to HNB Garhwal University, Srinagar-Garhwal (India). 2012.
7. Bagenal TB. The breeding and fecundity of the long rough dab, *Hippo glossoidesplatessoides* (Fabr.) and the associated cycle in condition. J Mar Biol Assoc UK. 1957; 36:339-375. http://dx.doi.org/10.1017/S0025315400016854
8. Bagenal TB. The relationship between food supply and fecundity in brown trout *Salmo trutta* L. J Fish Biol. 1969a; 1:167-182.
9. Bagenal TB. Relationship between egg size and fry survival in brown trout *Salmo trutta* L. J Fish Biol. 1969b; 1:349-353.
10. Bagenal TB. Aspects of Fish Fecundity. In: S.D. Gerking

(ed.). Ecology of Freshwater Fish Production. Wiley, New York. 1978, 75-101.
11. Bhuiyan AS, Shamima A, Zaman T. Food and feeding habit of the juvenile and adult snake head, *Channa punctatus* (Bloch). J Life Earth Sci. 2006; 1(2):53-54.
12. Brown CJD, Camp GC. Gonad measurements and egg counts of brown trout (*Salmo trutta*) from the Madison River, Montana. Trans. Amer. Fish. Soc. 1942; 71:195-200.
13. Cetinkaya O. Investigations of some biological properties of brown trout (*Salmo trutta macrostigma* Dum., 1858) living in the Catak Stream (Tigris River, Turkey). Istanbul Univ. J Aqua Prod. 1999; 9:111-122.
14. Chad Holbrook MS, Bettoli PW. Spawning Habitat, Length at Maturity and Fecundity of Brown Trout in Tennessee Tailwater. Tennessee Wildlife Resources Agency Nashville, TN 38204. Fisheries Report. 2006, 06-11
15. Crisp DT, Mann RHK, McCormack JC. The populations of fish at Crow Green, upper Teesdale, before impoundment. J Appl Ecol. 1974; 11:969-996.
16. Demir O, Gulle I, Gumus E, Kucuk F, Gunlu A, Kepenek K. Some reproductive features of brown trout (*Salmo trutta macrostigma* Dumeril, 1858) and its larval development under culture conditions. Pak. Vet J. 2010; 30(4):223-226.
17. Doha S, Hye MA. Fecundity of Padma River Hilsa, *Hilsa ilisha* (Ham.). Pak J Sci. 1970; 22(3-4):176-178.
18. Elliott JM. Quantitative Ecology and the Brown Trout. Oxford University Press. 1994, 286.
19. Gortazr J, De Jalon DG, Alonso-Gonzalez C, Vizcaino P, Baeza D, Marchamalo M. Spawning period of a Southern brown trout population in highly unpredictable stream. Ecol. Freshw. Fish. 2007; 16:515-527.
20. Gunderson DR. Population biology of Pacific Ocean perch, *Sebastes alutus,* stocks in the Washington-Queen Charlotte Sound region and their response to fishing. Fishery Bulletin, U.S. 1977; 75:369-403.
21. Hardy CJ. The fecundity of brown trout from six Canterbury streams, New Zealand. Mar. Dep. Fish. Tech. Rep. 1967; 22:14.
22. Hao F, Chen Y. The reproductive traits of brown trout (*Salmo trutta fario* L.) from the Yadong River, Tibet. Env. Biol. Fish. 2009; 86:89-96.
23. Hobbs DF. Natural reproduction of quinnot salmon, brown and rainbow trout in certain New Zealand waters. New Zealand Marine Dept. Fish Bull. 1937; 6:104.
24. Jhingran VG, Sehgal KH. Coldwater Fisheries of India. Inland Fisheries Society of India, Barrackpore. 1978, 1-239.
25. Jonsson N, Jonsson B. Trade-off between egg mass and egg number in brown trout. J Fish Biol. 1999; 55:767-783.
26. Kara C, Alp A, Fatih Can, Growth M. reproductive properties of flathead trout (*Salmo platycephalus* Bhenke, 1968) population from Zamanti Stream, Seyhan River, Turkey. Turk. J. Fish. Aquat. Sci. 2011; 11:367-375.
27. Karatas M. Age at sexual maturity, spawning time, sex ratio, fecundity of population of trouts (*Salmo trutta* L.) inhabiting in the Tifi brook (Tokat-Turkey). Symposium development and growth of Fishes. St. Andrews, Scotland. 1999.
28. Kaya CM. Reproductive biology of rainbow and brown trout in a geo-thermally heated stream: The Firehole River of Yellowstone National Park. Trans. Amer. Fish. Soc. 1977; 106(4):354-361.
29. Kocabas M, Kayim M, Can E, Kutluyer F, Aksu O. The reproduction traits of native brown trout (*Salmo trutta macrostigma* T., 1954), Turkey. J Anim Vet Adv. 2011; 10(13):1632-1637.
30. Korner O, Etiënne L, Vermeirssen M, Burkhardt-Holm P. Reproductive health of brown trout inhabiting Swiss Rivers with declining fish catch. Aquat. Sci. 2007; 69:26-40.
31. Lobon-Cervia J, Utrilla CG, Rincon PA, Amezcua F. Environmentally induced spatio-temporal variations in the fecundity of brown trout *Salmo trutta* L. Trade-offs between egg size and number. Freshw. Biol. 1997; 38:277-288.
32. Mann RHK, Mills CA, Crisp DT. Geographical variation in the life-history tactics of some species of freshwater fish. In: G.W. Potts and R.J. Wooton (eds.). Fish Reproduction: Strategies and Tactics. Academic Press, London. 1984, 171-186.
33. McFadden JT, Cooper EL, Anderson JK. Some effects of environment on egg production in brown trout (*Salmo trutta*). Limno. Oceano. 1965; 10(1):88-95.
34. Moyle PB. Inland Fishes of California. Berkeley: University of California press. 2002.
35. Moyle PM, CechJr JJ. Fishes: An Introduction to Ichthyology. Prentice - Hall, Inc. 2000, 611.
36. Nautiyal P. Length weight relationship and relative condition factor of Garhwal Himalayan mahseer with reference to it fishery. Ind. J Anim Sci. 1985; 55(1):65-70.
37. Nicholls AG. The egg yield from brown and rainbow trout in Tasmania. Aust. J. Freshw. Res. 1958; 9(4):526-536. http://dx.doi.org/10.1071/MF9580526
38. Nikolskii GV. On some adaptations to the regulation of population density in fish species with different types of stock structure. "The Exploitation of Natural Animals Populations."(E.D LeCren & M.W. Holdgate, eds.). Blackwell Scientific Publication, Oxford. 1961.
39. Nicola GG, Almodovar A. Growth pattern of stream-dwelling brown trout under contrasting thermal conditions. Trans. Amer. Fisheries Soc. 2004; 133:66-78.
40. Nikolsky GW. The Ecology of Fishes. 1st ed. Academic Press, London and New York. 1963, 352.
41. Olsen EM, Vollestad LA. Microgeographical variation in brown trout reproductive traits: Possible effects of biotic interactions. Oikos. 2003; 100(3):483-492.
42. Olsen EM, Vollestad LA. Small-scale spatial variation in age and size at maturity of stream-dwelling brown trout, *Salmo trutta*. Ecol. Freshw. Fish. 2005; 14:202-208.
43. Pender DR, Kwak TJ. Factors influencing brown trout reproductive success in Ozark Tailwater Rivers. Trans. Amer. Fish. Soc. 2002; 131:698-717.
44. Pokhriyal RC. Fishery Biology of *C. latius latius* from Alaknanda, Garhwal Himalaya. D. Phil. Thesis, H.N.B. Garhwal University, Srinagar Garhwal. 1986.
45. Qasim SZ, Qayyum A. Fecundity of some freshwater fishes. Proc. Nat. Inst. Sci. India. 1963; 29:273-382.
46. Raina HS. Biological resources of high mountainous lakes of Kashmir Himalaya. In: K.L. Sehgal (ed.). Recent Researches in Cold Water Fisheries. 1992, 45-60.
47. Rasool N, Jan U. Study on the fecundity of *Salmo trutta fario* (Brown trout) in Kashmir. J Biol and Life Sci. 2013; 4(1):181-193.

48. Rawat MS, Bantwan B, Singh D, Gusain OP. Status of brown trout (*Salmo trutta fario* L.) in Garhwal Himalaya with a note on its morphometric characteristics. Env. Cons J. 2011; 12(3):47-52.
49. Rawat MS, Bantwan B, Singh D, Gusain OP. Length-weight relationship and condition factor of brown trout (*Salmo trutta fario* L.) from river Asiganga, Uttarkashi, Uttarakhand (India). Env. Cons. J. 2014; 15(3):41-46.
50. Scott DP. Effect of food quality on fecundity of rainbow trout, *Salmon gairdneri*. J Fish Res Board Can. 1962; 19:715-731. http://dx.doi.org/10.1139/f62-047
51. Schubert S, Peter A, Burki R, Schonenberger R, Suter MJF, Segner H *et al*. Sensitivity of brown trout reproduction to long-term estrogenic exposure. Aquat Toxicol. 2008; 90:65-72.
52. Singh HR, Badola SP, Dobriyal AK. Ecology of River Nayar of Garhwal Himalaya. Uttar Pradesh J Zool. 1982; 2:72-76.
53. Taube CM. Sexual maturity and fecundity in brown trout of the Platte River, Michigan. Trans. Amer. Fish. Soc. 1976; 4:529-533.
54. Vass KK. Breeding biology of trout. In: H.R. Singh and W.S. Lakra (eds.) Coldwater Aquaculture and Fisheries. Narendra publishing house, Delhi-6. 2000, 155-168.
55. Vladykov VD. Fecundity of wild speckled trout (*Salvelinus fontinalis*) in Quebec lakes. J Fish Res Board Can. 1956; 13(6):799-841.
56. Wootton RJ. The effect of size of food ration on egg production in the female three spined stickle back, *Gastero steusaculeatus* L. J Fish Biol. 1973; 5:89-96. http://dx.doi.org/10.1111/j.1095-8649.1973.tb04433.x
57. Yeldan H, Avsar D. A preliminary study on the reproduction of the rabbit fish (*Siganus rivulatus* (Forsskal, 1775) in North Eastern Mediterranean. Turk. J Zool. 2000; 24:173-182.