International Journal of Bio-resource and Stress Management https://pphouse.org/ijbsm.php

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IJBSM October 2022, 13(10):1115-1123 Print ISSN 0976-3988 Online ISSN 0976-4038 **Article** AR3066a

Research Article *Natural Resource Management*

DOI: HTTPS://DOI.ORG/10.23910/1.2022.3066a

Assessment of Spawning Fecundity and Its Relationship with Body Parameters of Rainbow Trout (*Oncorhynchus mykiss*) and Brown Trout (*Salmo trutta fario*)

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ABSTRACT

The present investigations were carried out at Trout Culture Farm Laribal, Srinagar (J&K Govt.), India during December, 2020. Relationship between length-weight, spawning fecundity and relative fecundity was observed in rainbow trout (*O. mykiss*) and brown trout (*S. trutta fario*). The mean length of male rainbow trout was (38.77±1.38 cm) and mean length of (38.05±1.32 cm) was observed in female rainbow trout. While as, the mean length of male brown trout was (38.86±1.41 cm) and for female brown trout mean length of (37.98±1.30 cm) was observed. The mean weight of male and female rainbow trout recorded was 794.6±49.3 g and 766.3±64.3 g respectively, while as, the average weight of male and female brown trout was 772.7±41.4 g and 757.6±57.22 g respectively. The spawning fecundity female^{-1} of rainbow trout ranged from 2002–2804 eggs and mean relative fecundity of 3.13±0.12 g^{-1} body weight was observed and for brown trout the spawning fecundity female^{-1} fish ranged from 961 to 1604 eggs, with a relative fecundity of 1.41 g^{-1} body weight to 1.56 g^{-1} body weight. The present study recorded a significant positive correlation between total body length and total body weight of male rainbow trout (r=0.938, p<0.05) and total body length and total body weight of female rainbow trout (r=0.989, p<0.05) and for brown trout a significant positive correlation was recorded between total body length and spawning fecundity, body weight and spawning fecundity was observed. However, relative fecundity formed a significant negative correlation between total length, body weight and spawning fecundity in brown trout.

KEYWORDS: Body size, brown trout, rainbow trout, spawning fecundity

***Citation* (VANCOUVER):** Bazaz et al., Assessment of Spawning Fecundity and Its Relationship with Body Parameters of Rainbow Trout (*Oncorhynchus mykiss*) and Brown Trout (*Salmo trutta fario*). *International Journal of Bio-resource and Stress Management,* 2022; 13(10), 1115-1123. HTTPS://DOI.ORG/10.23910/1.2022.3066a.

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 29th April 2022 RECEIVED in revised form on 28th September ACCEPTED in final form on 17th October 2022 PUBLISHED on 27th October 2022

1. INTRODUCTION

The trout was introduced in Kashmir in the year 1912, has thrived well since then and is now established in almost all the cold water streams, lakes and rivers of the valley. Cold-water fish rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta* fario) belongs to family Salmonidae (Bazaz et al., 2021b). Trout is an important fish species for recreational fishing because of its aquaculture potential, economic worth, and widespread consumer demand (Bazaz et al., 2021a). Rainbow trout and brown trout have been introduced globally, but there appear to be differences in their patterns of invasiveness and ecological impact (McGlade, 2022). Fecundity refers to the number of mature eggs in a female fish's ovary prior to spawning. Estimating fecundity is important not only for these criteria, but also for acquiring knowledge about different speciess, as different species have different fecundity and egg diameters, which helps identify whether a population is homogeneous or heterogeneous (Shafi, 2012, Jan et al., 2014). Length-weight associations are considered basic and important objective in fisheries research and it provides helpful information for fishery managers (Bilge et al., 2014, Huang et al., 2018, Torres et al., 2012, Bromage and Cumaranatunge, 1988). Reportedly brown trout prefer water temperature ranging from 12–19°C (Bazaz et al., 2021b). It feeds on variety of prey items and feeding changes by habitat, season and size of fish however, it does not vary by sex (Rasool et al., 2012). Brown trout is currently thriving in the cold water streams of Kashmir Valley, and is the most well-known freshwater species found in Sindh, Bringi, Lidder, Ferozpur, Erin, and other areas (Bazaz et al., 2021a, Shah et al., 2022) for best growth. The trout fishery in the Indian uplands comprises of brown trout and rainbow trout in streams, lakes, and reservoirs (Sarkar et al., 2008). The trout produced in the Himalayas could easily be branded as "Himalayan rainbow trout" for domestic as well as global market (Gurung et al., 2017). Fecundity is often referred to as total or absolute fecundity, or simply fecundity, when expressed in terms of the number of eggs produced brood^{-1} fish. There are scientific objections to using relative fecundity because the number of eggs produced for each unit increase in weight varies significantly (Bagenal, 1978). With increasing age of the fish, both fecundity and egg size also increase (Springate and Bromage, 1984). It's probable that fecundity has increased in past few decades as food availability has increased at spawning areas as eutrophication and climate change have encouraged the growth of filamentous algae (Andersen et al., 2017, Takolander et al., 2017). Jammu & Kashmir and Himachal Pradesh are leading trout farming states in India where trout culture is undertaken in both private & public sectors. The trout production in India has increased remarkably from 755.27 t (2014–15) to 842.23 t (2015–16), with a growth rate of 11.51% The trout production of Jammu & Kashmir has increased from 90 t during 2002–03 to 650 t in the year 2019–20 (Anonymous, 2020, Bazaz et al., 2021a).

Fish length-weight relationships are essential in fish biology because they are used to estimate the average weight of fish in a specific length group by developing a mathematical relation between them (Mir et al., 2014, Shah et al., 2022). The length-weight relationship can be used to estimate fish condition, with the assumption that larger fish of a given length are in better condition (Froese, 2006).

For most salmonids these measures of fecundity are readily made because eggs are artificially stripped from each female at spawning (Bagenal, 1978). This study was aimed to describe the relationship between spawning fecundity and body parameters of rainbow trout and brown trout from Dachigam hatchery in Kashmir valley.

2. MATERIALS AND METHODS

2.1. Sampling Site

The present study was conducted in the month of December, 2020. Healthy parent stocks of male and female rainbow trout and brown trout were collected from Trout Culture Farm, Laribal, Srinagar (J&K Govt.), which is located around 20 kms from district Srinagar. A total of 40 fishes were observed for total length, total weight and spawning fecundity. The data were recorded from anaesthetized fish.

2.2. Spawning fecundity

Male and female rainbow trout and brown trout were segregated before stripping. Eggs were stripped in a dry, clean plastic bowls by applying gentle pressure to the abdomen of female rainbow trout. Spawning fecundity was determined by counting total number of stripped eggs female^{-1} rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta fario*) (Plate 1).

Plate 1: Collecting eggs of brown trout (*Salmo trutta fario*)

2.3. Relative fecundity

It was calculated as total number of stripped eggs divided by weight of fish in gm (Bagenal, 1978).

2.4. Estimation of total length and total weight

The total length of male and female rainbow trout and brown trout was determined using a Vernier caliper (Trusize absolute digimatic) (Plate 2). The total weight was determined using an electronic weighing balance (Thomson weighing scale, D-112) (Plate 3).

Plate 2: Total length measurement of rainbow trout using a vernier caliper

Plate 3: Total weight measurement of rainbow trout using a digital weighing balance

3. RESULTS AND DISCUSSION

The total length of male rainbow trout ranged from 30.3–45.1 cm with a mean value of 38.77±1.38 cm and for male brown trout, the length ranged from 30.3–45.7 cm with a mean value of 38.86±1.41 cm. While as for female rainbow trout, the length ranged from 34.5–47.4 cm with a mean value of 38.05±1.32 cm and the length of female brown trout ranged from 32.3–45.4 cm with a mean value of 37.98±1.30 cm. The observed total weight of male rainbow trout ranged from 623–1065 g with a mean value of 794.6±49.3 g while as the male brown trout weighed in the range of 613–975 g with a mean value of 772.7±41.4 g. The female rainbow trout weighed in the range of 635–1237 g with a mean value of 766.3±64.3 g while as the observed weight of female brown trout ranged from 615–1137 g with a mean value of 757.6±57.22 g (Figure 1 to 4). The spawning fecundity female^{-1} in rainbow trout ranged from 2002–2804 eggs and the mean spawning fecundity of 2337.4±92.33 eggs was observed while as in brown trout the spawning fecundity of female brown trout ranged from 961–1604 eggs and the mean spawning fecundity of 1124.8±71.60 eggs was observed. The relative fecundity ranged from minimum of 2.26 g^{-1} body weight to maximum of 3.49 g^{-1} of body weight with mean value of 3.13±0.12 g^{-1} of body weight somatic weight of rainbow trout, while as the relative fecundity in brown trout ranged from minimum of 1.41 to maximum of 1.56 g^{-1} of fish weight with mean value of 1.49 g^{-1} of fish.

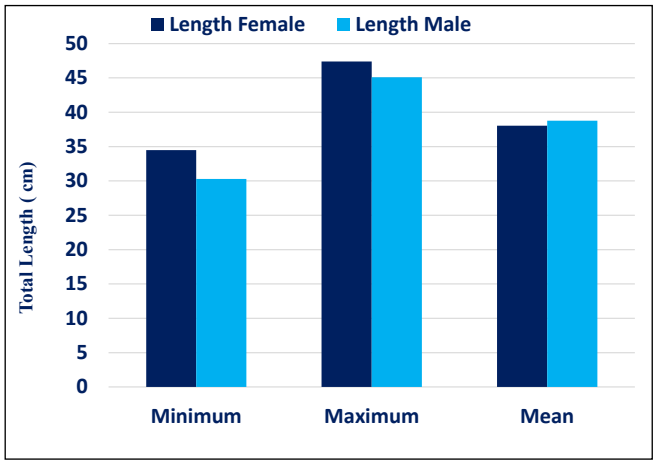

Figure 1: Minimum, maximum and mean values of length of male and female rainbow trout

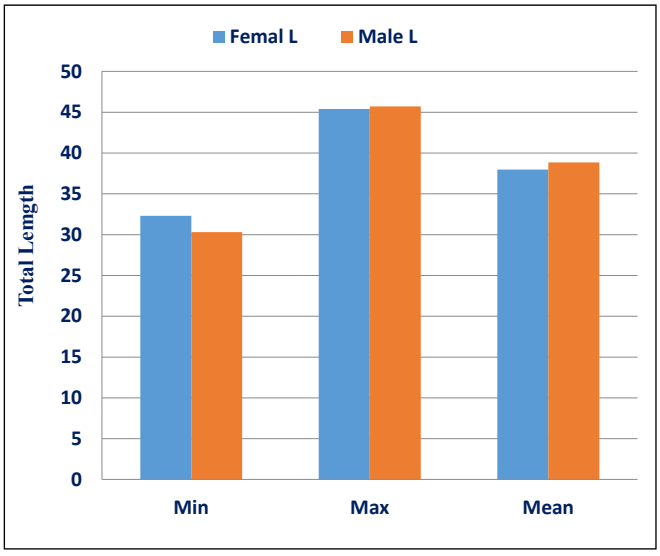

Figure 2: Minimum, maximum and mean values of total length (cm) of male and female brown trout

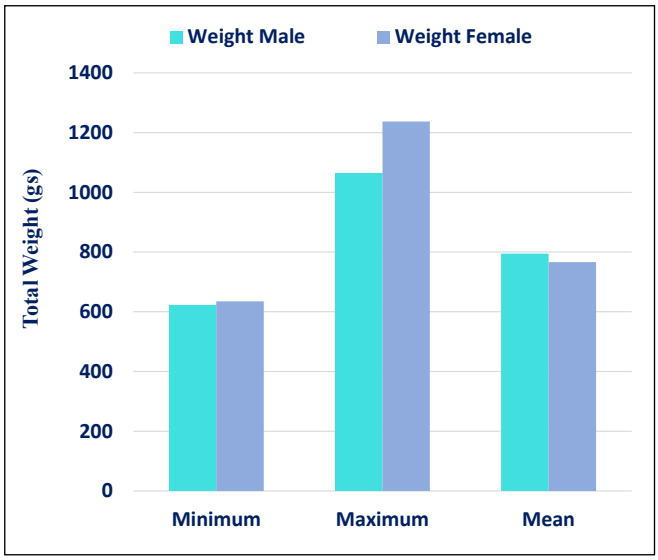

Figure 3: Minimum, maximum and mean values of total weight of male and female rainbow trout

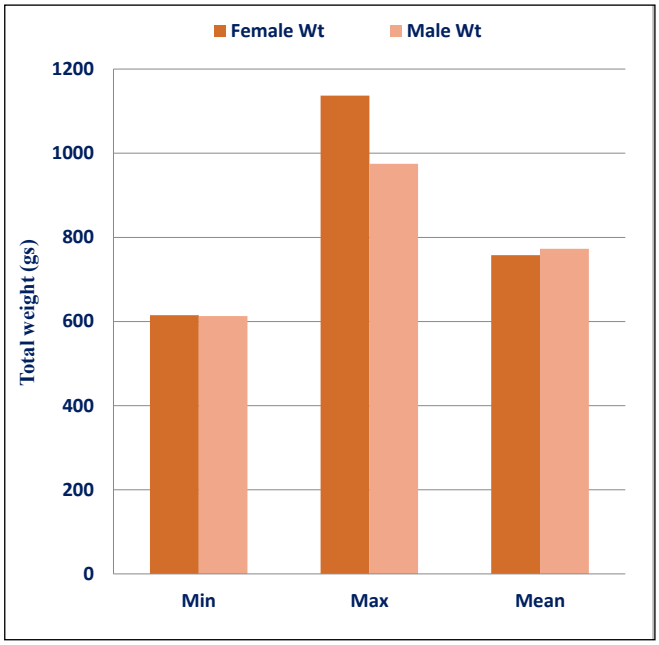

Figure 4: Minimum maximum and mean values of total weight of male and female brown trout

The Pearson's correlation between total length and total weight of male and female rainbow trout is given in (Table 1) below. It was found that there was a significant positive correlation between total length and total weight of male rainbow trout (r= 0.938, p<0.01) and total length and total weight of female rainbow trout (r=0.989, p<0.01).

The data revealed that there was a significant positive correlation observed between length and weight of male brown trout (r=0.947, p<0.01) and length and weight of female brown trout (r=0.924, p<0.01) (Table 2).

Table 1: Pearson's correlation between total length and total weight of male and female rainbow trout

	Length-Female	Weight-Male
Length- Male		0.938**
Weight- Female	0.989**	

**Significant at (p=0.01) level of significance

Table 2: Pearson's correlation between total length and body weight of male and female brown trout (*Salmo trutta fario*)

	Length-Female	Weight-Male
Length-Male		0.947*
Weight- Female	0.924*	

*Correlation is significant at (p=0.01) level

The Pearson's correlation between total length, total weight and fecundity of rainbow trout is given (in table 3), there was significant positive correlation between total length and fecundity (r=0.897, p<0.01), total length and total weight (r=0.968, p<0.01) as well as between total weight and fecundity (r=0.845, p<0.01).

Table 3: Pearson's correlation between total length, total weight and fecundity of rainbow trout

	Total Length	Total Weight
Total length		0.989**
Spawning fecundity	0.897**	0.845**
Total weight	0.968**	

**Correlation is significant at (p=0.01) level

The Pearson's correlation between total length, total weight and relative fecundity of rainbow trout is given in table 4, significant negative correlation was observed between total length and relative fecundity (r=-0.839, p<0.01) and total weight and relative fecundity (r= -0.900, p<0.01).

Table 4: Pearson's correlation between total length, total weight and relative fecundity of rainbow trout

	Total weight	Relative fecundity
Total weight		-0.900
Total length	0.989*	-0.839
Spawning fecundity		- 0.537

*Correlation is significant at (p=0.01) level

The Pearson's correlation between total length, body weight and spawning fecundity of brown trout indicated that there was significant positive correlation between total length and spawning fecundity (r=0.913, p<0.01), between total length and body weight (r=0.924, p<0.01), between body weight and spawning fecundity (r=0.997, p<0.01). However,

a significant negative correlation was formed among the total length of fish and relative fecundity (r=-0.902, p<0.05) and between spawning fecundity and relative fecundity (r= -0.849, p<0.05) (Table 5 and Figure 5, 6, 7 and 8).

Table 5: Relationship between total length, body weight and spawning fecundity and relative fecundity of brown trout

	Total length	Body weight	Relative fecundity
Total length		0.924**	-0.902*
Spawning fecundity	0.913**	0.997**	-0.849*

**Correlation is significant at (p=0.01) level

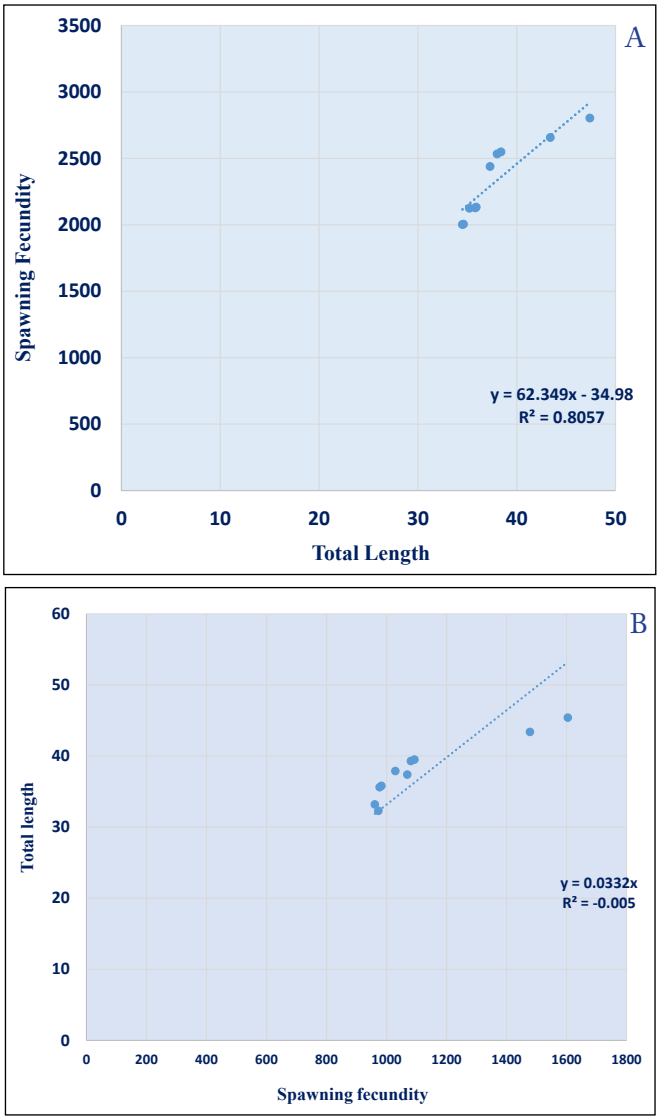

Figure 5: Scatter plot of correlation between spawning fecundity and length of rainbow trout (A) and brown trout (B)

Since there is such a wide range of reproductive patterns in teleosts, an accurate definition of fecundity that is acceptable in all circumstances has not been established, nor is it simple to do so. Individual or absolute fecundity is defined as the number of ripening eggs found in the female shortly prior to spawning (Bagenal, 1978). Effective identification of fish maturity stage is a fundamental strategy for the efficient management of exploited stocks in the fishery, and the fisheries scientists and managers utilise it frequently (Rahman et al., 2018). Fecundity estimates for teleosts range from a few hundred to several lakhs. Fish that live in cold water streams and lakes have a lower fecundity than those that live in warm water streams and lakes Das

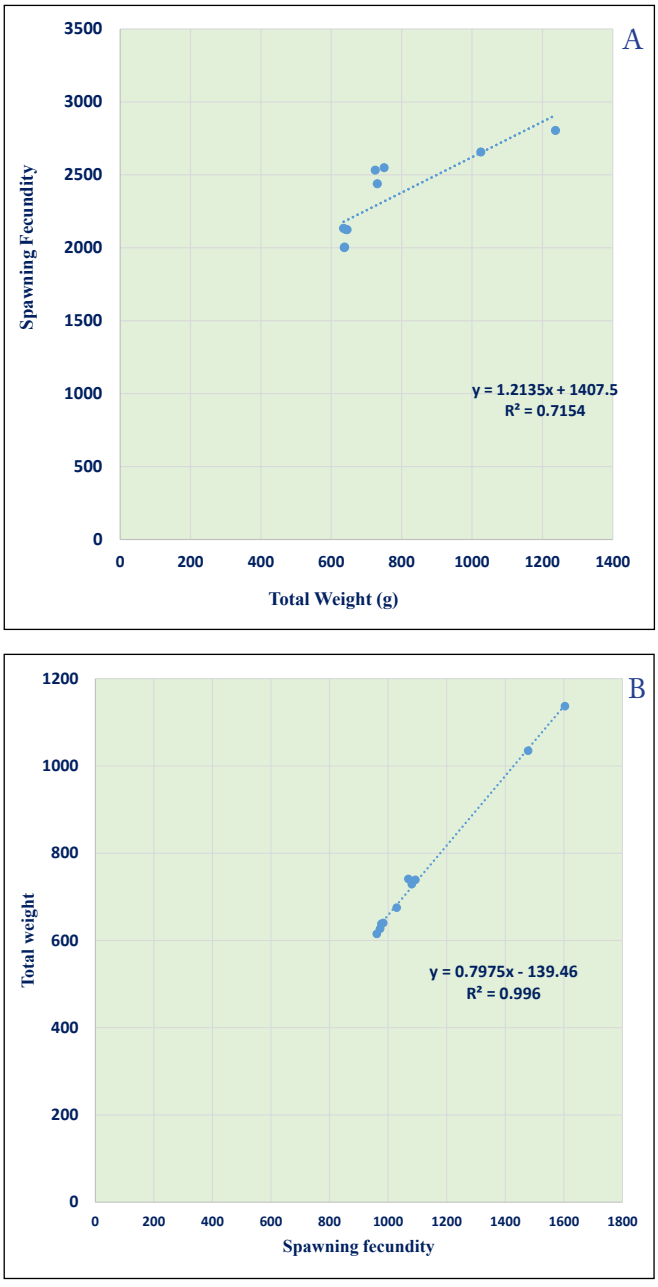

Figure 6: Scatter plot of correlation between spawning fecundity with total length of rainbow trout (A) and brown trout (B)

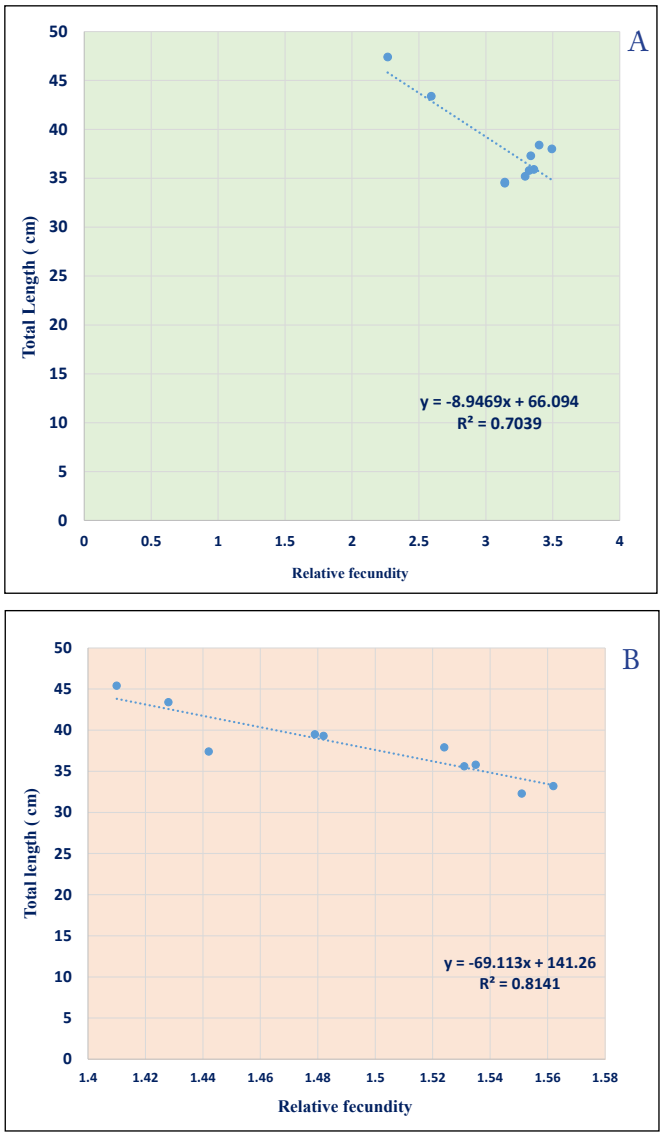

Figure 7: Scatter plot of significant correlation between total length and relative fecundity of rainbow trout (A) and brown trout (B)

and Subla (1969) recorded the fecundity of *Crossocheilus diplocheilus* from 6424–21432 in the fish length group of 95–128 mm. Fecundity estimates of *Tor putitora* from Kumaon lakes revealed that the fish measuring 339–517 mm in length possessed 7076–18525 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 160–761 eggs female^{-1} (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 388.6 mm (15.3").

Taube (1975) found that in the length range of 202–354 mm (8–14"), the average number of eggs produced female^{-1} trout by inch group ranged from 241–936. When present results are compared with these fecundity estimates, rainbow trout appears to be equally productive having an average fecundity of 2337.4±92.33 in an average total fish length of 38.77±1.38 cm. Fish fertility is usually related to the length, weight, and age of the fish, as well as the length, weight, and volume of the ovary. A straight line correlation between fish weight and fecundity was found by several researchers (Nautiyal, 1985). In *Salmo trutta fario* also various workers including Allen (1951), Hardy (1967), Nicholls (1958), Bagenal (1969) and Alp et al. (2003) correlated the fish weight and

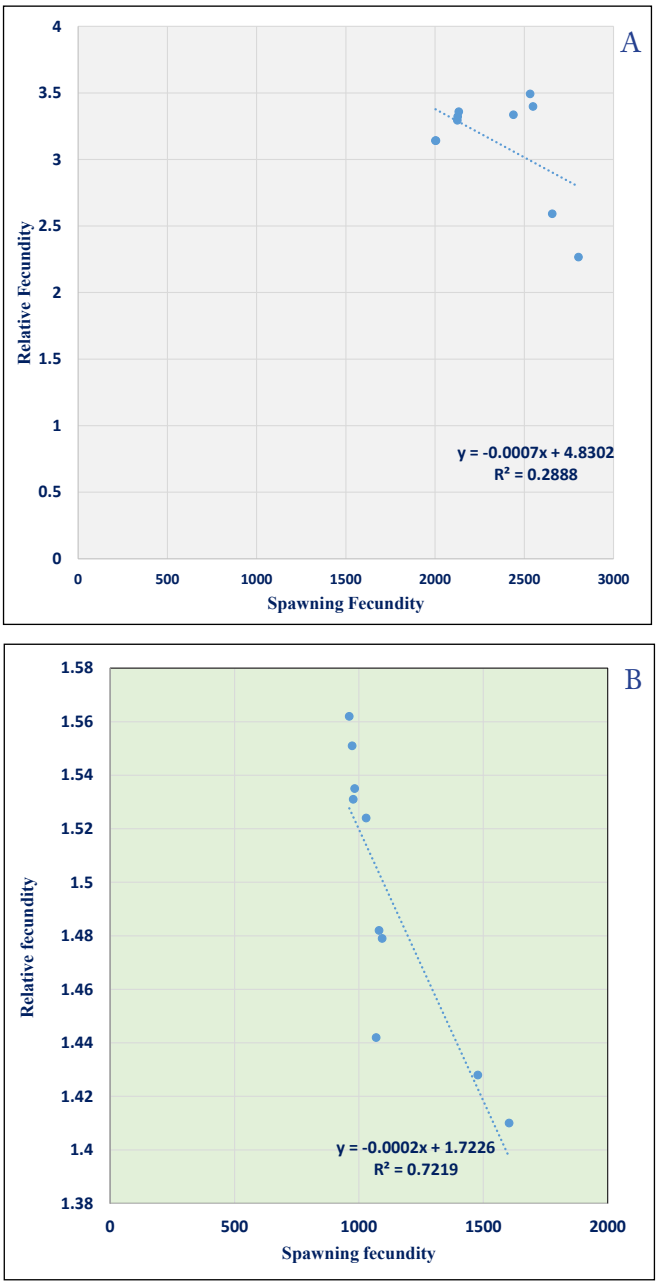

Figure 8: Scatter plot of significant correlation between spawning fecundity and relative fecundity of rainbow trout (A) and brown trout (B)

fecundity Allen (1951) found this relationship to be linear. McFadden et al. (1965) found a direct relationship between egg weight and fish weight. In *Oncorhynchus mykiss* this relationship is also found to be linear. Linear relationships of fecundity with body measurements were also reported by Jhingran (1968), Rao et al. (1979) and Pathani (1981). In brown trout populations, Hao and Chen (2009) found positive associations between female length, body weight, and gonad weight and fecundity. The findings of the present work are in agreement with these observations and many other studies including (Mehanna, 2019, Torres et al., 2012, Bilge et al., 2014, Kara et al., 2017, Huang et al., 2018).

Bagenal (1969) stated that the fecundity increases with the increase in the body measurement, a liner relationship was observed between the fecundity and the body parameters. In the present study, significant positive correlation was established between total length and spawning fecundity (r=0.913), between total length and body weight (r=0.924) as well as between body weight and spawning fecundity (r=0.997). Hence, both the studies are in proximity with each other. Fecundity generally increased with total length in several fishes. Fish that were larger in body size were found to be more fecund than those that were smaller in size. Similar findings have been reported by various researchers Shah et al. (2011); Qadri et al. (2015), Shah et al. (2018), Wali et al. (2018). Significant positive correlation was observed between total length of females and fecundity of *Mugil parsia* (Sarojini, 1957) *Osteogenesis militaria* (Pantulu, 1963) *Polynemus paradiscus* (Gupta, 1968), and *Labeo rohita* (Varghese, 1973). In rainbow trout, Wali et al. (2018), observed a significant positive relationship between absolute fecundity and fish weight as well as fish length. According to Ali et al. (2020), fecundity had a stronger relationship with fish length, fish weight, and ovarian weight, but a weaker relationship with ovary length. Shah et al. (2011), Shah et al. (2018) reported similar results with oil sardine from the west coast of India. The results reported by above mentioned researchers are in agreement with the present study as relative fecundity formed a significant negative correlation between body weight, total length and spawning fecundity in brown trout.

4. CONCLUSION

Spawning fecundity increased with increase in fish length and weight of both rainbow trout and brown trout. Furthermore, it was observed that the spawning fecundity of rainbow trout was significantly higher than the brown trout.

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