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Adaptive skill of *Schizothorax sp*. of river Alaknanda under long term pressure of urbanization and anthropogenic activities in Garhwal Himalaya

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Abstract

It is universally accepted that humans are having a major impact on every aspect of earth's ecological habitats because humans are engaged in urbanization and anthropogenic activity. All the major watershed areas of Garhwal Himalayan region (Alaknanda, Bhagarathi/Ganges and Yamuna) have witnessed urbanization and anthropogenic activity. One hydroelectric power project (330 MW) is located on river Alaknanda at Srinagar Garhwal in Garhwal Himalaya. The project started during the mid1990s by GVK group and completed around 2014. A long term study on fecundity of *Schizothorax sp.* at Srinagar Garhwal was carried out between the years 1996 to 1998. This study was compared to other recent studies on same species at same location between the years 2016-19. This period covers the entire timeline of construction phase to commissioning phase of this hydroelectric power project. Various parameters with reference to breeding biology and fecundity were measured from *Schizothorax sp*. Mature specimens ranging in average weight from 384g to 1482g and average length from 320mm to 544mm were observed. Weight of ovary in the fish fluctuated from 38g to 219g. Fecundity of samples varied from a minimum to 3009 to a maximum of 13649 to 13840. The mathematical relationship of fecundity with other variables viz: fish length, fish weight, ovary weight and ovary length, and between fish weight and ovary weight and ovary length was calculated. The computed relationships were found to be highly significant especially between fecundity and fish length ($r=0.940$, $p<0.01$), fecundity and fish weight ($r=0.937$, $p<0.01$) and fecundity and ovary volume ($r=0.913$, $p>0.01$). The values of regression coefficient (b) and correlation coefficient (r) were computed separately. The data when compared to recent data of other authors reveals that *Schizothorax sp*. have sustained their fecundity due to their unique adaptive skill but have shifted their breeding grounds slightly. This shifting of breeding ground might be due to anthropogenic activity. Further studies would be needed to see if the breeding grounds are also restored.

Key words: ***Fecundity, Gonadosomatic Index, Schizothorax, Sringar Garhwal, Garhwal Himalaya, Hydroelectric Power* project**

Introduction

There are three main watersheds in Garhwal Himalayan region of Uttarakhand of India. These are the Alaknanda, Bhagirathi (Ganges) and the Yamuna watershed. Due to their perennial water supply, and keeping in view the tremendous energy demand due to increasing population, several hydroelectric power projects have been either constructed or are under construction in these watersheds. Because of these constructions, the aquatic habitat and aquatic diversity is threatened. Fishes are most abundant species in river and directly connected to us in the form of food (economics) and aesthetic value. Besides they are also the key indicators of ecosystem as they live in specialized niches. Since they are among the key components of biodiversity and indicators of habitat, the study of their reproduction biology and fecundity is important. If the habitat for the fish species is perfect, they will reproduce at specific spawning grounds and if there are issue with the habitat, then they will preferably migrate to suitable grounds. Besides spawning grounds the number of eggs produced by female fish is also a key parameter which is also referred as fecundity. There are several studies documenting fishes in Alaknanda river and Bhagarathi since the 1970s and 80s (Agarwal *et al.,* 1988; Agarwal and Singh, 2009; Bisht and Joshi, 1975; Singh and Sharma

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1995; Thapliyal *et al.*, 2011 and 2012; Sharma and Bargali, 2018). Reproductive biology *Schizothorax sp.* has also been investigated in Kashmir and other locations (Wagle, 2015; Sunder and Subla 2013; Sabha *et al.*, 2017; Roy *et al.*, 2011; Roopam *et al.*, 2009; Qadri *et al.*, 2013; Gandotra *et al.*, 2009; Jan *et al.*, 2014). In our present paper, we documented the fecundity of *Schizothorax sp.* from 1996 to 1998 and then compared it to studies which were done at the same location.

Materials and Methods

Study site was located at Srinagar Garhwal in Uttarakhand (30º13'28.83"N and 78º47'55.03"E (Fig. 1). The sampling site was located 500 meters down-stream from the dam wall just by the bridge (Fig. 2 and Fig 3). The river meanders at this location resulting in some shallow pools that are used as breeding grounds by *Schizothorax sp*. Collection of fully mature female fishes was done

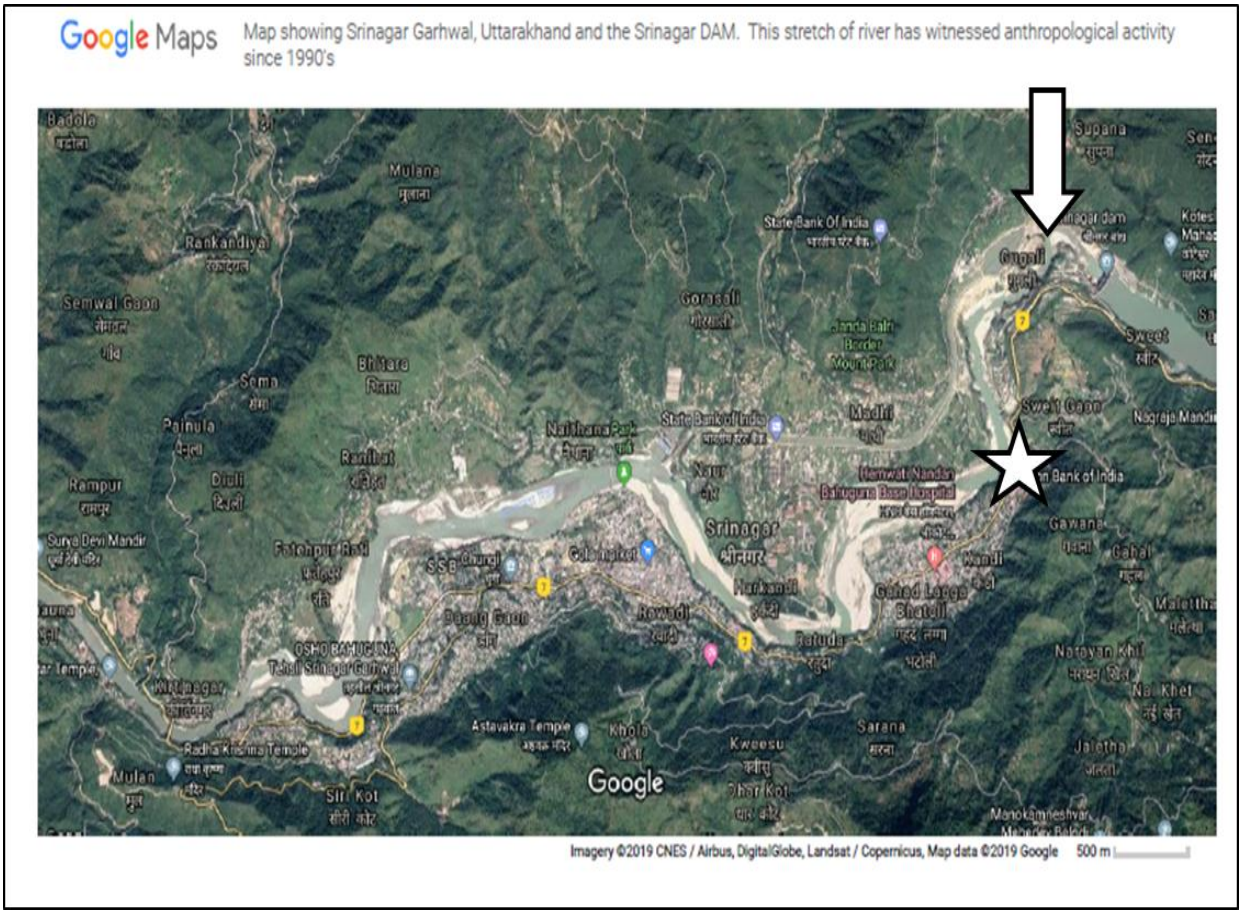

Fig 1. Location of study site. The dam wall is marked by an arrow. The study site is marked as a star. Map has been taken from Google Earth. The area between the arrow and the star was the dumping ground for all the soil / construction material.

during 1996 – 98. A total of 81 fishes were procured from the local fisherman and market having high state of maturity with ripe ovary (transparent, broad and highly vascular and smooth uneven surface due to presence of ripe ova heavily loaded with yolk). The length and weight of each fish was recorded/measured in fresh condition. The ovaries were then dissected out and preserved in 4% formalin to impart hardness. After allowing the ovaries to attain some hardness, they were kept out, wiped with blotting sheets for 30 min so that the ovaries had no moisture. The weight and volume of the preserved ovaries were recorded carefully. The sub-samples from the anterior, middle and posterior regions of both the ovaries were mixed randomly and subject to volumetric (Kandler and

Fig. 2. Photograph of study site 1996-1998 corresponding to star shown in Google map. This bridge was damaged during floods of 2013 and now a new bridge has been constructed at same location (source – Thesis of Dr. Madhu Thapliyal)

Fig 3. Photograph of eggs at study site during 1996-1998. This site was near the bridge along the curved region of river (source – Thesis of Dr. Madhu Thapliyal).

pirwitz, 1957) and gravimetric analysis (Simpson, 1959).

a. **Volumetric method:** A specific volume (1 ml) of the samples was taken and subjected to counting. The final results were computed to determine the number of eggs in the total volume of the ovary. The average of five counts was taken into consideration.
b. **Gravimetric method:** The preserved and washed eggs were kept on a blotting paper to remove the excess moisture and felt to air dry. The fecundity estimate was obtained by weighing the random samples of 200 eggs five times and fitting the values obtained into the formula:

$$\textbf{Fecundity} = \frac{\textbf{Total weight of the eggs}}{\textbf{Weight of the sub sample}} \textbf{ X 100}$$

The mean value of both the methods (volumetric and gravimetric) were recorded as the absolute fecundity. Relative fecundity was determined by the ratio of total number of ova to total weight of fish. The relationship between the fecundity and the fish weight/fish length / ovary volume / ovary weight / ovary length were established by applying the method of least square i.e.

$$Y = a + bx$$

$$\text{Log } Y = \text{Log } a + b \log X$$

Where Y = fecundity, X = Body measurements such as body length / body weight / ovary volume / ovary, a= intercept, b = slope are constants. Analysis of variance ANOVA was carried out on the data to examine the effect of various body parameters on fecundity.

Result and Discussion

All that data is tabulated in tables (table 1, table 2 and table 3). The results are as follows:

Fecundity and fish length (TL): It was observed that normally the larger fishes had relatively more eggs. For a fish measuring 555 mm, the maximum number of ova was estimated to be 13,862 the minimum was 3,880 for a fish of 350 mm in total length. The fecundity value and total fish length group has been computed in table 10. The average fecundity value of different length groups were recorded to range from 3007 to 13,649 in the mean total length of 320.4 mm to 544.4 mm. The correlation coefficient 'r' is 0.940, which indicates that the fecundity was more and directly related to fish length. The relationship between fecundity and fish length can be expressed as:

Log F=2.9942 + 2.5709 Log TL (r = 0.940)

Where F represents fecundity and TL is the total length of fish.

Fecundity and Fish weight (FW): The data related to fish weight and fecundity has been computed in table. The number of ova ranged from 3128 at mean weight of 662 gm to 13, 52 at 1833.5 gm. The data between log weight and log fecundity may be expressed as:

Log F = 0.8403 + 1.0323 Log FW (r = 0.937)

Fecundity and ovary volume (OV): The average egg production corresponding to average ovary volume has been tabulated in table. The maximum ovary volume was recoded to be 175 ml and the fecundity being 13,862. The relationship may be expressed as:

Log F = 2.2291 + 0.813 Log OV (r = 0.913)

Fecundity and Ovary Weight (OW): The relationship between ovary weight and fecundity was found to be linear and the relationship is expressed as:

Log F = 2.4545 + 0.6966 log OW (r = 0,852)

Fecundity and Ovary Length (OL): For evaluating the relationship of ovary length and average number of eggs was computed – table. It was observed that ovary length ranges from 124 mm to 268 mm and total fish length range from 300 to 590mm. Fecundity increased with ovary length but there seems to be no direct relationship as 'r' value was 0.568. The relationship can be expressed as:

Log F = 1.9299 + 0.7867 log OL (r = 0.5688)

Ovary Weight (OW) and Fish Length (FL): Weight of ovary in fish is influenced by its size. The relationship between total fish length and ovary weight was found to be fairly close and linear and the 'r' value was 0.825. The relationship between length and ovary weight may be expressed as:

Log OW = -6.5726 + 3.2145 Log (FL) (r = 0.825)

Ovary weight and Fish Weight (FW): Relationship between the two can be expressed as:

Log OW = 2.487 + 0.0082 log (FW) (r = 0.865)

Fecundity has been expressed as the total number of eggs produced in one spawning season. The number of eggs in ovary of a fish is of importance in estimating the number of individuals at the start

Table 1. Relationship between fecundity and various body/ovary parameters.

Total Fish Length (mm)		Fish Weight (g)		Ovary Weight (g)		Ovary volume (ml)		Ovary length (mm)		Fecundity	
Range	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**	**Average**
300-350	320.4	330 – 430	384.5	43.9 – 45	38.5	37 – 44.5	44.23	124 – 199	154	2250 – 3880	3007
351 – 410	386.3	432 - 614	483.7	43.63 - 50.8	45.70	43 – 48.8	44.87	195 – 209	195.3	4210 – 5778	4925
411 - 470	490.1	620 – 760	765.2	52.8 – 70.1	73.08	50 – 110	80.84	212 – 230	227.4	5856 - 7008	5757
471 – 530	500.1	772 – 1244	1043.9	75 – 198	153.2	112 – 170	143.28	232 - 254	244	7620 - 12110	8784
531 – 590	544.4	1250 – 2000	1482.2	200 – 228.3	219.75	170 – 178	175.71	255 – 268	260.6	13261-13862	13649

Table 2. Relationship between fish weight, fecundity and Ovary weight.

Fish Weight (g)		No. of fishes observed	Fecundity		Ovary weight (g)		% of ovary in total weight of fish
Range	Average		Range	Average	Range	Average	
330 – 664	662	39	2250-4006	3128	45 – 58.2	51.6	7.79
665 – 998	831.5	25	4420-8949	6584	60 – 189.5	124.75	15.00
999-1332	1165.5	16	9924 - 13766	11845	194-198	196	16.81
1667 – 2000	1833.5	02	13840 - 13862	13851	200 – 228.3	214.15	11.67

Table 3: Statistical comparison of depend and independent variables of *S. richardsonii*

Dependent Variable (Y)	Independent variable (x)	Equation Log Y=Log a + b log x	Regression Coefficient (b)	Correlation Coefficient (r)	ANOVA F-value	p-value
Fecundity (F)	Total length of fish (TL)	Log F = 2.9942 + 2.5709 log TL	2.570	0.940	85.96	<0.05
Fecundity (F)	Total body weight (FW)	Log F = 0.840 + 1.0323 log FW	1.0323	0.937	122.49	<0.005
Fecundity (F)	Weight of Ovary (OW)	Log F = 2.4545 + 0.699 log OW	0.6966	0.8526	21.76	<0.118
Fecundity (F)	Volume of Ovary (OV)	Log F = 2.229 + 0.813 log OV	0.813	0.9134	39.53	<0.005
Fecundity (F)	Length of ovary (OL)	Log F = 1.9299 + 0.7867 log OL	0.7867	0.56884	22.33	???
Wt. of Ovary (OW)	Total length of fish (FL)	Log F = -6.5726 + 3.2145 log FL	3.2145	0.8251	16.83	<0.005
Wt. of Ovary (OW)	Total weight of fish (FW)	Log F = -2.4870 + 0.008 log FW	0.0082	0.868154	21.62	<0.005

of new generation and this estimate is the starting point of many production and population studies. The eggs laid by the female are a link between generations. Populations of fishes appear to adopt as per the environmental condition through food supply and so it is one of the basic means of adjusting the rate of reproduction to changing conditions (Nikolsky, 1969). Fecundity of *Tor* (Pathani, 1981, in Kumaon region and Nautiyal and Lal, 1985, in Garhwal region) and *Schizothorax plagistomas* (Agarwal *et al.,* 1988) has been investigated earlier. In the present study, fecundity of *Schizothorax richardsonii* was investigated and it ranged from minimum of 3007 / 3128 to a maximum of 13649 to 13851 whereas the total average fish length ranged from 384mm to 544 mm.

The fecundity of fishes is often correlated with the total length of fish, weight, and age of fish along with the length, weight and volume of the ovary also. In the present study, it was observed that the fecundity increased at the rate of 2.57 times of the length of fish. In S. plagiostomus, it was found that the fecundity rate increased at rate of 2.29 times of the length (Agarwal *et al.,* 1988). A similar high exponential value of fecundity to fish length of 2.36 in *S. richardsonii* (Misra, 1982) and 2.68 in *S. niger* (Joyti and Malhotra, 1972) were also recorded earlier. A linear correlation was also observed in case of fecundity versus ovary volume where as other parameter did not so a liner correlation.

However the most important highlight of this study is the comparison of present data set of 1996 to 1998 to the data of 2016 to 2019 for Schizothorax species in same region. *Singh et al.,* (2016), have worked on fecundity of *Schizothorax sp. (plagiostomous)* at the exact same location and have published their results. They report that "the number of ripe ova was found to vary from 3206 to 33611 in fish ranging in total lengths 23.4cm to 46.6cm, body weight between 150g and 2050g, ovary length from 8.8cm to 22.6cm and ovary weight ranging from 11.4g to 122.4g. Fecundity was related to the total length of fish, body weight and total ovary length and weight using regression equations" (quoted verbatim). These values are even towards the higher sides from the earlier values and are indicative that the population of *Schizothorax sp* has sustained the fecundity despite anthropogenic pressures. It has been reported that anthropogenic pressures and urbanization might drive evolution process in fishes (Kern and Langerhans, 2018; Oke *et al.,* 2017). This is unique adaptive skill of the *Schizothorax sp* as it has survived through the evolutionary age of Himalaya. We hypothesize that the population of Schizothorax species can sustain its population after anthropogenic damage to its breeding grounds if the habitat conditions improve after 15 to 20 years. Hence, this unique adaptive skill can be used as a conservation strategy for all the areas of Garhwal Himalaya where anthropogenic activity is disturbing the aquatic habitat.

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Conclusion

Schizothorax sp. is the most abundant fish species that is found in all the fresh water systems of Uttarakhand and comprises of major portion of fish catch. This is one of the most accepted food fish and is sold extensively all over Uttarakhand but the commercial market is totally unorganized. Present research suggests that *Schizothorax sp*. can adaptive very well to long term pressures of urbanization and anthropogenic activities and sustain its populations. Thus this species has a potential to become a very good commercial model for the local population. This is also important keeping in view that in the mountainous terrain of Uttarakhand there are no industrial setup as such and fisheries based on *Schizothorax sp*. can be developed well with technical inputs and can eventually impact the socio-economic condition of locals.

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