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Study on Gonadosomatic index (GSI) during the three seasons (pre-spawning, spawning and post-spawning periods) of *Schizothorax niger* Heckel in dal lake, Kashmir

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Abstract
The present study was conducted to investigate changes in Gonadosomatic index (GSI) of *Schizothorax niger* Heckel during the three seasons (pre-spawning, spawning and post-spawning periods) in Dal Lake, Kashmir from November, 2014 to July, 2015. Fishes ranging in length from 75-374mm and in weight from 56-557g were taken during the study. The mean GSI of the fish *Schizothorax niger* Heckel was found to be 7.94 and its range varied from 0.78-27.28. The mean value of GSI in *S. niger* Heckel during pre-spawning period was found as 2.02±1.22. During spawning and post-spawning periods, the mean values of GSI were recorded as 20.37±3.87 and 1.43±0.42 respectively. The results suggest that the maximum Gonadosomatic Index in *Schizothorax niger* Heckel were recorded in March, i.e. during spawning period (mean value of 20.37 in females). The GSI then started decreasing gradually and was recorded minimum in July (mean value of 1.43 in females). Thus the peak breeding season of the fish during the present study was found in March. Absolute Fecundity and Relative Fecundity of *S. niger* were recorded with a mean values of 21981.60 and 109.82 respectively. A positive correlation was observed during spawning period between GSI and Relative Fecundity at $p<0.05$ level of significance. Understanding reproductive behaviour of fishes is not only important for elucidating the basic biology of the fishes but it can also help in their management and conservation.

Keywords: *Schizothorax niger*, Dal Lake, Gonadosomatic index (GSI), fecundity, Kashmir valley

1. Introduction
The state of Jammu & Kashmir covers an area of about 2, 22, 236 sq. km and extends from 32° 17′ N to 36° 58′ N latitudes and from 73° 26′ E to 80° 30′ E longitudes (Sodhi *et al*., 2013) [35]. The valley of Kashmir is surrounded by the mighty Himalayas which vary in their heights between 1000 to 1800 feet above mean sea level, extending from 33º 22′ N to 34º 43′ N and 73º 52′ E to 75º42′ E covering an area of about 15,948 sq. km. It has a total water spread of about 32765.3 hectares which constitute about 2% of its total area of J & K (Sodhi *et al*., 2013) [35]. The valley has a temperate climate and is known for its seasonality. It has a unique position in harboring rich and diverse types of aquatic habitats, occupying 6% of its total land area (Zutshi and Gopal, 2000) [44]. These water bodies are of immense importance for providing potable water and also ensuring stability of the microclimate of the area, ground water recharge and generating employment by boosting tourism, fisheries and recreation. The valley is famous throughout the world for its waters both lentic and lotic. The lentic waters include Wular lake, Dal lake, Manasbal lake, Nilnang and many other lakes, while the lotic habitats include numerous streams like Sind, Lidder, Branghi, Veshu, Dudhganga, etc. all being directly or indirectly connected with the River Jhelum (also called Vitasta/Vyeth), the lone natural drainage system of the valley. These aquatic habitats harbour a number of native fishes like *Schizothorax* spp., *Glyptothorax* spp., *Triplophysa* spp., etc. as well as the exotic fishes like *Onchorhynchus mykiss*, *Salmo trutta fario*, *Cyprinus carpio*, *Carassius carassius* etc. The water bodies of Kashmir valley support a wide variety of indigenous and exotic fish species. The major ichthyofauna of Kashmir is represented mainly by the Central Asiatic fauna in which *Schizothorax* group is predominant (Sunder *et al*., 1979) [36]. Fishes belonging to families Cyprinidae, Cobitidae, Siluridae, Poecilidae, Sisoridae and Salmonidae are found in the valley. The cyprinidae is mainly represented by the schizothoracids (snow trouts). A comprehensive survey to assess the potential of Schizothoracines from various lakes and streams of Kashmir valley was made by Raina *et al*. (1985) [30]. Schizothoracids are indigenous fish species and are commercially important with wide market demand. Yousuf (1996) [41] reported 42 species of fishes from Kashmir while Balkhi (2007) [3] reported 40 species.

However, not more than 22 species are existing at present (Kullander *et al*., 1999; Bhat *et al*., 2010) [19, 4]. Dal lake of Kashmir is situated in the north-east of Srinagar at mean latitude of 34° 07' N and longitude of 74° 52' E and at an altitude of 1584 m.a.s.l., is probably of fluvial origin having been formed from the ox-bows of the river Jhelum. The lake covers an area of about 11.4 km^2 (Qadri and Yousuf, 2008) [29]. Fishes like *Cyprinus carpio* var. *communis, Cyprinus carpio* var. *specularis, Schizothorax niger, Carassius carassius, Crossocheilus diplochilus, Schizothorax esocinus, Schizothorax curvifrons, Puntius conchonius* have been reported to be present in the Dal Lake (Shafi *et al.*, 2005) [32].
Among Schizothoracids, *Schizothorax niger* Heckel is a valuable fish of Kashmir region, but is now, in stiff competition with other exotic fishes e.g. *Cyprinus carpio* (Yousuf, 1996) [41]. *Schizothorax niger* Heckel locally known as Ael Gad is a prized fish of Kashmir and belongs to family Cyprinidae. *Schizothorax niger* being a lacustrine fish occurs in lakes of Kashmir in good numbers including Dal Lake. This fish is restricted to lentic water bodies of Kashmir and differs from the other species of genus *Schizothorax* in color pattern, morphometry, scale counts, gill racker counts, pharyngeal bone and tooth shape. *Schizothorax niger* Heckel prefers clean and cold pockets of water in lakes for egg-laying, and it also lays eggs on the roots of willow trees. *Schizothorax niger* Heckel is fusiform with a short blunt slightly prognathous upper jaw having inferior mouth (upper jaw a little projecting beyond lower jaw) horse-shoe shaped, nearly horizontal broader than long. *Schizothorax niger* Heckel is herbi-omnivore. As all other Schizothoracids shows breeding migrations, moving upstream to spawn, however, *S. niger* does not show any such migration and spawns in the shallow peripheral areas of the lake in close vicinity of springs on sandy bottoms (Vass and Raina, 1979) [38]. It plays an important role in capture fishery of the flat land lakes of the valley, especially Dal, Manasbal, and Wular. The spawning season extends from spring to early summer.
Understanding reproductive behaviour of fishes is not only important for elucidating the basic biology of the fishes but it can also help in their management and conservation. The term 'fecundity' denotes the egg laying capacity of a fish or the number of ripe eggs produced by a fish in one spawning season. Knowledge of fecundity is also an important aspect in stock size assessment, stock discrimination (Holden and Raitt, 1974) [14] and rational utilization of stock (Morales, 1991) [24] and in explaining the variation of population as well as to make efforts for increasing the amount of fish yield. Thus, studies on reproduction behavior (fecundity) of fish are important and a basic requirement for improvement of and effective fishery resources management and conservation (Marshall *et al*., 2003; Grandcourt *et al*., 2009) [22, 13]. The aim of this work was to determine the biological parameters GSI and fecundity during three seasons of *Schizothorax niger* Heckel in Dal Lake, Kashmir.

2. Materials and methods

A total of 45 specimens of *S. niger* Heckel were collected from Dal Lake on seasonal basis (15 specimens each during pre-spawning, spawning and post-spawning periods respectively) and were brought from the site to the Fisheries Resource Management of Faculty of Fisheries, Rangil, Ganderbal, SKUAST-Kashmir in plastic buckets. The length and the weight of fishes were recorded. The fishes were dissected for the study of gonads. The ovary was weighed and was preserved in 4% formalin for further study of developments.

2.1 Morpho-histological study of gonads:

The fish specimen (female) were dissected open and their gonads were collected to record their weight. GSI (Gonado Somatic Index) was determined using the formula as given by Desai (1970) [11]:

$$\text{GSI} = \frac{\text{Weight of gonads}}{\text{Weight of fish}} \times 100$$

2.2 Fecundity

The gravimetric method was used for studying fecundity, which is based on the relation between ovary weight and the oocyte density in the ovary (Murua *et al*., 2003) [25]. Fecundity was estimated by counting the number of mature ova from a known weight of mature/ripe ovary. The ovary sub samples were obtained from the anterior, middle and posterior regions of both the ovaries (James *et al*., 1978) [16]. The subsamples were spread evenly on a counting slide with a few drops of water and the number of mature ova was counted and average number of three portions was used to determine the fecundity by the following formula:

$$\text{Absolute fecundity} = \frac{\text{No. of ova in the subsample} \times \text{total ovary weight}}{\text{Weight of subsample}}$$

Relative fecundity i.e. number of eggs/1g of body weight (unit body weight or ovary weight) was obtained by dividing absolute fecundity with total weight of fish (in grams).

$$\text{Relative fecundity} = \frac{\text{Absolute fecundity}}{\text{Weight of fish}}$$

The gravimetric method was used for studying fecundity, which is based on the relation between ovary weight and the oocyte density in the ovary (Murua *et al*., 2003) [25]. The data collected was analyzed using appropriate statistical tools with the help of statistical software SPSS version 20 and Microsoft excel.

3. Results

3.1 Length of fish (mm)

The mean length of *Schizothorax niger* Heckel collected from Dal Lake was found to be 249.05 mm and its range varied from 75-374 mm. However, during pre-spawning, spawning and post-spawning periods, the mean length of the fish was recorded as 247.6±44.3 mm, 266.6±32.5 mm and 267±48.4 mm respectively.

3.2 Weight of fish (g)

The mean weight of the fish *Schizothorax niger* Heckel collected from Dal Lake was found to be 211.02 g and its range varied from 56-556.7 g. The mean weight during pre-spawning, spawning and post-spawning periods was recorded as 163.72±118.51 g, 202.43±56.14 g and 232.96± 89.15 g respectively.

3.3 Gonadosomatic Index (GSI)

Gonadosomatic Index (GSI) indicates gonadal development and maturity of fish (Rheman *et al*., 2002) [31], besides being useful for determination of fish reproductive period. The mean GSI of the fish *Schizothorax niger* Heckel was found to be 7.94 and its range varied from 0.78-27.28. The mean GSI in *S. niger* Heckel during pre-spawning was found as 2.02±1.22 (table 1). During spawning and post-spawning it

ranged from 20.37±3.87 and 1.43±0.42 (table 2 and table 3) respectively. There was a significant difference during the three seasons in GSI (ANOVA: F= 295; p=0.00000 i.e. $p<0.01$). There was a positive correlation between GSI and Relative Fecundity with 'r' value of. 632 at $p<0.05$ level of significance during spawning period.

Table 1: Range and mean of length, weight and GSI of *Schizothorax niger* Heckel during pre-spawning period

Parameters	Range	Mean ±S.D
Length of fish (mm)	180-370	247.6±44.3
Weight of fish (g)	56-556.7	163.72±118.51
GSI	0.78-5.78	2.02±1.22

Table 2: Range and mean of length, weight and GSI of *Schizothorax niger* Heckel during spawning period

Parameters	Range	Mean ±S.D
Length of fish (mm)	200-315	266.6±32.5
Weight of fish (g)	130-291	202.43±56.14
GSI	13.27-27.28	20.37±3.87

Table 3: Range and mean of length, weight and GSI of *Schizothorax niger* Heckel during post-spawning period

Parameters	Range	Mean ±S.D
Length of fish (mm)	75-374	232.95±48.5
Weight of fish (g)	160-330	267.0±48.4
GSI	0.78-2.47	1.43±0.42

3.4 Fecundity

Knowledge of the fecundity of a species is an important factor in fish stock management, apart from being biologically significant. During the study period the total number of mature eggs in the ovary (absolute fecundity) varied between 10812 and 34199 in fish specimens having total body weight of 200g and 315 g respectively. Relative fecundity (eggs per gram body weight) varied between 65.85 and 163.33. The mean value of absolute fecundity was found as 21981.6±6625.97 and mean relative fecundity as 109.825±24.20 (Table 4).

Table 4: Mean of Absolute fecundity and Relative fecundity in *Schizothorax niger* Heckel

S. No.	Length of fish (mm)	Weight of fish (g)	Absolute fecundity	Relative Fecundity
1.	300	194.36	28448	146.36
2.	290	194.3	22110	113.79
3.	255	164.2	10812	65.85
4.	230	141.6	11783	83.21
5.	240	155.3	15789	101.67
6.	270	243.5	21937	90.09
7.	200	130	21234	163.33
8.	295	291	30369	104.36
9.	235	143	18850	131.81
10.	245	147.20	16594	112.73
11.	260	198.1	22036	111.23
12.	315	284	34199	120.41
13.	285	250	24497	97.98
14.	305	280	28284	101.01
15.	275	220	22782	103.55
Mean ± SD	266.6±32.5	202.43±56.14	21981.6±6625.97	109.825±24.20

4. Discussion

Reproduction has four key points viz sexual maturity, reproductive period, gonadosomatic index and fecundity, which are vital demographic characteristics essential to an understanding of a species life history (Cortes, 2000) [9]. Teleosts exhibit different spawning periodicity and are seasonal breeders (Jhingran, 1982) [17]. According to Badola and Singh (1984) [2], most of the Garhwal Himalayan hill stream fishes spawn during summer and monsoon months as *Tor tor* and *Tor putitora* (April to July), *Labeo dyocheilus* and *Labeo dero* (March to june), *Barilius* spp. (April-June), *Glyptothorax pectinopterus* and *Pseudecheins sulcutaus* (April to August) and *Nemacheilus* species (July to August). In Schizothoracids, diversity in spawning season and periodicity exists because of varied ecological environments. Accoding to Jhingran (1982) [17], *S. richardsonii* in Himachal Pradesh spawns from March to June, in Kumaon waters from July to December (Bisht, 1974) [5] and in Garhwal Himalaya from July to September (Misra, 1982) [23]. According to Bouain and Siam (1983) [7], Biswas *et al.* (1984) [6], Sinovcic (2000) [34], GSI is an indicator of fish spawning in temperate and tropical region. The values of Gonadosomatic index (GSI) increase with the maturation of the fish and reaches maximum during peak of maturity and decrease abruptly and sharply when the fish becomes spent and females generally exhibit comparatively higher GSI than males (Khan, 1945; Ganpatti and Chako, 1954; Pathak and Jhingran, 1977; Piska and Devi, 1993) [18, 27, 28]. Similar observations were recorded in the current study in *Schizothorax niger* Heckel which showed the maximum GSI values in spawning period (20.37, in females).The GSI then started decreasing gradually and was recorded minimum in July (1.43, in females). Thus the peak breeding season during the present study was found in March which are in conformity with the findings of Hussain (2014) [14] who also reported the spawning period of *S. niger* during March-April. Sunder *et al.* (1984) [37] have reported similar observations in *Schizothorax longipinnis* as the GSI in the fish has been reported lowest in July (1.0) and started increasing till September (5.2).

Study on fecundity forms an important part of fishery science as it has direct bearing on fish production and exploitation. Nikolskii (1963) stated that fecundity is a specific feature that arises during the evolution of a new species adapted to a certain environmental conditions. Fecundity is known to vary within species with latitude and location (Cushing, 1968; Mann *et al.*, 1984) [10, 21] and also with spawning time (Ware, 1975) [39]. According to Murua and Saborido-Rey (2003) [25] different fish species reflect marked differences in their reproductive patterns and exhibit different reproductive potential in terms of fecundity. Cental Inland Fisheries Research Institute (CIFRI, 1977) [8] while suggesting measures for the development and conservation of the Dal

Lake fishery, reported the absolute fecundity of *S. niger* Heckel to be 7929 eggs in the fish ranging in weight from 100-250g and in length from 170-315 mm. This reproductive characteristic of *S. niger* Heckel has been related to different ecological conditions at this high elevation and this phenomenon has also been described in other Schizothoracids like *Gymnocypris przewalskii* by Zhang *et al.* (2005) [43] and *Gymnocypris waddellii* by Yang *et al.* (2011) [40] in Tibet.

In the present study it was found that in addition to late maturation, low fecundity was another reproductive trait of *S. niger* Heckel as compared to other cyprinids at low elevations (Abedi *et al*., 2011; Liu *et al*., 2011) [1, 20] and showed variations throughout the year. Absolute fecundity of *S. niger* Heckel (10812-34199) was found lower than the *Cyprinus carpio* var. *communis* as reported by Shafi *et al*. (2012) [33] who reported the absolute fecundity of fish as 629230. The mean relative fecundity was found to be lower than other cyprinids as reported by Yousuf *et al.* (1992) [42]. In the current study the mean relative fecundity of *S. niger* Heckel was found to be 109.82 as compared to 53.23 (Yousuf *et al*., 1992) [42]. The reason behind the higher relative fecundity seems due to presence of only gravid fishes taken during the present study.

5. Conclusion

Schizothoracids also popularly called snow trouts are important food fishes of Kashmir with a long interesting history of origin. The fishes inhabit the entire network of snow and spring fed cool water rivers and streams. Among them *Schizothorax niger* Heckel proves to be one of the most important food fish from the commercial point of view. Locally known as Ael Gad, is considered as a prized fish of Kashmir. *Schizothrax niger* Heckel is an annual breeder, releases eggs over a short period of time with peaks in February and March. Thus these months form the spawning period of the fish. Gonadosomatic Index in *Schizothorax niger* Heckel recorded maximum mean values in March during spawning period (20.37, in females). The GSI then started decreasing gradually and was recorded minimum in July (1.43, in females). Thus the peak breeding season during the present study was found in March. Absolute Fecundity and Relative Fecundity of *S. niger* with mean values of 21981.6 and 109.825 respectively.

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