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Present status of breeding biology of *Schizothorax niger* in Dal Lake Kashmir

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Abstract
Present study was undertaken to study the breeding biology of *Schizothorax niger* (Heckel,) in Dal Lake, Kashmir with respect to its gonadal development, fecundity and gonadosomatic index. The fish samples consisting of total number of 238 specimens of *S. niger* were collected from four sites (Gagribal, Nishat, Hazratbal and Nigeen) of the lake and assessed for the analysis of gonadal development, fecundity and gonadosomatic indices using standard methodologies. Results revealed that *S. niger* is an annual breeder, with maximum GSI values observed during spawning periods (February to March). Mean monthly GSI in males fluctuated between 1.12 ± 0.08 and 6.77 ± 0.56 in female from 3.13 ± 0.35 to 13.80 ± 1.21. The peak values of GSI were 13.80 in females and 6.77 in males. The mean absolute and relative fecundity observed was 11590 ± 718.33 and 48.90 ± 1.83 respectively. Gonadal cycle was concluded to be divided into five stages viz. Early Maturing stage, Maturing stage, Spawning stage, Spent stage and Resting stage.

Keywords: Reproduction, breeding biology, *Schizothorax niger*, Dal lake, Kashmir

1. Introduction
Understanding reproductive behavior of fishes is not only important for studying the basic biology of the fishes but it can also help in their management and conservation. Conservation and survival of any fish species depend more importantly on its reproductive potential. Reproduction has key components of gonadal development (maturity stages), gonadosomatic index (GSI) and fecundity, which are vital demographic characteristics essential to an understanding of a species life history [1]. The knowledge of gonadal development or gonadal cycle and their functional mechanism is of prime importance for successful fish seed production and breeding practices. Temporal variations in the GSI and gonadal maturity are used to assess the reproductive pattern of fish species. Fecundity denotes the egg laying capacity 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 [2] and rational utilization of stock [3] which has direct bearing on fish production and exploitation. It is a specific feature that arises during the evolution of a new species adapted to a certain environmental conditions [4]. So studies on these components are important and a basic requirement for improvement and effective fishery resources management and conservation [5]. *Schizothorax niger* Heckel, locally known as Alghad is a prized fish of Kashmir. The fish belongs to the family Cyprinidae. *S. niger* being a lacustrine fish occurs in good numbers in Dal Lake. The overall population of *Schizothorax* has shown a declining trend due to multiple factors especially habitat destruction, over fishing, competition for food and breeding grounds from exotic carps, water pollution, etc [6]. The aim of the present study was to find the present breeding potential of *S. niger* form Dal lake so that an understanding can be developed along with studies on morphometrics for better conservation and management of the fish in Kashmir.

2. Materials and Methods
2.1 Study area
The present study was carried out in Dal Lake (34º 5' and 34º6'N latitude and 74º 8' and 74º12' E longitude) situated at an altitude of 1584m above mean sea level. Total eight sites were selected for collection of fish in four different basins, one peripheral and one central from each basin viz., Gagribal, Nishat, Hazratbal and Nageen.

2.2 Sample collection

A total of 238 fish specimens were collected, stored in ice and transported to the laboratory for further analysis. Identification of fish species was done with the help of standard taxonomic works [7, 8, 9, 10]. The samples were cleaned and the surface moisture was removed using tissue paper. Each fish sample was measured for its total length (TL) to the nearest 1 mm and total weight to the nearest 1.0 g using digital vernier caliper and an electronic digital balance respectively. The sex of individual specimens was determined after dissecting the specimens, as there is no clear sexual dimorphism in this fish except in the spawning season where males were found to have small whitish tubercle like structures on their mouth [11]. After recording morphometric characters, the fishes were sacrificed and both the testes and ovaries were taken out carefully and were fixed in Bouin's fluid for 24 hours to bring hardness in eggs for accurate calculation and morpho-histological study. Stages of maturity of gonads were distinguished on the basis of morphological appearance (macroscopic observations) in males. Macroscopic as well as microscopic observations were used in case of females, following the standards laid down by Nikolsky [4]. While macroscopic observations were based on fresh samples, microscopic observations were based on materials preserved. Fecundity was calculated following gravimetric method [12, 13]. The ovary subsamples were obtained from the anterior, middle and posterior regions of the mature preserved ovaries [14] and considered as one sample. The absolute fecundity was worked out then by calculating the number of ova in the whole ovary and relative fecundity was calculated as number of ova/gm of the body weight.

The G.S.I. was calculated for both sexes according to de Vlaming [15] by using the formula:

$$GSI = \frac{\text{Weight of Gonads}}{\text{Weight of Fish}} \times 100$$

The average G.S.I. value for each size group was also calculated.

3. Results

3.1 Maturity Stages

Reproductive cycle of *S. niger* exhibited the sequential phases of multiplication, growth, differentiation, maturity and depletion. Based on morphological examination and gross morpho-histological changes (Figure 1 and Figure 2) in the gonads the maturity stages of *S. niger* were divided into five different phases (Table 1).

Table 1: Maturity stages of *S. niger*

Morphological characteristics of gonads		
Maturity stage	**Testes**	**Ovaries**
Stage I: Early Maturing Stage	Small, thin, transparent, filamentous, and occupied a very small proportion of the body cavity. The testes start to increase in weight and become slightly thick. The length of testes is also about 2/3rd of the body cavity.	Ovaries were long, fleshy in texture, running along almost 3/4th length and occupied about 1/3rd of the abdominal cavity. They start to enlarge resulting in increase in weight and volume and thus occupying greater part of body cavity. During this period, the ovaries become light yellow in colour and blood supply was inconspicuous. This showed the beginning of the maturation phase. The ova were very small.
Stage II: Maturing Stage	Increased length and weight in comparison with immature stages. Well developed and start to get opaque, dark gray, and extend up to less than half of the abdominal cavity. As testes developed, they became moderately thick, slightly flattened, and gray-whitish extending up to half of the abdominal cavity. The histological observation of testes revealed high spermatogenic activity and rich blood supply during this phase. The spermatogenetic activity showed progressive enhancement. During this period, the testicular lobules were small and the interlobular spaces were packed with dense stroma consisting of loose connective tissue and blood vessels.	In females, this stage was characterized by obvious enlargement in the ovary size, with a yellow/opaque orange colour invaded with blood vessels and they cover almost half of the body cavity. Ova were quite visible to the naked eye.
Stage III: Spawning stage	Obvious enlargement in the testes size was clear and they look like mature. Testes increased in thickness and reached their maximum development and occupied almost the entire length of the body cavity. Their colour was creamy-white and milt could be easily extruded also by a slight press on the belly. Testes had high blood supply during this phase and some of them were slightly pinkish.	Ovaries reached their maximum development and were greatly enlarged attaining their maximum weight and volume, filling up the entire body cavity. They were stretched, very turgid and typically orange-yellow in colour. The oocytes were large and the belly of the female looked swollen, a slight pressure on abdomen evacuates eggs from the belly. This stage is the spawning stage as the fish is ready to spawn.
Stage IV: Spent stage	Shrunken, strap-like and reduced considerably in weight and volume, flaccid and flabby, thin testicular and lobular walls and the presence of spermatozoa are the characteristic features; They are reduced to about one third of the body cavity. The colour changed to whitish grey and the residual of spermatozoa appeared as white areas.	Slightly flaccid and flabby due to the spawning process, decrease in the weight of the gonads. As the ovaries during this phase undergo spent stage and contain remains of unspawned eggs, walls get harder and wrinkled.
Stage V: Resting stage	The testes undergo the phase of relaxation and start the rehabilitation phase and prepare for next season.	Ovaries get more slender and flaccid and light in colour and undergo regeneration of degenerated tissue.

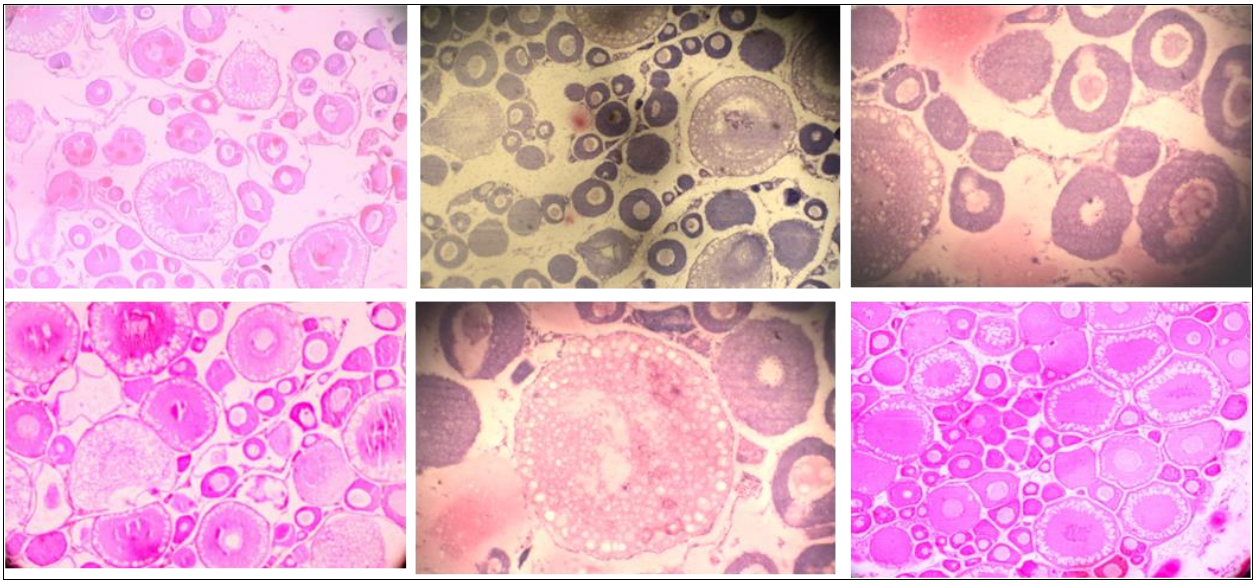

Fig 1: Photomicrographs (50 X) of T.S of Ovary of *Schizothorax niger* Heckel showing different stages

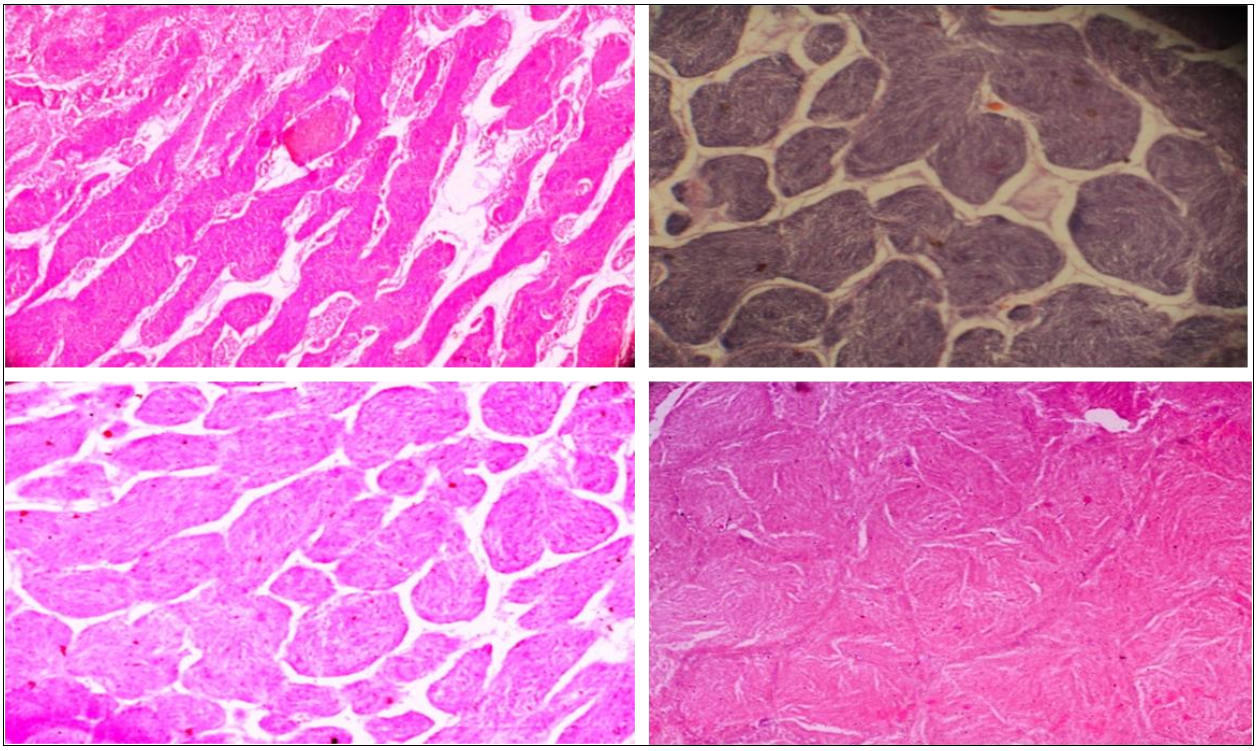

Fig 2: Photomicrographs (50 X) of T.S of Testis of *Schizothorax niger* Heckel showing different stages

3.2 Fecundity

The total number of mature eggs varied from 5471 to 18385 in individuals of 110 to 431 grams with 215mm to 331mm total length. The mean absolute fecundity observed was 11590 ± 718.33. The mean relative fecundity (number of ova/gram of body weight) was found to be 48.90 ± 1.83 with highest of 67.57 and minimum of 31.21.

3.3 Gonado Somatic Index (GSI)

The fluctuations in gonadosomatic index of *S. niger* with respect to season and length are presented in Tables 2 and 3 and graphically shown in Figures 3 and 4. The mean monthly GSI in males fluctuated between 1.12 ± 0.08 (September) and 6.77 ± 0.56 (March) and in female from 3.13 ± 0.35 (July) to 13.80 ± 1.21 (March). The maximum and minimum GSI values recorded for male individuals were 12.56 and 0.48 respectively during the month of January and April and for females it was 24.67 and 0.86 during March and June, respectively. During the period from November to January, the weight of the gonads and the GSI increased gradually. The GSI value reached its peak during February and March i.e. during the spawning months then it decreased gradually during the following months with a minimum value recorded during July when the fish had completely spawned all the eggs and ovary was in spent phase. The average GSI values recorded in males and females were 3.35±0.14 and 7.69±0.38, respectively. Females showed higher mean GSI values than males. Among different size groups the highest GSI was recorded in >400 mm size group (10.21±1.04) whereas the smaller fishes < 50mm recorded minimum GSI values (3.06±0.18).

Table 2: Monthly fluctuations in GSI of *Schizothorax niger*

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Overall
Male	5.81± 0.77	6.18± 0.80	6.77± 0.56	3.44± 0.64	1.74± 0.18	1.5± 0.11	1.19± 0.10	1.22± 0.10	1.12± 0.08	2.08± 0.14	3.65± 0.67	5.49± 1.21	3.35± 0.14
Female	12.15± 0.60	12.52± 1.41	13.8± 1.21	8.86± 1.16	4.63± 0.59	4.28± 0.48	3.13± 0.35	3.8± 0.41	5.3± 0.68	6.7± 0.62	9.67± 0.52	10.26± 1.66	7.69± 0.38
Combined	8.98± 0.64	9.35± 0.48	10.285± 0.52	6.15± 0.93	3.185± 1.10	2.89± 0.95	2.16± 0.25	2.51± 0.337	3.21± 0.98	4.39± 0.12	6.66± 0.83	7.875± 0.58	5.64± 0.46

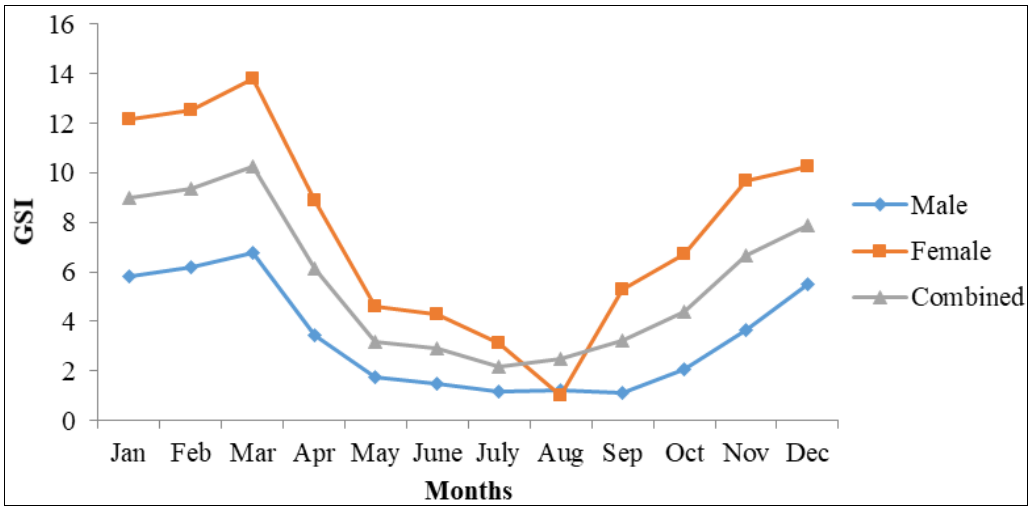

Fig 3: Monthly fluctuations in GSI of *Schizothorax niger* Heckel

Table 3: Variation in GSI among different size groups of *Schizothorax niger*

Length Group(mm)	<50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	>400
GSI	3.06±0.18	5.91±0.48	6.57±0.94	5.48±0.36	7.19±0.42	6.94±0.33	8.89±0.45	7.22±0.69	10.21±1.04

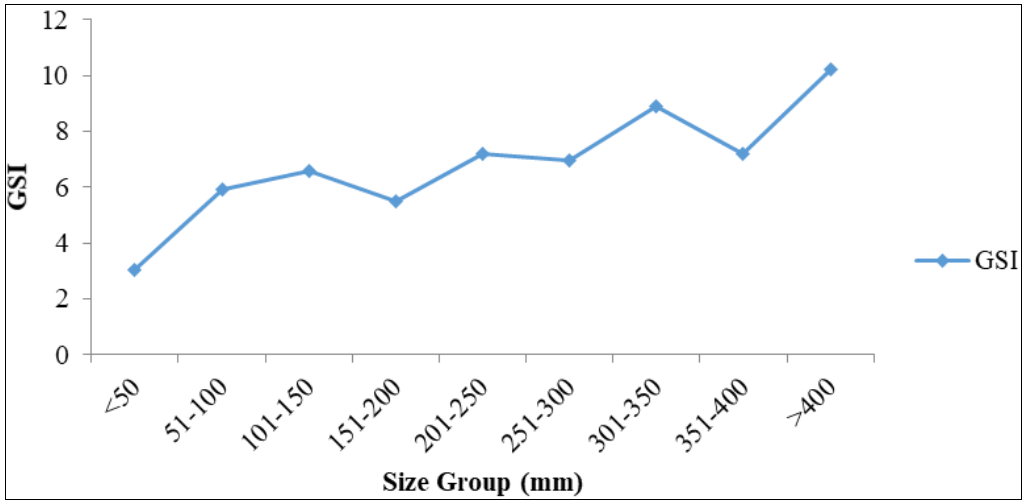

Fig 4: Variation in GSI among different size groups of *Schizothorax niger* Heckel

4. Discussion

In most fishes, the male and female reproductive functions occur in separate individuals in which males produce sperms and females produce eggs. Fertilization is external and the large numbers of eggs produced by each female are left to develop, hatch and grow. Some fishes exhibit a distinct sexual dimorphism [16] while others do not [17, 18]. Owing to the absence of sexual dimorphism, the sexes in *S. niger* can be identified by opening the abdomen. However, during the breeding period, white tubercles appear on the snout of males and milt oozes out by applying slight pressure on the abdomen, and that the female fish have a bulging belly due to enormously enlarged ovaries fully packed with ripe ova. In breeding season, the body color becomes darker and color of the testes appears pinkish due to the increased vascularisation. Reproductive cycle of *S. niger* exhibited the sequential phases of multiplication, growth, differentiation, maturity and depletion. The Reproductive cycle has been divided into five phases on the basis of histology, duration of various developmental stages of oocytes, increase and decrease in gonadosomatic index. The phases are (i) Early Maturing stage, (ii) Maturing stage, (iii) Spawning stage, (iv) Spent stage and (v) Resting stage. The testes in *S. niger* are fused posteriorly to form the common spermatic duct. Both left and right testes are generally equal in length as observed during the present study. They are enclosed within a connective tissue envelope called as "the outer wall" formed by two layers also reported earlier [19]. The testes were small, thin,

transparent, and filamentous in early maturing stage and they start to get opaque and dark gray in maturing phase while as in spawning period they reach to their maximum development. In spent stage, they looked slightly flaccid and flabby because of the discharge of the sexual products. The oocytes in the adult are developed from the germinal epithelium of the ovigerous lamellae. *S. niger* releases eggs over a short period of time, which extends from February to April with peaks in February and March in the Dal Lake.

The assessment of fecundity is one of the important components of the reproductive biology, since it is not a stable character due to changes in environmental conditions and species specific factors [20]. Fecundity is known to vary within species with latitude and location [21] and with spawning time [22]. According to Murua and Saborido-Rey [23] different fish species reflect marked differences in their reproductive patterns and exhibit different reproductive potential in terms of fecundity.

In the present study fecundity of *S. niger* was found to be very low as compared to other cyprinids at low elevations [24, 25] and showed variations throughout the year. Absolute fecundity of *S. niger* (5471 to 18385) was found to be lower than the other carps and way lower than the *Cyprinus carpio* var. *communis* as reported by Shafi *et al*. [26] who reported the absolute fecundity of fish as 629230. The mean relative fecundity was also found to be lower than other cyprinids as reported earlier [27]. In the current study, the mean relative fecundity of *S. niger* was found to be 48.90 as compared to 53.23 reported in earlier studies [27]. The changing environs of Dal Lake may be accounted for the decrease in fecundity. Central Inland Fisheries Research Institute annual report (CIFRI 1977) while suggesting measures for the development and conservation of the Dal Lake fishery, reported the lower absolute fecundity of *S. niger* to be 7929 eggs in the fish ranging in weight from 100-250 gm and in length from170-315mm [28].

Gonadosomatic Index is an indicator of fish spawning in temperate and tropical region. The values of GSI increase with the maturation of the fish and become maximum during peak of maturity and decrease abruptly and sharply when the fish becomes spent and females generally exhibited comparatively higher GSI than males [29, 30]. Similar observations were recorded in the current study which showed the maximum recorded GSI values in March (13.80 and 6.77 in females and males respectively) followed by February (12.52 in females and 6.18 in males) which correspond to the maturity of the fish. The GSI then gradually decreased and was recorded minimum in July (3.13) and September (1.12) in females and males, respectively. Thus, the peak breeding season during the present study was found in March. Similar observations and values in *Schizothorax longipinnis* were observed in earlier studies [31] as the GSI was lowest in July and started increasing till September. Among different size groups the highest GSI was recorded in >400 mm size group (10.21±1.04) whereas the smaller fishes < 50mm recorded minimum GSI values (3.06±0.18). Overall females showed higher mean GSI values than males.

5. Conclusion

S. niger is a moderately fecund fish showing fluctuations in fecundity and the variations are closely associated with, fish length, weight and gonad weight and gonad length. The fish is an annual spawner, releasing eggs over a short period of time, which extends from February to April with peaks in February and March in the Dal Lake. Gonadosomatic index showed seasonal variation and increased with the maturation of fish, being maximum during peak maturity and declining abruptly thereafter, when the fish becomes spent.

S. *niger* still exists in good numbers and good conditions in Dal Lake, though over the past few years due to changing and deteriorating environs the growth, fecundity and reproductive capacity of fish has decreased and if proper fishery management steps are taken at an earliest the *S. niger* fishery in Dal Lake can be enhanced for fish production and gene pool conservation.

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