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Sex ratio, fecundity and gonado somatic index of spotted snakehead, *Channa punctatus* (Channidae) from a lentic ecosystem

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Abstract
Sex ratio, fecundity and gonado somatic indices give important clue about any fish's reproductive biology. The study was conducted to know the sex ratio, fecundity and gonado somatic index of spotted snakehead, *Channa punctatus* from a closed water body. Data on male-female ratio, fecundity and gonado somatic indices were calculated round the year. Fish samples were caught using the traditional cast nets from the earthen ponds. The female to male sex ratio for spotted snakehead in closed ecosystem found to be 1.16:1. Fecundity ranged from 2538±51 to 32987±111.52 and peak value was recorded in July. The highest mean gonado somatic index was 5.34±0.07 for female and 0.49±0.04 for male in July, showing that the gonadal development reached its peak during this month. Monthly pooled values of GSI indicated that the peak breeding season of *C. punctatus* occurred in the month of July in closed waterbody like earthen pond. The results of the present study revealed that *C. punctatus* breeding season starts from April and ends in September i.e., the rainy season in Bangladesh. The observation of the present study will be helpful for selective breeding programme, conservation and sustainable fishery management of *C. punctatus* in its natural waterbodies.

Keywords: Sex ratio, gonado somatic index, spotted snakehead, *Channa punctatus* and lentic ecosystem

1. Introduction
Sex ratio of any species affords necessary information on the representation of male and female fish present in a population. It statuses the proportion of male to female fish in a population and indicates the dominance of sex of fish species in a given population. Sex ratio also constitutes basic information indispensable for the assessment of the potential of fish reproduction and stock size estimation in fish population [1, 31]. Furthermore, gonadosomatic index is one of the important parameter of fish biology, which gives the detail idea regarding fish reproduction and reproductive status of the species and help in ascertaining breeding period of fish [14, 23, 26]. The method of studying the spawning season is to follow the seasonal changes in gonadal weight in relation to body weight, expressed as the gonadosomatic index. The percentage of body weight of fish that is used for production of eggs is determined by the gonadosomatic index [2].
Moreover, other reproductive parameter like fecundity is useful in the estimation of population and productivity. Fecundity is the total number of ripe eggs prior to spawning in the female fish gives the clue about ripeness of that particular fish [7]. The knowledge of fish fecundity has much relevance in fish population studies and in successful management and exploitation of the fishery [4].
Environment itself is an influencing factor causing the egg production, varies not only among different species but also within the same species depending upon the length and weight of gonad [8, 19]. Maturity determination by gonadosomatic index has proved significant role in the life of fishes. It is helpful in fish breeding too [27].
Spotted snakehead, *Channa punctatus* is well known for its taste, high protein content and low intramuscular spines, high nutritive value, recuperative and medicinal qualities, and is recommended as a diet during convalescence [15]. This fish has been gaining importance not only as a food fish but also as an aquarium fish for its body shape and behaviour [25]. However, the fish have been disappearing from the wild in Bangladesh. Reasons may include disease, siltation, pollution, poisoning, and loss of habitat, overexploitation, destructive fishing and

introduction of alien species. Information on reproductive characteristics will be helpful to conserve this fish in the wild condition. It is easy to ascertain the spawning season of a fish by studying the seasonal changes of the fecundity and gonado somatic indices. The current initiative was undertaken to determine the gonad maturity and spawning period influenced by different seasons in *C. punctatus*.

2. Materials and methods

2.1 Study area

The study area was Sylhet Agricultural University, Sylhet, Bangladesh and is located between 24°54' North latitude and 91°54' East longitude.

2.2 Collection of specimens and sampling

Samples of *C. punctatus* were collected fortnightly from small ditches of Sylhet Agricultural University campus. The specimens were collected for one year. The simple random sampling technique was used [10]. A total of 312 samples were collected during the study period. The samples were transported to the laboratory and preserved in a deep freezer at -20°C until examination and analysis.

2.3 Body measurements

The specimens were taken out of the deep freezer and allowed to thaw and the body length and weight were measured. Total and standard lengths were measured using a one-meter measuring board graduated in cm.

The fish was wiped with a dry napkin before weighing and body weight and ovary weight were measured using a weighing balance (model: GemPro 250 digital gems scale).

2.4 Sex ratio

Each specimen was dissected and the gonads were removed. The sex of each specimen was identified by examination of the gonads. The proportion of the two sexes relative to one another was used to calculate the sex ratio.

2.5 Gonadosomatic index

A total of 312 (Female 165; Male 147) *C. punctatus* from lentic ecosystem were collected and maintained in accordance with the guidelines of the Sylhet Agricultural University. The gonads were removed by abdominal dissection and weighed to the nearest gram. The gonado somatic index (GSI) was obtained according to the following equation:

GSI =GW/ (TW-GW) x 100

Where, GW= gonad weight, and TW= total body weight [13]. Then the gonad samples were preserved in 10 % buffered formalin and kept at room temperature for further use.

2.6 Fecundity

To estimate the fecundity, three sub-samples of ovaries weighing 0.1 g to 0.2 g were obtained from the anterior, posterior and the middle of gonad. The eggs were placed into a dish and counted under stereo light microscope (Nikon, YS-100). The mean from the three sub-samples were used to calculate absolute and relative fecundity using gravimetric method.

Fecundity was calculated by the following formula:

$F = n \times G/ g$

Where "F" is fecundity, "n" is the average number of eggs in sub-sample, "G" is weight of the gonads and "g" is the weight of the sub-sample.

3. Results

3.1 Sex ratio

Out of 312 specimens of *C. punctatus* collected, 47.12 % were males and 52.88 % were females (male: female = 1: 1.16). The overall sex ratio did not differ statistically from the expected value of 1:1 (df = 1, $\chi 2 = 0.04$, $p < 0.05$). Females were dominant in the peak of the spawning period, occurring in June (Table 1).

3.2 Gonado somatic index (GSI) of *C. punctatus*

Gonado-somatic-index (GSI) of the species gives idea about the seasonal variation and sexual maturity of the fish. Monthly variations in GSI exposed that both sexes followed nearly the same trend. The GSI value of female was mostly higher than male, especially during and at the end of the spawning periods (Fig. 1 and Table 1). The higher values of GSI appeared from March to July for both the sexes. The spawning seasons were June and July for both sexes with a peak in July (0.49±0.04 for male and 5.34±0.07 for female). The minimum values of GSI were perceived during September (0.13±0.01 for male and 0.53 ± 0.03 for female) representing the resting phase of this species. There was a sharp fall in the GSI values after July and reaches minimum in September which to continue to rise in subsequent months. The GSI was significantly different during the sampling months ($P < 0.05$).

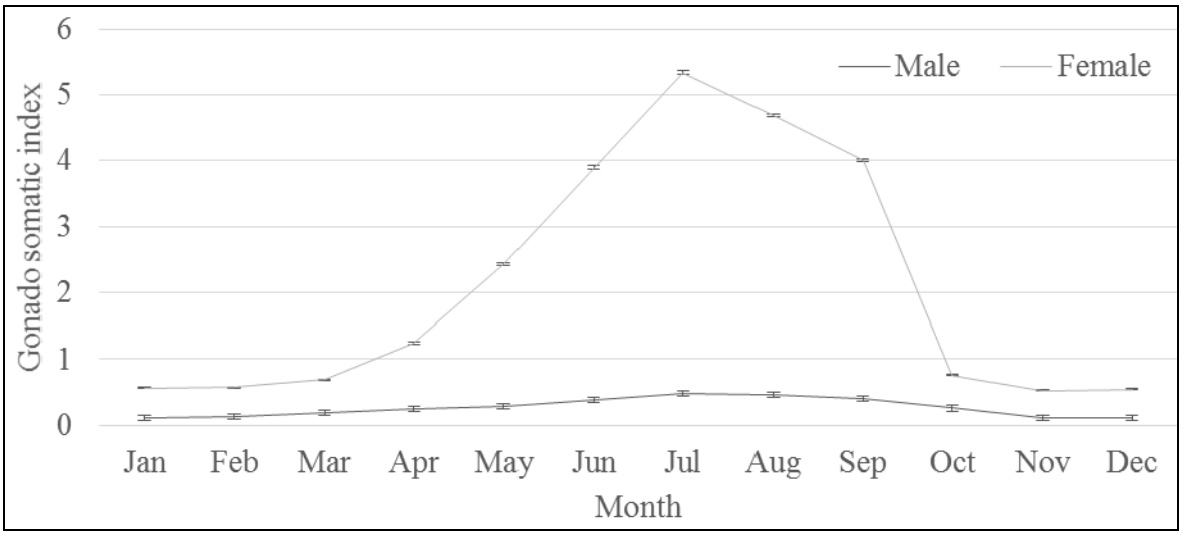

Fig 1: Monthly variation of gonado somatic indices of the sampled *C. punctatus*

3.3 Fecundity

Table 2 represents the fecundity of mature female *C. punctatus*. In the current study, the highest fecundity found to be 32987±111.52 in July. There was a decreasing trend in the subsequent months until it reaches lowest in November which indicates the resting phase of this fish. On the contrary, there was an increasing trend in fecundity values until it reaches to highest in July (Table 2).

Table 1: Number and sex ratio of *C. punctatus* throughout the study period

Month	Total Sample	Female		Male		Sex ratio (F:M)
		No.	%	No.	%	
January	26	16	61.50	10	38.50	1.60:1
February	25	13	52.00	12	48.00	1.08:1
March	24	12	50.00	12	50.00	1.00:1
April	35	16	45.71	19	54.29	0.84:1
May	30	15	50.00	15	50.00	1.00:1
June	32	19	59.38	13	40.62	1.46:1
July	25	11	44.00	14	56.00	0.78:1
August	26	15	57.69	11	42.31	1.36:1
September	24	14	58.33	10	41.67	1.40:1
October	23	15	65.22	08	34.78	1.87:1
November	22	09	40.91	13	59.09	0.69:1
December	20	10	50.00	10	50.00	1.00:1
Total	312	165	52.88	147	47.12	1.16:1

4. Discussion

In our study, out of the 312 specimens of *C. punctatus*, the male-female sex ratio found to be 1: 1.16. Hossain *et al* [17]. have stated that a deviation from a 1:1 sex ratio is not expected for most aquatic species, despite the fact some finfish and prawn populations may show a strong bias in this ratio. However, our current investigation revealed there was no significant difference with the expected value of 1:1. Avsar [6] has pointed out that in a typical population, female to male ratio will vary between 1:1 and 1:1.3. In estimating the reproductive potential of fish, information on sex ratio of fish can be included to determine female spawning biomass. Reproductive strategies depend on the abiotic environment, food availability, pressure of predators and the habitat of parental fish [33]. Total spawners are said to produce a large number of small eggs which are deposited over short period of time while multiple spawners produce fewer and larger eggs and with a longer breeding period which may last throughout the year, where only a proportion of the eggs ripe in the gonad at one spawning [21], though total spawners are said to have a higher GSI than multiple spawners [33].

Table 2: Mean GSI and fecundity in different sampling months

Month	GSI % (Female)	GSI% (Male)	Fecundity (no.)
January	0.57±0.01	0.14±0.01	5038±51
February	0.58±0.01	0.15±0.01	5804±62
March	0.69±001	0.19±0.02	6543±55
April	1.24±0.02	0.25±0.01	13700±45
May	2.44±0.04	0.29±0.02	21342±75.01
June	3.90±0.04	0.39±0.05	25598±76.53
July	5.34±0.07	0.49±0.04	32987±111.52
August	4.69±0.09	0.46±0.03	22393±147
September	4.00±0.04	0.40±0.02	11160±27
October	0.76±0.02	0.26±0.03	9457±139
November	0.53±0.03	0.13±0.01	4532±41.50
December	0.55±0.02	0.14±0.01	4760±19.91

The GSI method is easier and cheaper to utilize and one of the main parameters used to evaluate gonadal development in fishes. The peak spawning season could be inferred observing high correlation of GSI with number of matured female and male fishes. In our study, GSI, which indicates growth and maturation of gonad was higher from April to July founding a peak in July for both the male and female. It is inferred that the fish has only one breeding season largely coincided with the rainy season and spawn during April to July with a peak in July. Al Mahmud *et al* [3]. have reported the highest GSI in *C. striata* in July from a lentic ecosystem. Likewise, Gaikwad *et al* [11]. and Ashwini *et al* [5]. have also stated highest GSI and fecundity of *C. gachua* during June-July. In another study, Rinku *et al* [24]. have re-counted the highest GSI of *C. bleheri* during April- July. Similarly, Sunita *et al* [30]. and Lalta *et al*. [20] have confirmed maximum GSI in the rainy season (May - August). Our results were also very similar with that obtained by Siddiquee [29] in giant snakehead *C. marulius* from the Sylhet basin and Kirti *et al* [18]. in *C. marulius* from a river. The increased water level, inundation of shallow areas, increase in water velocity and turbidity may be responsible for inducing the fish to spawn especially for fishes in the inundated areas [32]. Thus it could be said that the rainy season (June-July in Bangladesh) plays an important role in reproductive period of *C. Punctatus* collected from lentic ecosystem. Sunita *et al*. [30] similarly reported that the gonadosomatic index of gonads of freshwater fish *Channa punctatus* increased at rainy season whereas lowest rates in winter and intermediate status in summer season. Hossain *et al* [16]. have found highest GSI values of *C. punctatus* in the month of July. Very similar observation has been made by Ghaedi *et al* [12]. in case of captive reared *C. striatus*.

In addition, fecundity is an important indicator for fish reproduction and population dynamics [34]. The knowledge of fish fecundity has much relevance in fish population studies and in successful management and exploitation of the fishery [4]. Huge variations in batch fecundity in teleosts were documented by many authors. Environment and geographical distribution are also the causes of variation in egg production in fishes is known to influence the fecundity [8, 28].

In the present study, fecundity of *C. punctatus* varied from 21342±75.01 to 22393±147during the spawning period. Similar findings were also reported by Al Mahmud *et al* [3]. This finding was similar to that of an earlier work done by Bhuiya and Islam [9]. A study made by Hossain *et al* [16]. reported, the highest absolute fecundity of mature female *C. punctatus* was 26294±416.74 in the month of July, followed by 23599±923.51 in June whereas the lowest fecundity was recorded in January as 2654±210.99. These findings are in line with the present and previous study of Lalta *et al* [20]. And Marimuthu *et al* [22]. for the same species.

5. Conclusion

Overall, the fecundity and gonado somatic index of *C. punctatus* in the different seasons in a lentic ecosystem found to be different. The high values of GSI appeared from March to July for both male and female with the peak in July, indicating the onset of the reproductive season. It is expected that the information generated in the current study will contribute better understanding of gonad developmental cycle of *C. punctatus* towards conservation action plans and rearing in captivity.

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