

# Reproductive Biology of Two Freshwater Small Indigenous Fishes *Securicula gora* and *Gudusia chapra* of Narmada River, Madhya Pradesh

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## ABSTRACT

Investigation of reproductive biology is an important aspect for knowing the reproductive behaviour of any species. In the present study, the reproductive biology of *Securicula gora* and *Gudusia chapra* was study for six months from August 2023 to 15 January 2024 in the Department of Zoology and Applied Aquaculture, Barkatullah University, Bhopal. The main aim of this study was to determine the reproductive cycle through observation of gonado somatic index, fecundity, ovary weight, Maturity stages, and spawning season of *Securicula gora* and *Gudusia chapra*, which were collected from Narmada River from Dongawada site Narmadapuram District. The length and weight of both fishes were measured. GSI was calculated by the standard method, Fecundity was calculated by sub-sampling method and ova diameter was measured with the help of ocular-micrometre. About 120 individuals were dissected and the result revealed that the average GSI value for *S. gora* and *G. chapra* peak at similar times in October month there is  $14.86 \pm 2.78$  and  $5.7 \pm 2.15$ , respectively. The maximum average for fecundity recorded in September month for *S. gora* was  $7664.44 \pm 6255.5$  and  $10900.07 \pm 598.59$  in month of September for *G. chapra*. Similarly, the maximum ovary weight recorded for *S. gora* was  $1.28 \pm 0.58$  g in the month of September and for *G. chapra*  $1.13 \pm 59$  g in the month of October respectively. The study provides the basic information of the reproductive pattern of both fish species which will be helpful for the management of the fish stock to promote conservation of such fishery resources.

**Keywords:** Reproductive Biology, Gonadosomatic index, Fecundity, Ovary weight, Maturity stages, Spawning Period.

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## INTRODUCTION

One of the commercially significant small native freshwater clupeid fish, *Gudusia chapra*, is a member of the family *Clupeidae* and order *Clupeiformes*. It is extensively found in the rivers of the Indian subcontinent, particularly the Ganga, Brahmaputra, and Mahanadi Rivers, as well as in ponds, lakes, ditches, and wetlands.<sup>[25]</sup> *Securicula gora* is a cyprinid fish in India, Bangladesh, Pakistan, and Nepal. It is a common freshwater small

indigenous fish of India and it is commonly called chela which is available in the rivers, canals, ponds, and lakes. These small indigenous fish are a great source of protein, fatty acids, vitamins, and minerals. They provide important nutrients that are essential for a healthy diet. For many commercial and subsistence fishermen, it is a vital source of nutrition and their means of subsistence. Because of the high nutritional value of the species, it has great market potential.<sup>[36]</sup>

The Narmada River ranks seventh in size in the country and is the largest river to flow west. It is the conventional border between North and South India and rises from the Amarkantak Plateau close to the Anuppur district. It travels 1,312 km west before emptying into the Arabian Sea via the Gulf of Khambhat, 30 km (18.6 mi) west of the Gujarati city of Bharuch. It passes through Madhya Pradesh (1,077 km), Maharashtra (74 km), and Gujarat

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(161 km). It also passes through Madhya Pradesh and Maharashtra (really along their boundary, 39 km), and then Maharashtra and Gujarat (74 km). It has been referred to as the Gujarat and Madhya Pradesh lifeline. Reproductive biology of fish is the scientific study of all aspects relating to fish reproduction. Reproduction is the sole method through which an organism endeavors to propagate and the evolutionary strategy is to have a maximum number of viable offspring for perpetuation of the species. Therefore, for studies on the biology of an organism, studies on its reproduction are imperative.<sup>[30]</sup> A population's capacity for reproduction is one of the requirements for classifying its members concerning to their gonadal states.<sup>[20]</sup> Understanding gonadal development and a species' spawning season facilitates research on the frequency of spawning in that population, which is crucial for population management.<sup>[10]</sup> Fish reproduce at specific times during their reproductive cycles; some breed only once a year, while others breeds frequently all year long. It is crucial to evaluate the culturable fishes' annual spawning cycle.<sup>[36]</sup> Fish culture, as well as better management and conservation of fisheries resources, depend on research on the reproductive biology of fish.<sup>[14,15]</sup> This study aims to calculate the fecundity, GSI, and maturity stages in various months, to understand the breeding seasons and their reproductive behaviors of these two-nutrition-sensitive small fishes.

## MATERIALS AND METHODS

### Study area and sample collection

For six months, from August 2023 to January 15, 2024, the reproductive biology of *Securicula gora* and *Gudusia chapra* was studied in the Department of Zoology and Applied Aquaculture at Barkatullah University, Bhopal, 464026, Madhya Pradesh, India. Several 120 female individual specimens of *Securicula gora* and *Gudusia chapra* were collected from the Dongadwada site of river Narmada, Madhya Pradesh. Cast net and dragnet (mesh size 20-40 mm) were used to catch SIFS, additionally, scoop net, and hook line, were also used for catching fishes. The samples were collected with the help of local fishermen and some samples were collected from Bengali fish markets and then, examined in the laboratory after collection. The total length (cm) of fish was measured by using a fish measuring board and weight (g) was recorded using a digital weighing machine. The gonads were dissected and weighed by a digital weighing machine.

### Gonadosomatic Index (GSI)

The gonads were inspected to determine the sex of the fish. In adult females, eggs are readily discernible in the ovaries.<sup>[13]</sup> The maturity stages could be identified based on the colour and relative size of the gonads concerning the body size, ova diameter, and extent of yolk formation.

The female fish specimens underwent open dissection, and their gonads were removed to determine their... their weight. Using this formula, the GSI was determined.<sup>[7]</sup>

$$GSI = \frac{BW}{GW} \times 100$$

GSI-Gonado somatic Index,  
BW-Body Weight of Fish,  
GW-Fish gonadal Weight,

The Gonado somatic index is an indicator of the state of gonadal development.<sup>[13]</sup>

### Fecundity

The quantity of eggs that are expected to be laid during the spawning season is known as fecundity. It is used to study the relation between ovary weight and the oocyte density in the ovary.

The subsampling method was adopted to assess fecundity.<sup>[9]</sup> It was calculated by dividing the measured weight of mature, ripe ova by the number of mature ova. The ovary has been divided into three sub-samples: anterior, middle, and posterior. The sub-samples were uniformly distributed on a petri dish with a few drops of water or formalin. The average number of the three sections was then used to calculate the fecundity using the following formula:

$$F = NG \div g$$

F-Fecundity,  
N-No of eggs in gonads in the subsample,  
G-Weight of Gonads,  
g-Weight of sub-samples.

The fecundity of a species is not a constant number; it fluctuates within a certain range and species species-specific.

### Ova diameter

Using an ocular-micrometer and an electronic compound microscope at 4X magnification, the diameter of the ova was measured.<sup>[31]</sup>

## RESULTS

Almost 120 individual species of *Gudusia chapra* and *Securicula gora*, varying in length and size, were dissected. Table 1 displays the maximum and minimum length, weight, fecundity, ovarian weight, and GSI during the investigation period.

*G.chapra* the fish length ranged from 10.04 to 19.23 cm, and the weight ranged from 9.81 g to 30.7 g, the ovary length ranged from 2.1 to 4.1 cm, the Ovary weight ranged from 0.12 g to 2.43 g, the GSI ranged from 0.8 to 11.93 and fecundity ranged from 2220 to 27279. *S. gora* the fish length ranged from 11.63 cm to 12.85 cm, and the Weight ranged from 14.3 g to 8.7 g, Ovary length ranged from 2.4 cm to 6.4 cm, the Ovary weight ranged from 0.12 g to 1.28 g, the GSI ranged from 1.82 to 14.86 and fecundity ranged from 863.92 to 7664.4.

The maximum average length of 12.85 cm was found in November month. The minimum average length of 11.63 cm was found in December. The maximum average weight of 14.3 gm was found in January and the minimum average weight of 11.63 g was found in December. The maximum average ovary length of 5.6 cm was found in September. In September, the average ovary weight was found to be at its highest, measuring 1.28 g. In contrast, the lowest average ovary weight of 0.12 g was recorded in December.

In the study of the gonado somatic index, it was observed that the highest average value of 14.86 occurred during the October month, while the lowest average value of 1.82 was recorded during the December and January. The ova diameter ranged from 0.48 to 2.15 mm, with the highest average diameter recorded in October and the lowest in November. In September, the maximum

average fecundity recorded was 7664.44, while in December; the minimum average fecundity was 863.92. Table 2.

### *Gudusia chapra*

The maximum average length of 12.38 cm was found in September. The minimum average length of 11.43 cm was found in December. The maximum average weight of 19.35 gm was found in October and the minimum average weight of 15.63 gm was found in December. The maximum average ovary length of length of 3.28 cm was found in October and the minimum average ovary length of 2.75 cm in December. The maximum average ovary weight of 1.13 gm in October and the minimum average ovary weight of 0.56 were found in December. The ova diameter ranged from 0.35 to 0.51 mm, with the highest average diameter recorded in August (0.51 mm) and the lowest in December (0.35 mm). In the examination of the gonadosomatic index, it was determined that the highest average occurred in October (5.7), while the lowest average was recorded in December (3.65). The maximum average fecundity was 10900.07 in September. All samples of fish collected in the month of January found spent (Table 3).

In *S. gora* linear relationship between fecundity and Ovary Weight is expressed by an equation  $y=0.0002x+0.1075$  whereas  $r^2=0.8263$  and their correlation coefficient is  $r=0.90$ , showing both variables are very strongly correlated. The relationship between ovary weight and GSI in *S. gora* showed a linear equation which is expressed as  $y=9.1899x+1.3527$  whereas  $r^2=0.691$  and their correlation coefficient is  $r=0.83$ , showing both variables are very strongly correlated. Fish Weight and Ovary weight in *S. gora* relationship is expressed by an

**Table 1: Showing Maximum- Minimum Fish length, fish weight, Ovary weight, GSI, and Fecundity of these species.**

Species	Fish length (unit)	Fish weight	Ovary length	Ovary weight	GSI	Fecundity
<i>Securicula gora</i>	12.85-11.63	14.3-8.7	6.4-2.4	1.28-0.12	14.86-1.82	7664.44-863.92
<i>Gudusia chapra</i>	19.23-10.04	30.7-9.81	4.1-2.1	2.43-0.12	11.93-0.8	27279.9-2220

**Table 2: Shows Average fish length, weight, Ovary weight, GSI, and fecundity of *Securicula gora*.**

	August	September	October	November	December	January
Fish length	12.28±1.15	12±1.47	12.84±1.09	12.85±1.09	11.63±1.94	12.84±1.96
Fish weight	11.78±1.84	8.7 ±1.45	11.8±2.43	11.7±1.78	12.6±3.64	14.3±3.45
Ovary length	4.70±0.95	5.6±0.75	5.3±1.55	-	-	-
Ovary weight	0.95±0.6	1.28±0.58	0.84 ±1.07	0.19 ±0.24	0.12±0.14	0.22±0.12
GSI	8.07±4.66	11.07±4.49	14.86±2.78	3.56±2.49	1.82±1.02	1.82±0.87
Fecundity	2773.48±3035.75	7664.44±6255.5	5431.9±1516.4	1065.8±244.78	863.92±295.68	1033.60±322.84
Ova diameter	1.43±0.37	2.06 ±0.14	2.15±0.06	0.48±0.03	0.59±0.1	0.68±0.1

Table 3: Shows Average fish length, weight, Ovary weight, GSI, and fecundity of <i>Gudusia chapra</i> .						
	August	September	October	November	December	January
Fish length Average±SD	11.92±1.40	12.38±2.61	11.95±0.87	11.90±1.20	11.43±0.63	11.26±0.25
Fish weight	18.71±7.06	16.21±5.50	19.35±4.58	16.75±5.85	15.63±2.63	14.21±1.03
Ovary length	2.9±0.50	2.65±0.63	3.28±0.55	3.07±0.43	2.75±0.38	-
Ovary weight	0.99±0.58	0.80±0.76	1.13±0.59	1.01±0.30	0.56±0.20	-
GSI	5.34±2.95	4.6±3.3	5.7±2.15	5.2±0.42	3.65±1.79	-
Fecundity	7013.83±4409.80	10900.07±5985.59	10,542.4±7248.79	7858.66±1223.29	-	-
Ova diameter	0.51±0.013	0.47±0.05	0.39±0.08	0.47±0.13	0.35±0.02	-

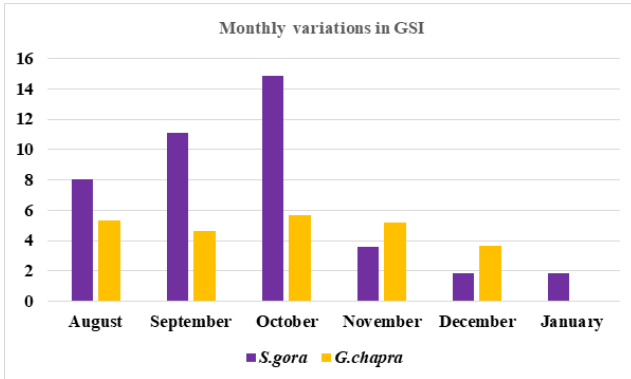


Figure 1: Monthly Variation in GSI of *S. gora* and *G. chapra*.

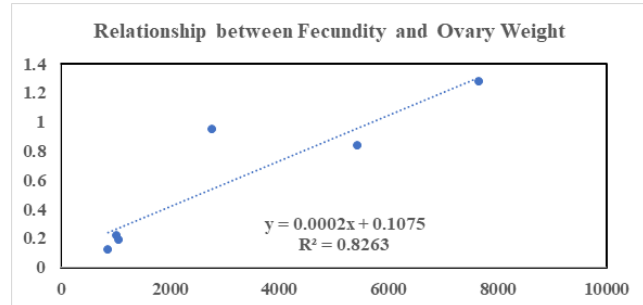


Figure 4: Relationship between Fecundity and Ovary Weight of *S. gora*.

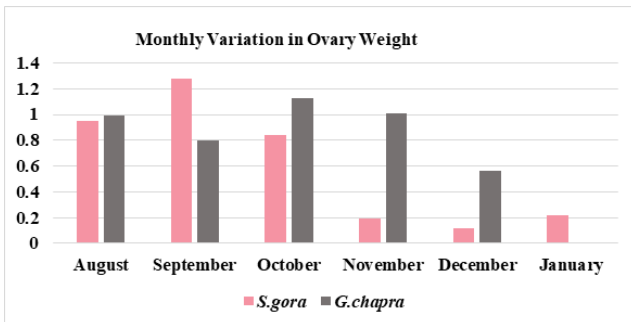


Figure 2: Monthly Variation in Ovary Weight of *S. gora* and *G. chapra*.

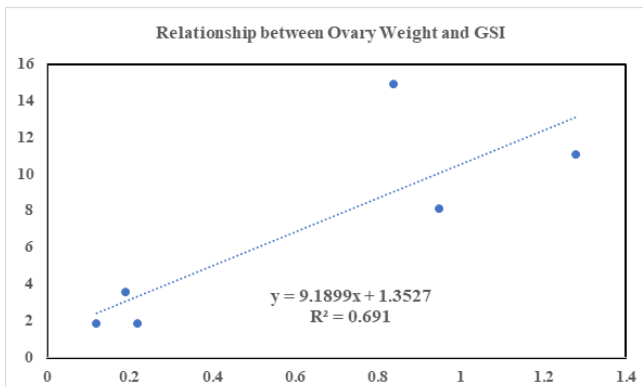


Figure 5: Relationship between Ovary Weight and GSI of *S. gora*.

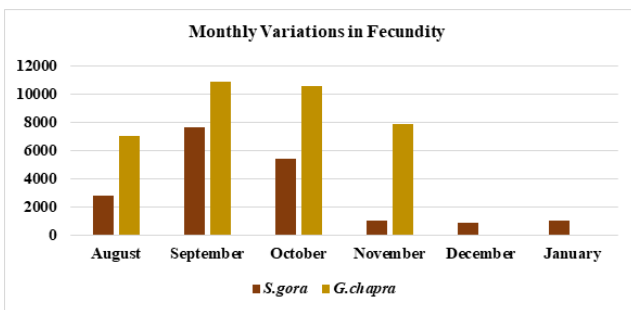


Figure 3: Monthly Variation in Fecundity of *S. gora* and *G. chapra*.

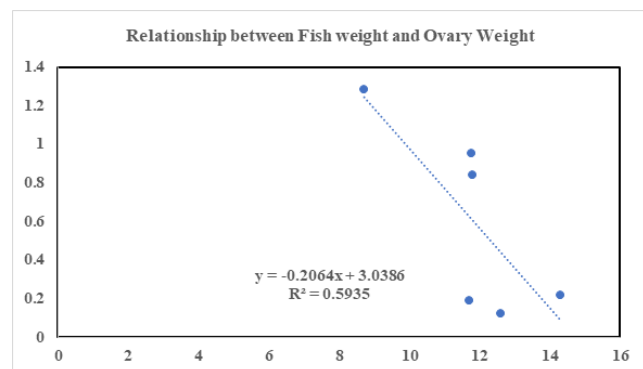
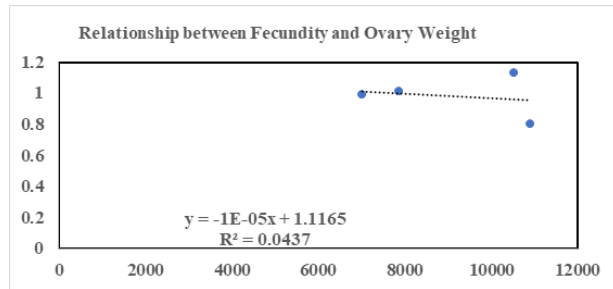
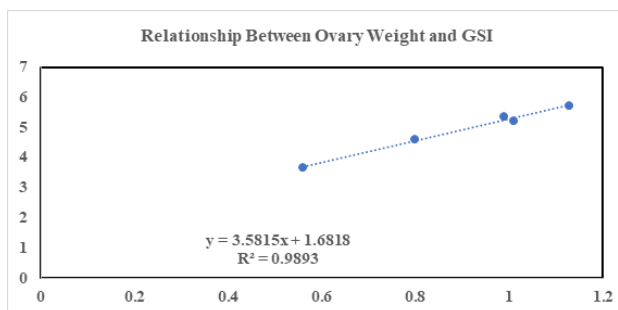


Figure 6: Relationship between Fish Weight and Ovary Weight of *S. gora*.

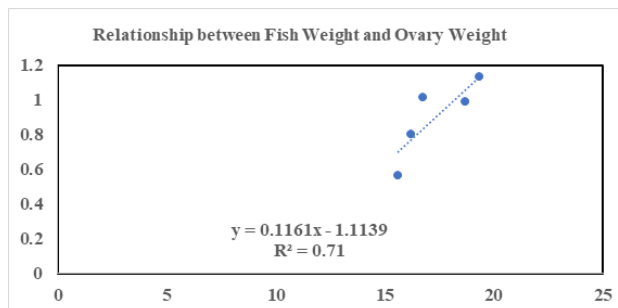
equation  $y = -0.2064x + 3.0386$ , whereas  $r^2 = 0.5935$  and their correlation coefficient was found  $r = -0.77$ , shows both variables are not correlated.



**Figure 7:** Relationship between Fecundity and Ovary Weight of *G.chapra*.



**Figure 8:** Relationship between Ovary Weight and GSI of *G.chapra*.



**Figure 9:** Relationship between Fish Weight and Ovary Weight of *G.chapra*.

In *G. chapra* linear relationship between fecundity and ovary weight is expressed by an equation  $y = -1E-05x + 1.1165$  whereas  $r^2 = 0.0437$  and their correlation coefficient is  $r = -0.02$ , showing both variables are not correlated. The relationship between ovary weight and GSI in *G. chapra* showed a linear equation which is expressed as  $y = 3.5815x + 1.6818$  whereas  $r^2 = 0.9893$  and their correlation coefficient is  $r = 0.99$ , shows both variables are very strongly correlated. Fish Weight and Ovary weight in *G. chapra* relationship is expressed by an equation  $y = 0.1161x - 1.1139$ , whereas  $r^2 = 0.71$  and their correlation coefficient was found  $r = 0.84$ , shows both variables are very strongly correlated.

The above analysis of correlation of fecundity and ovary weight in *G. chapra* results in a negative correlation which means they are no longer correlated as well dependent on each other, but in case of *S. gora* both variables are correlated as well dependent on each other. Fish weight and the ovary weight in *S. gora* are no longer correlated maybe it is due to the multi-fecund nature or a year-round spawner but having a low fecundity, as according to our results it was found that eggs were present in all 6 months in the ovary of *S. gora* but in *G. chapra* egg were not found from December and *G. chapra* has high fecundity as compare to *S. gora*. But further study of ovarian structure development is needed. The monthly variation of fecundity, Ovary weight, GSI of both fishes is clearly shown in Figures 1, 2 and 3 respectively. The correlation analysis of both fishes were shown in Figures 4 to 9 respectively.

## DISCUSSION

To understand the reproductive pattern and timing of maturation phases, the reproductive biology of *Gudusia chapra* and *Securicula gora* was examined in the present research investigation. The value of GSI rises as fish mature, reaches its peak at this time, and then sharply falls as the fish spent out. GSI is an index of an individual's maturity and the stage of gonadal development.<sup>[17]</sup> Fish gonadal conditions can be influenced by factors such as age, size, availability of food, and environmental variables, which is one reason why spawning peaks could vary in various regions. Fish fecundity is a crucial concept to understand population dynamics, effective management practices, and fish stock exploitation.<sup>[4]</sup> The findings of these studies will be essential to the effective management and conservation of species.

During the study on *Gudusia chapra*, the Gonadosomatic Index (GSI) was measured monthly from August to January. The GSI peaked in October and was at its lowest in December. This pattern provides valuable insights into the reproductive cycle and breeding behaviour of *Gudusia chapra*. The Gonadosomatic Index (GSI) of *Gudusia chapra* exhibited a relatively low value in January, from April and it increased, followed by a decrease in May, and maintained a low level in the subsequent months from a small perennial lake in Bangladesh.<sup>[3]</sup> Similarly, our study results found three different peaks in maturity and spawning were observed (August, September and November) and then decreases from December and January. The GSI reached its peak from March to April, July, and October, with GSI values of 6.02, 6.56, and 6.85, respectively. The lowest GSI values were recorded during January and February was

recorded by another researcher.<sup>[26]</sup> The GSI showed peaks from March, April to June, and lower values in November to January, as observed also reported.<sup>[38]</sup> Similarly, from our study according to the pattern of reproductive biology parameter GSI, it will be estimated for *G. chapra* that after February, March to May will be the peaks.

Another study recorded GSI value and its spawning season were extended from March to October, exhibiting 2 distinct peaks, one in April 5.98 and another in August 8.14, and the minimum GSI was recorded in January with a value of 1.64 suggesting that it breeds twice a year and the mean GSI varied from 0.82 in January to 4.83 in April.<sup>[2]</sup> The value began to rise in March and remained high until September with a peak in April and then decreased from October and remained low until February showed two spawning peaks, the lowest peak was recorded in April and the highest in August (2.04-13.32) and also concluded that GSI value increases with the maturation of fish and decreases abruptly thereafter in the pond.<sup>[21]</sup> The GSI value of female *Gudusia chapra* was found to increase gradually from November to February and attained a peak in February.<sup>[19]</sup> The above variation in GSI might be due to differences in habitat and other climatic and hydrological factors. The change in the gonadal condition of fishes may be subjected to size, age, food availability, and the environment conditions and that is why the spawning peaks may vary from region to region.

*Gudusia chapra* spawns throughout the year with peak spawning in October, March-April, and July. The absolute fecundity ranges from 749 to 15044 were also reported.<sup>[26]</sup> The investigation of the fecundity of *G. chapra* in West Bengal wetlands found that it varied from 936 to 13,860.<sup>[38]</sup> We observed that September has the highest fecundity during the duration of the current investigation. Fecundity levels peak during this period, with a lowest level of 2220 and a highest of 27279.9. Our investigation observed similar reproductive pattern and estimated that this species is multiple or batch spawner or spawns twice in a year. The fecundity of mature *G. chapra* ranged from 7095.6 to 48,238 with an average of 21,150.60, was observed. Because each individual may have a different capability for egg production, there might be variations in the number of ova of equivalent stages bearing the same weight.<sup>[11]</sup> The fecundity of *G. chapra* varied from 1106 to 28532 eggs in a fish collected from fishponds of Chilya hatchery.<sup>[29]</sup> Fecundity ranged from 10800 to 36200 eggs, and the fecundity of *G. chapra* in the Ganges River in northwestern Bangladesh was also relatively high.<sup>[18]</sup> The fecundity of the fish ranged from 25,220 to 154,528 with an average value of

72,383 and was found to increase with the increase in length and weight of the fish.<sup>[21]</sup> In the present study, the fecundity of *G. chapra* was consistent with the findings from Pakistan.<sup>[29]</sup> However, it was significantly lower than the results reported from a floodplain wetland in West Bengal,<sup>[38]</sup> as well as those by from India.<sup>[26]</sup> The present study indicated *Gudusia chapra* as a highly fecund fish.

The present study indicated that the GSI for *Securicula gora* reached its peak in October and was at its lowest in December-January. A similar investigation was observed in the range of GSI values was found to be highest from April to August.<sup>[5]</sup> The reproductive cycle of *Securicula gora* was determined using four different methods, all of which focused on fish breeds occurring between April and August. It was discovered that during this period, the fish spawn more than once. *Chela cachius* the peak value of GSI was found in July-August and then sharply declined in August. This indicates that the fish might spawn in these months.<sup>[24]</sup>

In the current investigation, the ova's diameter varied between 0.48- and 2.15-mm. October had the greatest average ova diameter ever measured. *Securicula gora* fecundity ranged from 863.92 to 7664.44. With a maximum average fecundity value of 7664.44, September had the highest fecundity. The fecundity, reproductive cycle, and ovarian development of *Securicula gora* were examined. Based on their data analysis, they found that the fecundity of this species ranged from 11,213 to 35,782. With an estimated mean fecundity of  $23860 \pm 4980.21$ , *S. gora* is a moderately fecund fish. Furthermore, because mature, ripe, and immature ovaries of the same size were discovered, they deduced that the fish spawn more than once during the single spawning period.<sup>[4]</sup> There is no such more research was found for *S. chela* about their reproductive pattern.

## CONCLUSION

Climate and ecological factors likely affect the dynamics of reproductive features like fecundity, spawning, and gonadosomatic index. In addition to helping and gain a deeper understanding important aspects of their lifecycle of fish species, this study provides basic information on the reproductive pattern of *Gudusia chapra* and *Securicula gora*, which is helpful to grasp the value of developing the most effective approach for the management of the fish stock to promote the conservation of such fishery resources. Multiple earlier studies have documented the presence of female dominance over male species in some communities. Our findings demonstrate that the species extraordinary capacity for adaptation and

reproduction allows it to sustain its population in reservoirs, marshes, etc. This adaptability enables the species to climate-resilient species within the reservoir and riverine environment, contributing to its population sustainability.

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## CONFLICT OF INTEREST

There is no conflict of interest among all the authors of the manuscript.

## ABBREVIATIONS

**GSI:** Gonado somatic Index.

## SUMMARY

*Securicula gora* and *Gudusia chapra* are Small Indigenous Freshwater fishes, the study on reproductive aspects of both fishes was important because both fishes are nutritive and wild species which is not culture by fish farmers, but have market value, affordable for poor peoples and caught from wetlands and rivers. According our aforementioned parameters which are taken reveals that *Securicula gora* and *Gudusia chapra* was multi spawner or multi fecund or batch spawner. Therefore, our study will be helpful to determining the breeding behaviour of these species.

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