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Reproductive biology of the Gora chela, *Securicula gora* (Hamilton, 1822) from the Narmada River, Madhya Pradesh, India

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Abstract

The reproductive biology of gora chela, *Securicula gora* (Hamilton, 1822), in the Narmada River was examined from July 2021 to January 2022. A total of 116 gora chela, *Securicula gora* (Hamilton, 1822) fish samples were obtained from the Narmada River in Madhya Pradesh, India. The highest Gonado somatic index (GSI) value was obtained in September (20) month during the seven months of monitoring of female gora chela fish. In comparison, samples obtained between November and January (0.57-2.53) showed lower levels. The fish with the highest fecundity was 16864 (TL 13 cm and BW 19.04 g). The mean fecundity was calculated to be 7162 ± 5543.26 , indicating that gora chela is a fairly fecund fish. During the month of September, the ova varied in size from 0.05 to 2.10 mm, whereas the mature eggs of *Securicula gora* (Hamilton, 1822) were spherical with diameters ranging from 0.90 to 2.10 mm. There were five gonadal developmental phases noted. Monthly mean ova diameters recorded were as follows: July (0.248 ± 0.12 mm), August (0.441 ± 0.13 mm), September (1.298 ± 0.39 mm), October (0.118 ± 0.17 mm), November (0.00 ± 0 mm), December (0.032 ± 0.06 mm) and January (0.09 ± 0.09 mm). Since a consequence of the findings, it was established that fish spawn more than once, since immature and maturing, ripe, and immature ovaries were detected in the same size group of females. The fecundity, ova diameter, and gonadal developmental stages of the same species in various populations may be due to eating, reproductive activity, and climatic factors.

Keywords: Gora chela, Gonado somatic index, gonadal maturity, fecundity

Introduction

Gora chela, *Securicula gora* (Hamilton, 1822), is a cyprinid fish found in India, Bangladesh, Pakistan, and probably Nepal. It is the sole species in its genus. *Securicula gora* is a pelagic freshwater species found in rivers, beels, and canals. It is a predatory species that feeds on insects, insect larvae, and crustaceans that it captures at or near the water's surface. Gora chela has been recognized as a tiny indigenous fish species. Small indigenous species (SIS) are fish that reach a mature size of 25 cm or 9 inches (Mandal *et al.* 2015) ^[12]. Small indigenous species are an important source of micronutrients such as calcium, zinc, iron, and fatty acids for the rural poor. However, the presence of these species in all bodies of water has plummeted due to indiscriminate capture using much lethal fishing equipment. A large number of tiny indigenous fish species are presently vulnerable due to recurrent declines in water area. The reproductive capacity of a population is one of the fundamental requirements for classifying people in terms of their gonadal circumstances (Jhingran and Verma, 1972) ^[9]. The period and season when a species generally breeds is referred to as the species' "breeding" or "spawning" season. Knowledge of reproductive events is required to determine the size and age of sexual maturity, the spawning season, and the development of oocytes (Uddin *et al.* 2017) ^[17]. Maturity phases correspond to the degree of ripeness, how close the fish is to spawning time, and the size of the ovaries and testis (Ali *et al.* 2021) ^[2]. The mating season repeats in cyclic sequence, during which the organism goes through maturation changes and prepares to reproduce again. Fish exhibit several sorts of spawning behaviour, with maturity stages of fish seen by microscopic inspection of the gonads (Muchlisin, 2014) ^[13]. The period and season when a species generally breeds is referred to as the species' "breeding" or "spawning" season. Knowledge of reproductive events is required to determine the size and age of sexual maturity, the spawning season, and the development of oocytes (Uddin *et al.* 2017) ^[17]. Maturity phases correspond to the degree of ripeness, how close the fish is to spawning time, and the size of the

ovaries and testis (Ali *et al.* 2021) [2]. The mating season repeats in cyclic sequence, during which the organism goes through maturation changes and prepares to reproduce again. Fish exhibit several sorts of spawning behavior, with maturity stages of fish seen by microscopic inspection of the gonads (Muchlisin, 2014) [13]. Fecundity varies per species, depending on climatic factors, length, age, and so on. Environmental conditions and food supplies may have an impact on fish fertility (Bagenal, 1957) [4]. The ova-diameters are always measured in micrometers, and the magnification compound must be of extremely high quality. The present study will be critical in determining the economic potential of the stock, as well as the life history and cultural practices of gora chela fish, as well as the actual management of tiny indigenous fish species.

Materials and Methods

Sampling area

Fishes were collected from Narmada River at Bhedaghat in Jabalpur, Madhya Pradesh, India (Latitude: 23° 07' 55.20" N; Longitude: 79° 48' 3.60" E). Total catchment area of Narmada River in Madhya Pradesh 85,658 square kilometre. Samples of gora chela, *Securicula gora* (Hamilton, 1822) were collected once a fortnight during the period of July 2021 to January 2022 month. Total 116 no of fresh fish samples were collected from Narmada River, Madhya Pradesh, India by using different fishing nets namely gill nets, drag nets and cast nets. After collection, the samples were carefully brought to the laboratory without rupturing their body parts. The present study mainly focused on the maturity estimation, fecundity, and gonadal developmental stages of *Securicula gora* fish. The standard measuring scale measures the total length (0.1 cm) of each individual and the electronic weighing machine measures the total weight and the gonad weight is determined by using a digital balance (0.01g) respectively.

Gonado Somatic Index (GSI)

Gonado somatic index (GSI) represented as a proportion of the fish's gonad weight (GW) to total body weight (BW) (Islam and Das, 2006) [8]. The formula (Lagler, 1956) [11] was used to compute the GSI, which is widely used to assess the spawning frequency of fish and crustaceans.

Gonado somatic index (GSI) estimated by applying the following formula:

$$GSI = GW / BW * 100$$

Where,

GSI = Gonado Somatic Index

GW = Gonad Weight (g)

BW = Body weight of fish (g)

Fecundity

Ovaries were subsampled using the weight approach of (Bagenal and Braum, 1978) [3] and (Grimes and Huntsman, 1980) [6]. After blotting out the extra moisture, fecundity was determined from the numbers of ova in sub-samples (randomly) of known weight using the following formula:

$$F = n * G / g$$

Where,

F = Fecundity

n = Number of eggs in sub-sample

G = Weight of the ovary (g)

g = Weight of the sub-sample (g)

Ova diameter

Ova diameters were measured using formalin-preserved samples. The front, posterior, and center parts of each ovary were sampled for 116 fresh fish ova. The eggs were dispersed on a glass slide before being separated from the tissue using a small needle and brush. The ocular micrometer's units were standardized with a stage micrometer for measuring ova diameter in micrometers (m) (Chakraborty *et al.* 2007) [5].

Data Analysis: For data analysis, Microsoft Excel 2010, SPSS Statistics 22.0 software and general statistical units were used.

Results and Discussion

The length and weight of fish are measured using a standard measuring scale, and the electronic weighing machine measures the total length (TL), body weight (BW), and gonad weight (GW) of the collected samples. The highest and lowest recorded Total Length (TL) was 12.7 cm and 7.5 cm and highest and lowest body weight (BW) was recorded as 22.5 g and 3 g (Table no. 1). Month-wise average total length (TL), body weight (BW), and gonad weight (GW) for female samples of *Securicula gora* (Hamilton, 1822) presented in (Table no. 2).

Table 1: Month wise variation in total length (TL), body weight (BW) and gonad weight (GW) of female *Securicula gora*

Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)	Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)
July	1.	8.7	4.77	0.15	August	1.	11.9	11	1.45
	2.	11.8	11	0.08		2.	12.2	12.88	2.22
	3.	13.5	15.76	0.12		3.	12.6	11	2.1
	4.	9.5	6	0.08		4.	12.2	9	0.33
	5.	13.7	16	0.12		5.	12.3	10	0.22
	6.	11.1	12.75	0.08		6.	13.2	13	0.47
	7.	13.8	17	0.09		7.	13.2	11.5	0.36
	8.	14.5	21	0.12		8.	13	11	0.34
	9.	14.2	20	0.10		9.	13.7	13	0.54
	10.	13	15	0.06		10.	13.6	15.5	0.32
	11.	13.4	16	0.36		11.	14	16.86	0.88
	12.	14.1	17.36	0.45		12.	13.6	13.44	0.60
	13.	13.2	15.5	0.42		13.	12	11.42	0.73
	14.	12.5	13.7	0.08		14.	12.2	11.51	0.71
	15.	13.4	15.9	0.12		15.	11.6	10.20	0.46
	16.	11.2	12.5	0.10		16.	8.7	8	0.33
	17.	9.3	6	0.07					

Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)	Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)
September	1.	13.4	15.5	1.53	October	1.	12.5	11.50	00
	2.	12.2	10.2	0.39		2.	12.1	10.11	00
	3.	13.3	13.92	0.56		3.	11.9	11.25	00
	4.	13	19.04	3.17		4.	11.5	9.80	00
	5.	13	15.11	2.02		5.	11.4	8.94	00
	6.	14.4	22.3	00		6.	14	16.57	2.5
	7.	11.6	10	0.69		7.	12.6	11.91	00
	8.	13.5	17	3.2		8.	12.5	11.59	00
	9.	13.1	16	3		9.	12.6	13.19	2.3
	10.	11.4	13	2.1		10.	14.4	18.17	2.1
	11.	12.2	14	1.40		11.	11.25	12.2	00
	12.	12.1	14	1.51		12.	12.67	11.59	1.5
	13.	13.1	16	1.63		13.	14.6	15.28	00
	14.	13.2	14	0.64		14.	11.9	8.5	1.7
	15.	12.5	15	1.7		15.	14.2	15.42	00
	16.	11.9	9	00					
	17.	13.5	16	1.42					
Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)	Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)
November	1.	10	7.5	00	December	1.	11.25	12.2	00
	2.	9.5	6	00		2.	13.2	13.60	0.15
	3.	10.6	7	00		3.	12.67	11.59	00
	4.	8.9	5	00		4.	15.7	22.32	0.37
	5.	8	4.1	00		5.	14.6	15.28	00
	6.	8.1	4	00		6.	12.6	12.21	00
	7.	8.5	4	00		7.	11.9	8.5	00
	8.	8.1	4	00		8.	8.7	8.77	0.05
	9.	7	3.5	00		9.	8.5	5.91	00
	10.	7.5	3	00		10.	8.8	5.92	00
	11.	12	9	00		11.	12	9.50	00
	12.	11.5	10.12	00		12.	14.2	15.42	0.11
	13.	13.5	17	00		13.	11.4	8.46	00
	14.	11.9	9.2	00		14.	12.7	10.75	00
	15.	14.4	22	00		15.	12.2	10.78	00
	16.	8.1	5.3	00		16.	12.3	10.17	00

Month	Sr. No.	Total Length (TL) (cm)	Body Weight (BW) (g)	Gonad Weight (GW) (g)
January	1.	13.5	13.73	0.20
	2.	9	5.19	00
	3.	11.5	8.92	0.15
	4.	11.2	8.29	00
	5.	11	8.46	00
	6.	13	12.45	0.15
	7.	11.8	11.4	00
	8.	14	17	00
	9.	13	12.45	00
	10.	13	14	00
	11.	12	11.17	00
	12.	13	15.16	0.15
	13.	14.9	22.5	0.26
	14.	14	18.44	0.39
	15.	13.6	15	0.38
	16.	14.9	18	0.13
	17.	13.5	14.08	0.10

Table 2: Month wise variation in mean total length (TL), mean body weight (BW) and mean gonad weight (GW) of female *Securicula gora* (Hamilton, 1822) fish

Month	Total Length (TL) Mean±SD	Body Weight (BW) Mean±SD	Gonad Weight (GW) Mean±SD
July	12.405±1.83	13.896±4.67	0.152±0.12
August	12.5±1.21	11.831±2.25	0.753±0.62
September	12.788±0.79	14.71±3.23	1.468±1.01
October	12.674±1.11	12.401±2.82	0.673±1.01
November	9.85±2.23	7.545±5.23	0
December	11.884±2.07	11.118±4.06	0.047±0.09
January	12.758±1.52	13.308±4.31	0.112±0.13

[SD = Standard Deviation]

The GSI, which achieves its maximum value at the highest degree of maturity, gradually increases with the development of fish. However, its abrupt descent implies spawning activity. During the research period (July 2021-January 2022), the female *Securicula gora* gonado somatic index varied from 0.00 to 20. In female *Securicula gora*, the lowest value was observed in November and the highest value was found in September (Figure 1).

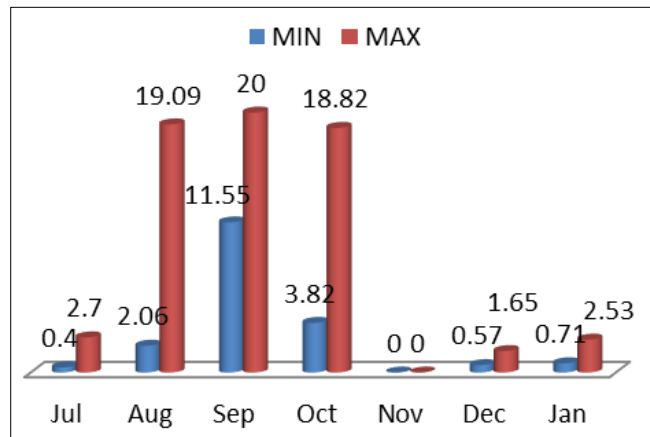


Fig 1: Month wise minimum-maximum Gonado Somatic Index (GSI) values of female *Securicula gora*

The gravimetric approach is used to determine fecundity. *Securicula gora* fecundity ranged from 127 (fish with TL 12.3 cm and BW 10 g) to 16864 (fish with TL 13 cm and BW 19.04 g). The mean fecundity was calculated to be

71625543.26 (Table no. 4), indicating that *Securicula gora* is a fairly fecund fish whose fecundity increases with gonadal length throughout the spawning season.

Table 4: Month wise variation in fecundity range of female *Securicula gora*

Month	No of female fish	Fecundity	
		Fecundity range	Mean±SD
July	17	214-10121	1680.471±2522.13
August	16	127-8650	3072.813±2916.33
September	17	5630-16864	7162±5543.26
October	15	227-850	192.266±312.35
November	16	0	0.00±0
December	18	0	0.00±0
January	17	0	0.00±0

During the month of September, the ova were 0.9-2.10 mm in size, whereas the mature eggs of *Securicula gora* (Hamilton, 1822) were spherical with a diameter of 0.90-2.10 mm (Figure no. 2). The diameter of ripe ova taken from the front, middle, and posterior areas of the ovary was about the same. Similarly, the ova from the two gonad lobes had identical sizes. The microscopic view and size of the ova of *Securicula gora* (Hamilton, 1822) fish were investigated (Table no. 3). Highest mean ova diameter also observed in the month of September (Figure no. 3). Out of 116 females, the study observed 19 fish in the immature phase, 21 fish in maturing phase, 12 fish in the mature phase, 17 fish in the spawning/ripe phase, and 47 fish in the spent phase (Figure no. 4).

Table no 3. Microscopic view and size of ova with regarding their maturation stages of *Securicula gora*

Stages	Months	Photograph	Microscopic view of Ova	Size of Ova (mm)
<p>1. Immature phase: The ovaries are small, thin, pale white in colour.</p>	July, August, September, October, November, January.			
<p>2. Maturing phase: Ovaries become slightly larger, opaque and light yellowish in colour.</p>	July, August, January			
<p>3. Mature phase: A large number of spherical ova are visible to the naked eye.</p>	August, September.			

<p>4. Spawning/ripe phase: Ovaries enlarged, deep yellow colour of eggs.</p>	<p>September, October</p>			
<p>5. Spent phase: The ovaries are shrunk and sac like reduced in volume; have a dull colour.</p>	<p>October, November, December</p>		<p>-----</p>	<p>-----</p>

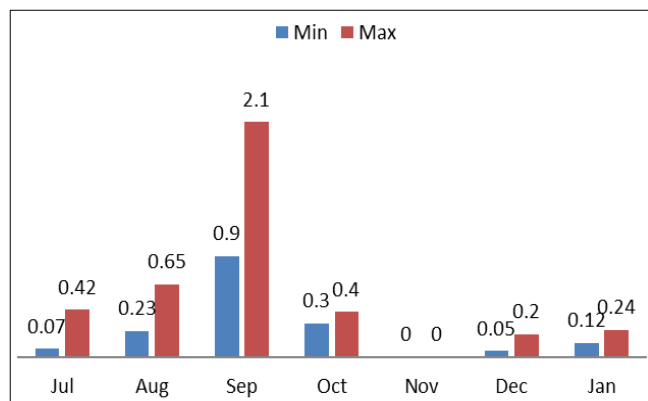


Fig 2: Month wise minimum and maximum range of Ova diameter of *Securicula gora*

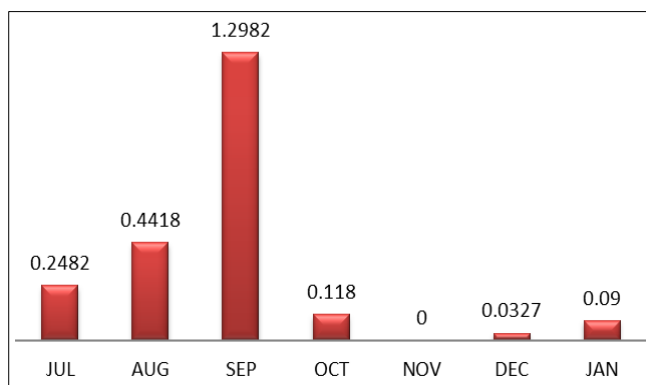


Fig 3: Month-wise changes in mean ova diameter of *Securicula gora*

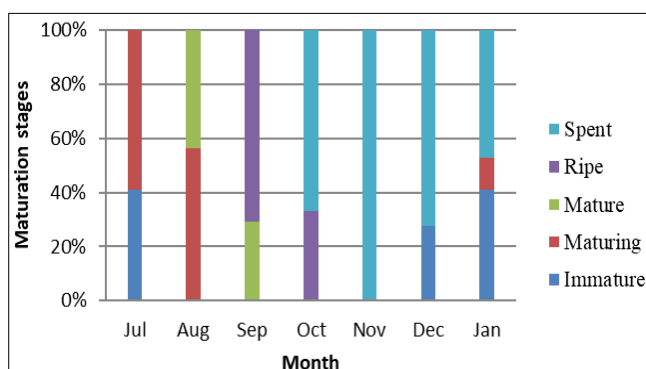


Fig 4: Graph showing month-wise ova developmental stages of female *Securicula gora*

Throughout the research period, the body weight (BW) of *Securicula gora* (Hamilton, 1822) fish specimens ranged from 3 to 22.5 g, with the maximum and lowest total length (TL) observed in December (15.7cm) and November (7 cm). The ovarian weight of the fish varies according on the amount of oocytes and the maturity level of the females. The gonado somatic index is calculated by dividing the gonad weight (GW) by the body weight (BW). Fish captured between August and October had higher GSI values, whereas those caught between November and January had lower values. The greatest GSI mean values were obtained in August (19.09), September (20), and October (18.82), with September having the highest value. These GSI values suggested that *Securicula gora* might spawn from July to October, with a peak in September. The GSI index's highest point also revealed that the monsoon had an important influence in gonadal growth. Similarly, (Kohinoor *et al.* 2005) ^[10] investigated the reproductive biology of three significant indigenous tiny fish, namely the mola (*Amblypharyngodon mola*), the chela (*Chela cachius*), and the punti (*Puntius sophore*). The maximum GSI values were achieved from May to September for mola and punti, and from April to August for chela fish. The findings reveal that the fish spawn between May and September.

Securicula gora (Hamilton, 1822) fecundity ranged from 127 (fish with TL 12.3 cm and BW 10 g) to 16864 (fish with TL 13 cm and BW 19.04 g). The mean fecundity of *Securicula gora* was calculated to be 71625543.26, indicating that it is a moderately fecund fish. According to the diameter of the observed eggs, 19 of the 114 female *Securicula gora* (Hamilton, 1822) fish were immature (0.05 mm-0.20 mm), 21 were maturing (0.22 mm-0.45 mm), 12 were mature (0.49 mm-0.95 mm), 17 were spawning/ripe (0.90mm-2.1mm), and 47 were spent. July (0.2480.12 mm), August (0.4410.13 mm), September (1.2980.39 mm), October (0.1180.17 mm), November (0.000 mm), December (0.0320.06 mm), and January (0.090.09 mm) were the month wise mean diameters of ova observed. Throughout the study period, five gonadal developmental stages: immature phase (July, December, January), maturing phase (July, August, January), mature phase (August, September), spawning/ripe phase (September, October) and spent phase (October, November, December) observed in female *Securicula gora* fish. Similarly, (Alam *et al.* 2012) ^[1] studied *Securicula gora* ovarian development, fertility, and reproductive cycle (Hamilton, 1822). The species' ovary goes through four phases of maturation: immature (mean ova diameter 0.5810.11 mm), maturing

(mean ova diameter 0.6450.16 mm), mature (mean ova diameter 2.2320.11 mm), and ripe (mean ova diameter 3.2630.09 mm). The fish is moderately fecund, with an average reproductive capacity of 23860.124980.21 eggs. Females in gestation are only seen from April to August. From April to August, the GSI value ranges are at their greatest (GSI, 10.63 to 14.44). Higher mean ova diameter ranges (2.6080.12 to 3.6240.12 mm) are also recorded in the same months. All four approaches utilized to assess the reproductive cycle of *S. gora* centered on the fact that the fish breeds from April to August, and that the fish spawns many times during this single spawning period, as mature, ripe, and immature ovaries were detected in the same size group of females.

Conclusion

The total length - body weight of female *Securicula gora* fish exhibits symmetrical development throughout the mature period. The ovarian weight of the fish varies according on the amount of oocytes and the maturity level of the females. The GSI index's highest point also revealed that the monsoon had an important influence in gonadal growth. The mean fecundity was calculated to be 7162 ± 5543.26 , indicating that *Securicula gora* is a moderately fecund fish. Since a consequence of the findings, it was established that fish spawn more than once, since immature and maturing, ripe, and immature ovaries were detected in the same size group of females. The fecundity, egg diameter, and gonadal developmental stages of the same species have been shown to differ in populations due to feeding, reproductive activity, and climatic circumstances.

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