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Original Article

Feeding and reproductive biology of a freshwater catfish, *Rita rita* (Hamilton, 1822) from the river Ganga

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Abstract: *Rita rita*, a freshwater catfish from the Bagridae family is facing threats of extinction due to over-exploitation and the loss of breeding grounds owing to anthropogenically-driven ecological changes in their native habitat. River Ganga is one of the most important rivers of India, which is affected by industrial and urban waste disposal, unsanitary rituals, and other anthropogenic activities. Therefore, the present study was undertaken to assess the feeding and reproductive biology of *R. rita* which is native to India and Asian countries. A total of 260 *R. rita* samples were collected from the Narora site of River Ganga on a monthly basis. Data on feeding habits, feeding intensity, Gonado-somatic index, and maturity stages based on macroscopic and histological studies, fecundity, and sex- ratio were examined. The gut contents of *R. rita* were composed mainly of molluscs, fishes, insects, crustaceans, annelids, and detritus. RGLs varied significantly with fish size but stayed within the omnivore feeding category. From the month of May to July, females and males had higher GSI values. The fecundity of the sampled *R. rita* specimens ranged from 9464-72,678 in different size classes. Fecundity was found to be linearly related to body length, body weight, and ovarian weight. The average male-to-female ratio was found to be 1:2.6.

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Introduction

Feeding and reproductive biology studies of a fish species are crucial for determining the stock's commercial viability as well as its life history, farming practices, and effective fishery management. Life history traits such as reproductive behavior, sex ratio, size at first maturity, lifespan, and mortality are essential to improve our knowledge of the ecology of the fish population and its significance, which may help in resource management and sustainable exploitation (Campana, 2001). Studies on feeding biology could provide important insights into the feeding habits and quantitative evaluation of food intake which is a key component of fishery management. The ability of fish to successfully reproduce depends on how well their physiology and reproductive behaviour have adapted to their surroundings.

Rita rita, a catfish from the Bagridae family inhabiting clear and muddy freshwaters, is a native of India and many other Asian nations. Because of its customer preference, nutrient contents, and palatability, this fish species has a high market value (Gupta, 2015). Molur and Walker (1998) categorized it as a threatened fish of the Indian subcontinent and suggested that it could face the risk of extinction mainly due to overfishing and loss of breeding sites. Bangladesh, IUCN (2015) categorizes fish as endangered in Bangladesh. There are few studies on food and feeding habits and reproductive biology of *R. rita* from the Ganges River in India (Saxena,1974; Devi et al., 1992; Alam et al., 2016). However, there is no report available on the feeding habits and reproductive biology of the *R. rita* population from the Ganga River at the selected sampling station, which possibly houses a stock distinct from other parts of the river as reported for other large-sized catfish species such as *Sperata aor* (Nazir and Khan, 2019). In the context of the changing environment, the present study has become important to know about the

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changes in food, feeding habits, and reproductive biology of the *R. rita* population for its proper management. Therefore, the current study aimed to examine the feeding and reproductive biology of the *R. rita* population from the river Ganga.

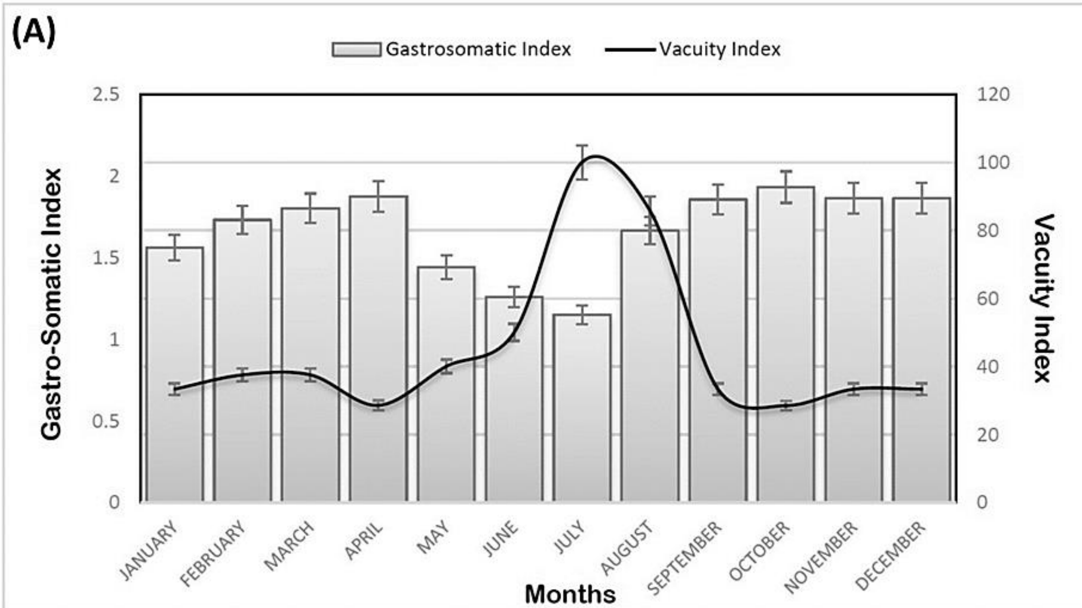
Materials and Methods

A total of 260 fish samples were collected from the Narora sampling location (28.1968°N, 78.3814°E) of river Ganga. The specimens were sampled on a monthly basis. Fish identification was done according to Talwar and Jhingran (1991). To the nearest centimeter, the total length (TL) was measured. The total weight (TW), which includes the gut and gonads was measured to the nearest gram. The specimens were classified according to their sex. Sexual dimorphism and a macroscopic examination of the gonads were used to identify mature males and females. The specimens were dissected and gut length, stomach weight, maturity stage, and liver weight were also recorded. The stomachs were preserved in 10% buffered formalin for the analysis of gut contents. Prey item was identified to the possible taxonomic level. The index of preponderance (I) for each food item was computed based on the total occurrence of all food items (Natarajan and Jhingran, 1961) and then ranked accordingly. Fish samples were taken from each size class (9-24, 24.1-41, and > 41 cm) to investigate the differences in food content between small, medium, and large-sized fishes (Li et al., 2016). Feeding intensity was estimated based on the Gastro-somatic index, (GaSI) = (weight of stomach/total weight of the fish) × 100, and vacuity index (VI) = (no. of empty stomachs/ total no. of stomachs) x 100. Relative gut length (RGL) was calculated as the ratio of the gut length to the total length. This ratio was used to classify fish as herbivores (RGL > 3), carnivores (RGL < 1), or omnivores (RGL = 1–3) based on their feeding habits (Al-Hussaini, 1949).

Gonads were preserved in 10% buffered formalin to calculate GSI, fecundity, oocyte diameter, and histological observation. The morphological and histological study of gonads was used to determine the maturity stages (ovary and testes). The stage of gonad maturity through a macroscopic evaluation was determined following Vazzoler (1996), which takes four maturity stages into account: A (immature), B (developing), C (mature), and D (spent). To perform the histological investigation of gonad samples, the standard histological procedure was done based on Van Dyk and Pieterse (2008). Histological slides were observed using a compound light microscope, and photographs were captured using the attached digital camera (Olympus Xcam-Alpha, Germany). The maturation stages were identified using the properties reported by Rahman and Mollah (2013). GSI and HSI were calculated using the formula of Vazzoler (1996): GSI = (weight of gonad/total weight of the fish) × 100 and HSI = (weight of liver/ total body weight) x 100.

The formula given by Hunter et al. (1992) was used to calculate fecundity (F) = (S/100) x OW, where S = an average number of ova obtained from three samples of 100 mg each, and OW = total weight of the ovary. An ocular micrometer coupled to a stereo-zoom microscope was used to measure the diameter of oocytes (Farrell et al., 2012). The total number of each sex in the collected samples was used to calculate monthly variations in the sex ratio (Qasim, 1966). A total of 260 samples were collected (70 males and 190 females). All methods were carried out in accordance with the relevant guidelines and regulations. The target fish species is a commercially exploited common food fish in India. The sex ratio was estimated for the full one-year study period, and its significance was determined using the Chi-square test (χ^2).

Data analysis: The monthly changes in the gastro-somatic index and the vacuity index were used to evaluate feeding intensity. The data from three fish size-class were subjected to a one-way ANOVA followed by a post-hoc test (Bonferroni Test) to investigate the variance in relative gut length (RGL) (Alcaraz et al., 2015). Monthly fluctuations in the gonadosomatic index were used to evaluate reproductive seasonality. Linear regression analysis was used to examine the relationships between fish fecundity and (i) total length, (ii) total body weight, and (iii) gonad weight. The sex ratio was estimated for



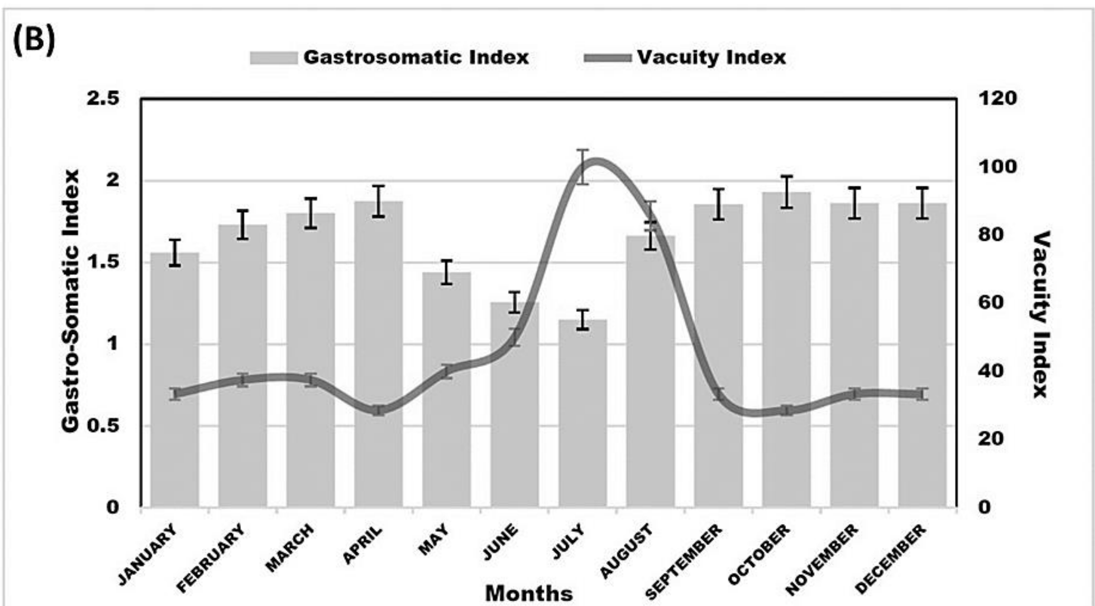


Figure 1. Monthly variation in gastrosomatic index and vacuity index in (A) Females and, (B) Males of *Rita rita*.

the full one-year study period, and its significance was determined using the Chi-square test (χ^2).

Results

Feeding biology: A total of 260 stomachs were examined out of which, 105 (40.38%) stomachs were empty. The monthly GaSI ranged between 1.18 and 2.11 in females, while in males it ranged between 1.15 and 1.87. The highest vacuity index was observed in July in both sexes, but the lowest vacuity index varied in sexes with April in males and September in females. The annual average vacuity index was 41.02 in females and 45.09 in males for the fish in the selected river. A significant rise and decline in feeding intensity were observed in different months. The feeding intensity was measured using the Gastro-Somatic Index (GaSI) and Vacuity Index (VI) taken every month (Fig. 1).

The gut contents were composed mainly of molluscs, fishes, insects, crustaceans, annelids, and detritus. Fishes in the gut content were identified as the teleost but many of the fish remains could not be

Table 1. Variations in diet composition of three length categories of *Rita rita*.

Food items	Fish size (cm)		
	09-24	24.1-41	>41
Molluscs	17.6	33.05	34.2
Detritus	16.6	26.8	22.2
Insects	37.6	18.2	12.8
Fish	2.1	12.4	20.1
Crustaceans	22.8	6.6	6.2
Annelids	3.3	2.25	4.5

Table 2. Index of pre-ponderence of various food items in *Rita rita*.

Food items	% of volume	% of occurrence	Vi × Oi	Vi Oi * 100 / Σ Vi Oi	Grading
Molluscs	46.54	67.47	3140.054	53.60567	I
Detritus	40.84	56.77	2318.487	39.58022	II
Insects	4.12	16.12	66.4144	1.133798	III
Fish	5.5	11.61	63.855	1.090105	IV
Crustaceans	0.22	5.16	1.1352	0.01938	V
Annelids	0.16	2.58	0.4128	0.007047	VI
Total	100	100	5590.358	100	

identified because of being in the advanced stage of digestion (Fig. 2). The Relative gut length (RGL) was 1.042. However, RGLs varied significantly with fish size (ANOVA, $P<0.05$; Fig. 3) but stayed within the omnivore feeding category, i.e., RGL = 1-3. The seasonal variation of food items in the fish gut is presented in Figure 4. Small-size classes (09-24 cm) mainly consumed insects, while molluscs were dominant in the medium-size class (24.1-41 cm). Large fish (> 41cm) consumed a varied range of prey species, primarily molluscs, followed by detritus and fishes (Table 1). Table 2 shows the preferred food items of *R. rita* population from the Ganga River as revealed by the index of preponderance. Molluscs and detritus exhibited higher index of preponderance values in the gut contents, as compared to other prey items: fishes, crustaceans, insects, and annelids.

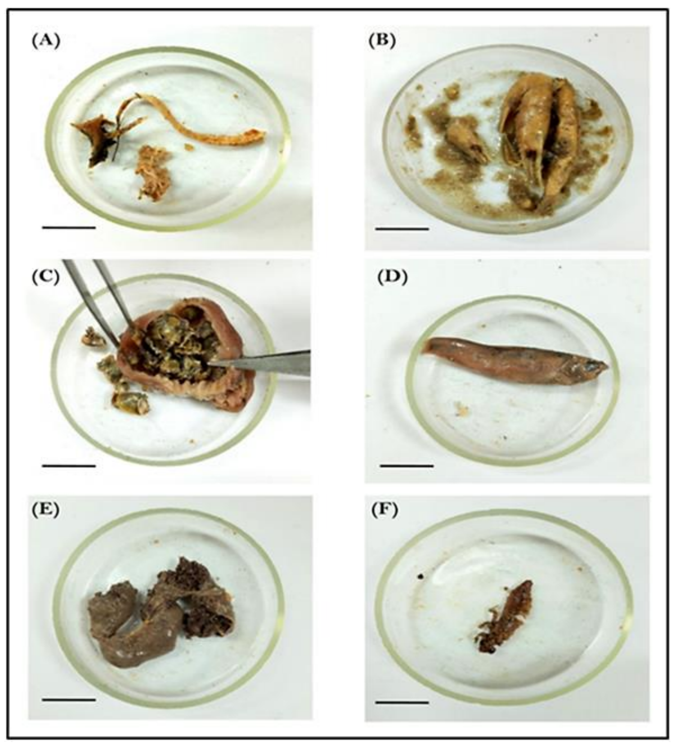


Figure 2. Gut contents found in the stomach of *Rita rita* (A) Hard parts of fish, (B) prawns, (c) molluscs shells; (d) fish, (e) detritus containing mud and plant matter, and (F) Insect.

Reproductive biology: Sexual dimorphism and a macroscopic examination of the gonads were used to identify mature males and females. The vent is pale and slit-like in males, whereas reddish and round in female fish. Genital papillae were round in females while long protruded papillae were found in males (Fig. 5). Based on the macroscopic examination, they were paired, elongated sac-like structures located ventral to the swim bladder and dorsal to the

Table 3. Macroscopic description of gonadal maturation in *Rita rita*.

Ovarian classification	**Morphological description**	**Histological description**
Immature	Whitish, translucent, and less amount of blood capillaries; Oocytes not seen with the naked eye; thin and ribbon-like ovary.	Growth is initially arrested at the primary growth of the oocyte. Early (PO1) and Late (PO2) perinucleolar stage of oocytes was seen in the ovary.
Maturing	Reddish in color; Oocytes were visible by the naked eye; blood capillaries present throughout the ovary	During this phase, yolk granule deposition increased in the oocyte. The yolk vesicle stage was found in the ovary.
Mature	Yellowish in color; ovaries were bulged and both lobules are of the same size; Vascularization was prominent and the ovary occupied the whole cavity; Oocytes extruded on slight pressure.	Early and late yolk granule stage was found. Theca, Granulosa, and Zona radiata all three layers were found in the oocyte. Ovary contain fully hydrated oocytes ready to spawn
Spent	The ovary was flaccid and the size of ovary was decreased; atretic oocytes were present.	The ovary contains post ovarian follicles (POF). Growth of peri- nuclear oocytes stop and yolk vesicles undergo resorption.
Testis classification	**Morphological description**	**Histological description**
Immature	Testis was thin and whitish, ribbon-like and translucent.	Testis lobules contain spermatogonia cells which were small, round, and densely packed structures called the primary spermatogonia.
Maturing	Whitish to light pinkish in color with a relatively larger size than stage one. Blood capillaries increase in number	During this stage, spermatogenesis takes place with the presence of many spermatocytes and spermatids.
Mature	Testis with maximum size and coloration is creamy; Vascularization was prominent; Turgid and voluminous.	Vascularization was prominent and less interstitial fluid was found. Spermatogenesis was found to be at its peak. All stages were present: (secondary spermatogonia, spermatocyte, spermatids, and spermatozoa).
Spent	Testis was flaccid; whitish in color and small in size	Seminiferous tubules were empty with few residuals. Spermatogonia were present. Spermatogonium and spermatocyte were less in number.

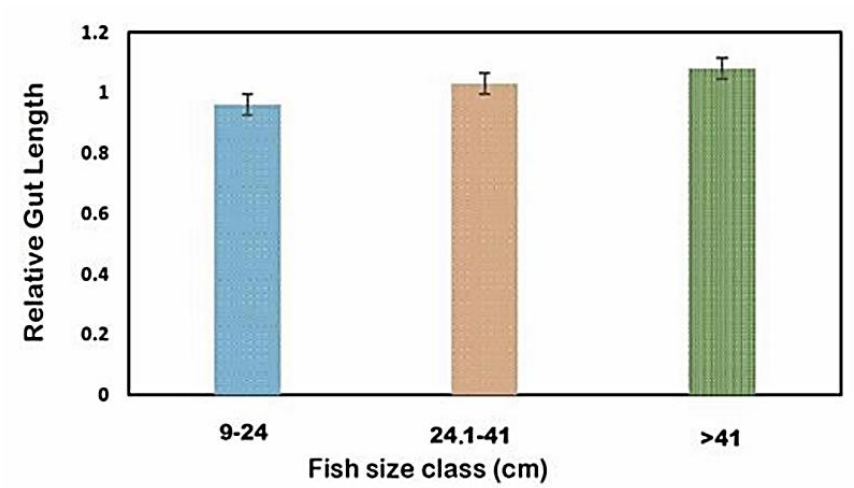


Figure 3. Relative gut length in *Rita rita*.

alimentary canal (Fig. 5). The color of the immature ovary was pinkish to reddish while in mature ovaries the color was light yellowish. The testes were white, elongated, and paired. Depending on the maturity, the color of the testes ranges from light pinkish to whitish. Maturity classification based on macroscopic and histological observation of gonadal characteristics is presented in Table 3. A photomicrograph of

Table 4. Fecundity in different size class and regression equations of relationships between fecundity versus body length, body weight, and ovarian weight in *Rita rita*.

Body Length (cm)	Mean Body Length (cm)	Mean Body Weight (g)	Mean Ovarian Weight (g)	Mean Fecundity
22.6-26.5	24.34	260	10.98	9464
26.6-30.5	28.22	320.4	11.43	14532
30.6-34.5	32.48	322.44	14.56	26442
34.6-38.5	36.32	480.42	26.43	34566
38.6-42.5	39.34	942.32	30.34	48234
42.6-46.5	43.23	800.12	40.42	72,678

Relationships	Correlation Coefficient	Regression Equation
Fecundity (Y) and Body Length (x)	0.95	Y= (0.286) + 0.288x
Fecundity (Y) and Body Weight (x)	0.92	Y= (-0.192) + 0.673x
Fecundity (Y) and Ovarian Weight (x)	0.97	Y= (-1.33) + 0.616x

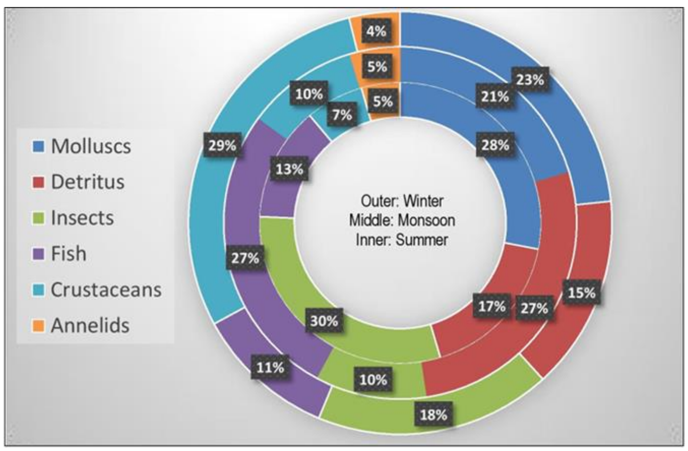


Figure 4. Seasonal variation in food items of *Rita rita*.

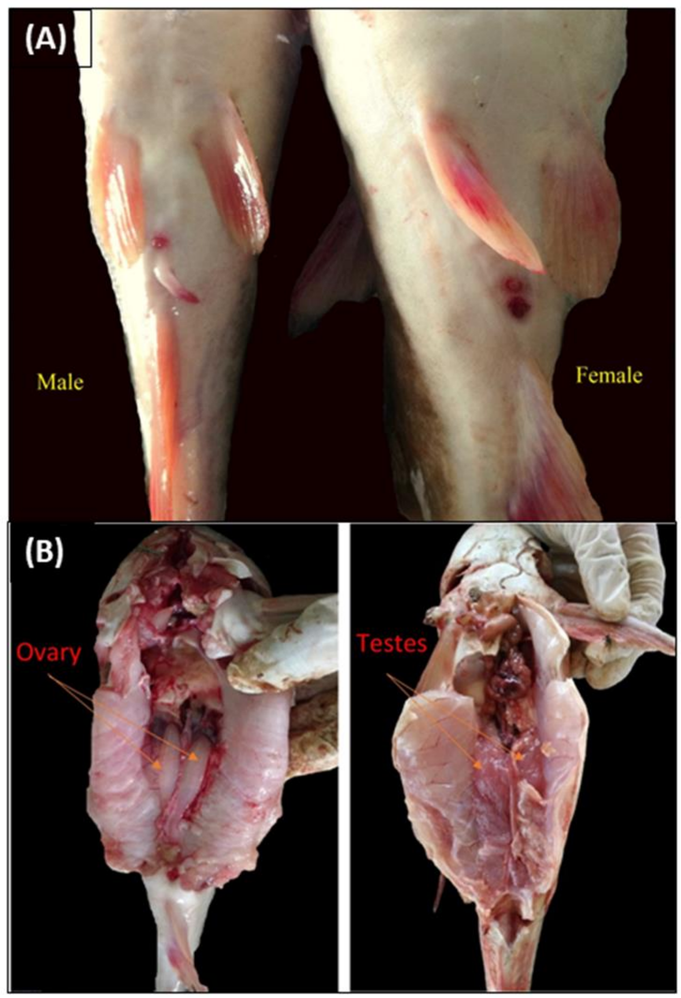


Figure 5. (A) Picture showing sexual dimorphism in Rita rita fish. (B) Ventral view after dissection showing gonads.

histological characteristics of the cross-section of ovaries and testes in different maturity stages present in different months has been shown in Figures 6 and 7, respectively. The months from October to January showed the largest percentage of immature stages in both males and females (Fig. 8).

The gonadosomatic index (GSI), and the Hepatosomatic index (HSI) showed significant variation (P<0.05) in different months of the year. From May to July, females and males had higher GSI values. Afterward, a gradual decrease in GSI was observed in August and reached its minimum value in October. The maximum HSI values for both males and females occurred in April and then decreased to their minimum value in July (Fig. 9).

The mean egg diameter ranged (P<0.05) from 342 to 1436 µm with the highest egg diameter observed in July and the least in October (Fig. 10). The fecundity ranged from 9464-72,678 (Table 4), and it was found to be linearly related to body length, body weight, and ovarian weight (Table 4). The fecundity increased with body size. Among the 260 collected specimens,

Table 5. Total number of sampled fishes, number of males, and number of females, with their respective percentage and sex ratio.

Months	Total samples	Male (Observed Value)		Female (Observed Value)		Ratio of male to female
		Number	%	Number	%	
January	26	6	23.07	20	76.92	1:3.3
February	23	8	34.78	15	65.21	1:1.8
March	25	8	32	17	68	1:2.1
April	22	7	31.81	15	68.18	1:2.1
May	17	5	29.41	12	70.58	1:2.4
June	17	4	23.52	13	76.47	1:3.2
July	9	2	22.22	7	77.77	1:3.5
August	24	7	29.16	17	70.83	1:2.4
September	23	6	26.08	17	73.91	1:2.8
October	27	7	25.92	20	74.07	1:2.8
November	25	6	24	19	76	1:3.2
December	22	6	27.27	16	72.72	1:2.7

χ^2=1.84, df= 11, *P* = 0.99 (not significant at *P*<0.05)

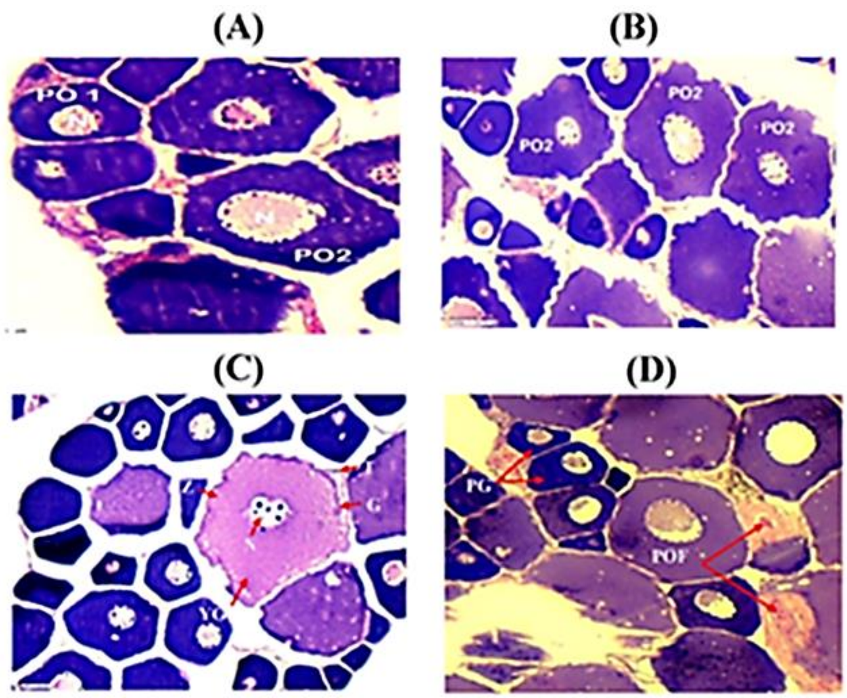


Figure 6. (A) Perinucleolar stages: Early (PO1) and Late (PO2) of oocytes in the ovary of *Rita rita* in January to February. N = Nucleus with nucleoli (H&E, 100×); (B): Late perinucleolar oocyte (PO2) stage in the ovary (March to April, H&E, 100×); (C): Yolk Granule stage of oocytes in the ovary in May to July. YG: Yolk Granule, T: Theca, G: Granulosa, Z: Zona radiata (H&E, 100×); (D): Spent stage of the ovary in September (H&E, 100×). POF- Post Ovulatory Folicle.

188 were females, and 72 males (Table 5). The average male-to-female ratio was found to be 1:2.6. Overall, the females showed significant (*P*<0.01) dominance over males in the collected fish samples.

Discussions

The relative gut length value being in the range 1-3 suggested *R. rita* belongs to the omnivore feeding category. Moreover, the presence of food items (molluscs, detritus, fishes, insects, crustaceans, and annelids) in the gut of *R. rita* further confirmed its omnivore nature. The nature of the fish diet and the RGL readings are closely related (Das and Moitra, 1956). The intestine length of the fish depends upon

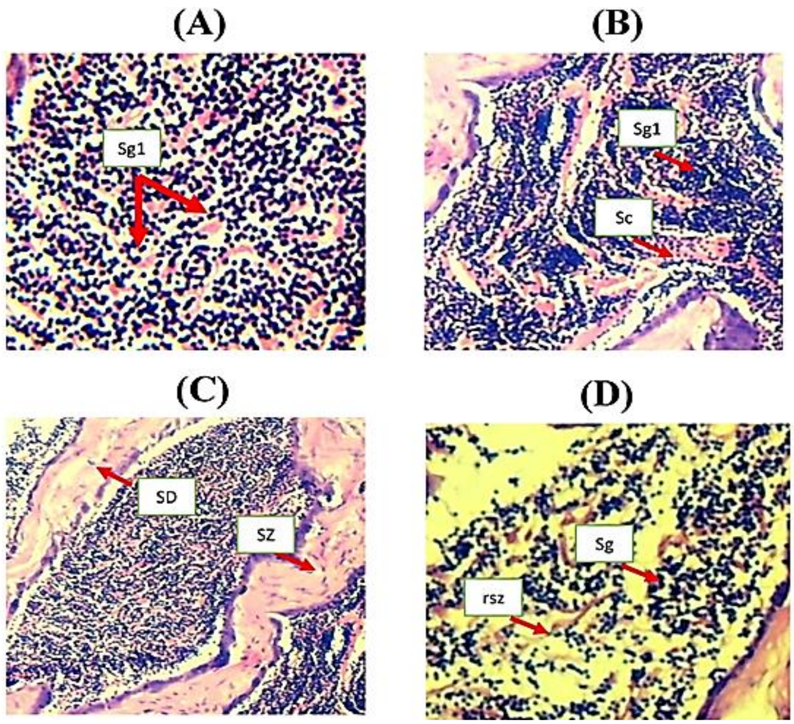


Figure 7. (A) Immature stage of testes of male *Rita rita* (H&E, 10×). (Sg1: Primary spermatogonia); (B) Maturing stage of testes of *Rita rita* containing primary (Sg1) and spermatocyte (Sc) (H&E, 100×); (C) Mature stage of testes of *Rita rita* containing spermatids (SD) and spermatozoa (SZ) (H&E,100×); (D) Spent stage of testes having residual spermatozoa (rsz) and less spermatogonia (Sg) (H&E, 100×).

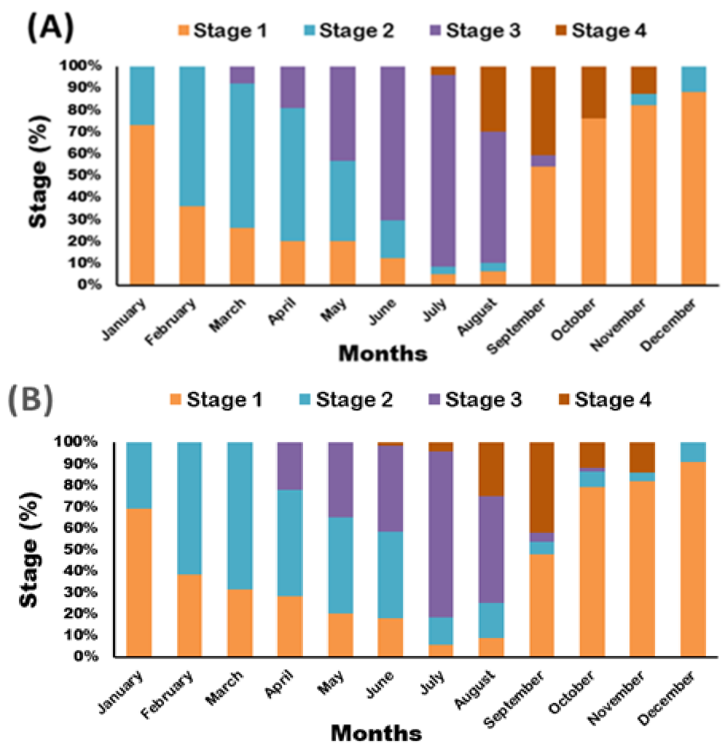


Figure 8. Percentage of the gonad developmental stages in female (A) and Male (B) of *Rita rita* (Stage 1: Immature; Stage 2: Maturing; Stage 3: Mature; Stage 4: Spent).

its dietary habits. Our results are in corroborate with Alam et al. (2016) who suggested *R. rita* has omnivore feeding habits. Devi et al. (1992) and Mushahida-Al-Noor et al. (2013) found *R. rita* to be a carnivore and feed on molluscs, crustaceans, teleosts, and insects. Catfishes are generalist feeders and have evolved adaptions to oxygen shortage and water restrictions (Padmakumar et al., 2009). A shift in the food

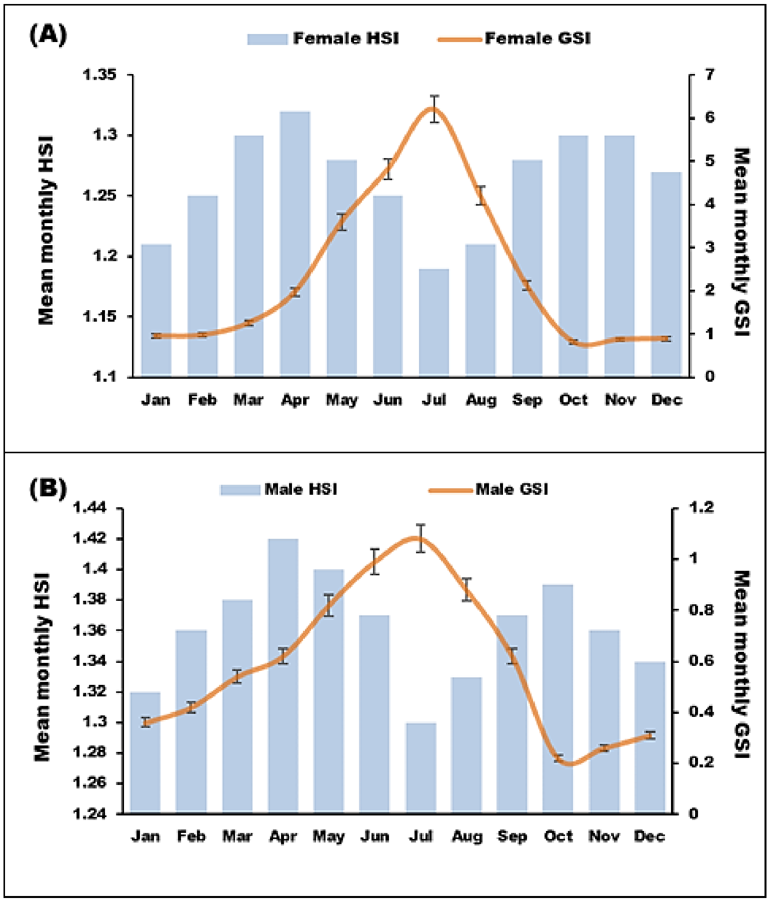


Figure 9. Monthly variation in gonadosomatic index and hepatosomatic index in (A) females and (B) males of *Rita rita.*

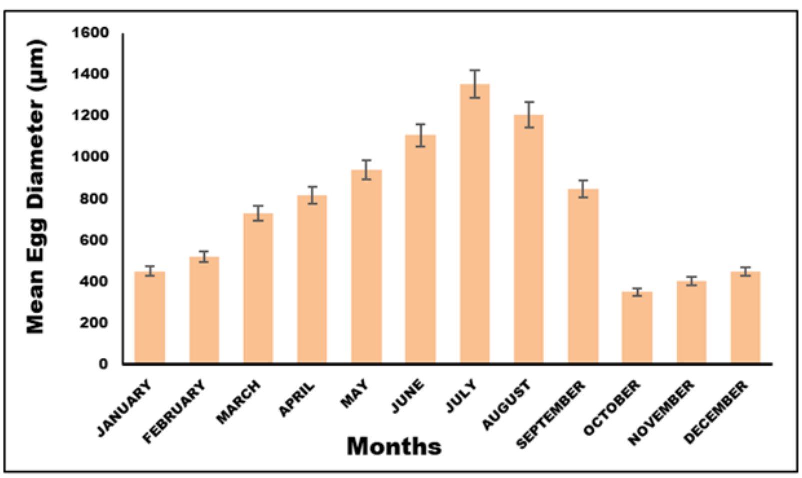


Figure 10. Mean egg diameter (µm) in different months of the year in *Rita rita*.

spectrum from a restricted to a wider variety of food signifies a change in the eating behavior from carnivorous to omnivorous, which shows the species' adaptability to a variety of environmental conditions (Alam et., 2016).

The feeding intensity exhibited variable monthly patterns in *R. rita*. Prior to and following the reproductive phase, fishes eat more intensively. The highest vacuity index along with the lowest value of GaSI was observed from May-August, which coincided with the spawning season of *R. rita.* According to the results, the spawning season of the fish occurs between May to August. The low feeding intensity during the breeding season may be due to the development of gonads, which occupy a large portion of the abdominal cavity, constricting the intestine and making feeding more difficult (Dadzie and Al-Qattan, 2000).

Rita rita showed changes in dietary composition with increasing body size. Smaller size-class consumed primarily, small insects and crustaceans, whereas molluscs, detritus, and fishes were the major prey items in larger individuals (> 41 cm TL). Small-sized fishes have small size of mouths and poor swimming abilities and might have confined their prey selection to small, slow-moving animals in their immediate surroundings. Larger individuals, on the other hand, with huge and terminal mouths and protruding lower jaws, can move fast and capture considerably larger prey (Courtenay Jr. and Williams, 2004). A size-related dietary shift is more likely to reflect a smaller individual's mouth-gape constraint rather than gut length and morphology. The variable diet composition in *R. rita* with increasing body size could possibly be attributed to the size of their jaws and ontogenetic changes in their dental characteristics (Li et al., 2016). Such ontogenetic dietary changes may be related to maximizing energy acquisition i.e., larger fish prefer bigger prey because they contain more energy and exploit their increased mobility to catch such prey (Stoner and Livingston, 1984).

Seasonal variations in fish feeding habits are linked to changes in food availability induced by environmental and physiological factors (Wootton, 1990). The significant rainfall during the monsoon causes a considerable change in nutrient content, thus resulting in a difference in the dietary composition of *R. rita* during pre-monsoon and post-monsoon periods. In the current study, the percentage composition of fishes as food in the gut of *R. rita* was highest in the rainy season. According to Solis (1988), physico-chemical parameters, including temperature, pH, conductivity, and salinity are appropriate to sustain aquatic life in the rainy season. The food spectrum of fishes is affected by a variety of parameters such as prey availability and habitat, fish age, prey energy content, prey size selection, and variations in the composition of food organisms that occur throughout the year (Manon and Hossain, 2011; Taieb et al., 2013). The seasonal percentage of insects in the gut contents of the fish was highest in the winter and summer and low in the rainy season, which could be due to an increased load of sediments; rainy season reduces the transparency and hence adversely affects the population of aquatic insects (Payakka and Prommi, 2014). The fish exhibited maximum detritus content in its gut during monsoon, which might be due to increased water volume and flow rate that carries high concentrations of dissolved and suspended solids; during monsoon, the heavy run off, from the soil could also play a role in the presence of increased detritus in the fish gut during monsoon. In the present study, molluscs in the gut of target fish species were found in all the seasons but the maximum percentage was observed in the summer season when water level in the aquatic systems reduces drastically, therefore, studied fish has easy access to these organisms. This feeding habit indicated that the target fish species is a bottom-dwelling fish.

Based on the percentage index of preponderance values, the main prey item in the diet of the fish consists of molluscs followed by detritus, insects, fishes, crustaceans, and annelids. The prey items found in this study were very similar to those reported for the *R. rita* from the river Ganga at Allahabad (Alam et al., 2016). Fish, in general, target the most abundant locally available prey, and this behavior may be affected by the catch success rate and/or the chances of encountering prey (Persson and Diehl, 1990).

The breeding season of *R. rita* appears to coincide with the rainy season and extends from May to August as evident from higher GSI values during this period. The histological examination of monthly ovarian samples corroborated this finding. In teleost fishes, gonadal development shows variation with respect to the duration of the breeding cycle as well as with various environmental factors such as temperature, photoperiod, and various physicochemical characteristics of the inhabiting water body. Qasim and Qayyum (1961) observed that freshwater catfishes *Wallago attu, Eutropiichthys vacha, Bagarius*

bagarius and *Ompok pabda* in plains of north Indian river bred between June and September with peaks in July and August. Analysis of the monthly mean GSI throughout the year showed the spawning season in *R. rita* to commence from May and last till August with a peak in July.

Some researchers have established relationships between HSI and GSI in fishes (Viana et al., 2008; Ghafouri et al., 2019). According to Zardo and Behr (2015), gonad development and reproductive activity involve the utilization of materials derived from ingested food and, in the majority of cases, from energy reserves accumulated in various regions of the body. Therefore, the development and maturity of gonads could be related to the changes in liver weight. This is supported by the current study, which found a rise in liver weight in both males and females during the months of March/April. During the peak of spawning in many fish species, the GSI is at its highest and the HSI is at its lowest. According to the results in different months, the lowest HSI in *R. rita* female was in July and the highest in April. Variation in the HSI could be related to the liver's vitellogenesis process. In fish, oocyte development is closely linked to the hepatic synthesis of vitellogenin, an egg-yolk precursor protein that is secreted into the blood and eventually carried to the developing oocyte and deposited as yolk (Singh and Srivastava, 2015). The low HSI values seen throughout the spawning season could be attributed to the use of accumulated reserve in the liver for meeting energetic requirements during times of scarcity of food, sexual product elaboration, and spawning activity.

The size of the ova in the fish ovary was observed to vary. Saigal (1964) observed this condition in several other catfish species. There is a gradual increase in egg diameter from the immature stage to the ripe stage. Even though most of the eggs attained maximum size during the spawning period, many immature eggs were noticed in all the stages as also suggested by Ali (1999). The maximum oocyte diameter was observed in July, implying that the oocytes are mature and fish may spawn under suitable conditions. The maturation of ova began to develop from March onwards and got bigger in May and attained the maximum diameter in July. Thus, it can be assumed that the spawning season began in May. Furthermore, the maximal ova diameter was found to be available in June and July. Several findings by Khan (1934), Das (1964), Saxena (1972) and Rahman and Mollah (2013) who reported that the spawning season of *R. rita* was restricted from June to July. Alam et al. (2015) observed the breeding of *R. rita* from May to September with peak in July and August, they suggested the lengthening of the spawning period by one month to September, may be due to the pollution in some segments of the river Ganga.

The current investigation found that the number of eggs was directly proportional to the fish's length and weight, and that fecundity increased significantly with ovary weight. The number of eggs produced by a female is determined by several factors, including the size and age of the samples (Lagler et al., 1967). Variation in the number of eggs present in different individuals of the same species could be due to environmental differences experienced by conspecific populations or a different method of fecundity interpretation. Fluctuations in fecundity could be reported if size and age variation is not taken into account by (Djumanto et al., 2019). In this study, fecundity was highly correlated with ovary weight, total length and total weight of the fish. Similar observations were reported by Rahman and Mollah (2013) for the same fish from the Brahmaputra River.

Sex ratio in the sampled specimens of *R. rita* exhibited deviation from the expected ratio of 1:1, with a dominance of females over males. Several researchers have already reported on the divergence of the sex ratio from the predicted value and female dominance over males in the populations of other fish species (Maskill et al., 2017; Ghofouri et al., 2019). Many factors, such as mortality, maturity, differing behaviors of males and females, higher predation rates in one sex, or even aspects connected to collection selectivity, could influence the predominance of one sex over the other (Raposo and Gurgel, 2001). The factors causing varied sex ratios in a fish population need to be identified and examined to understand whether it could be a strategic adaptation ensuring population success and diversity in varied environments.

Seasonal reproductive cycles can be strongly influenced by biotic factors like competition and food availability, as well as abiotic factors like photoperiod, temperature fluctuations, and rainfall (Dala-Corte and Azevedo, 2010). Moreover, the availability of habitat and food is determined by river water levels, and rainfall tends to have a significant effect on the fish reproductive cycle. The primary environmental component that affects the gonadal cycle and spawning in the majority of tropical and subtropical fish species might be rainfall (Bhattacharyya and Maitra, 2006). Climate change-related precipitation patterns may have a significant impact on the periodicity of fish spawning (Whitney et al., 2016). Rainfall and other climatic conditions prevailing during the monsoon season may be considered as the important environmental cues inducing the fish to mature and breed in monsoon months.

Conclusion

The relative gut length value suggested *Rita rita* to belong to the omnivore feeding category. Moreover, the presence of food items (molluscs, detritus, fishes, insects, crustaceans, and annelids) in the gut of the fish further confirmed its omnivore nature. The feeding intensity varied according to season and fish size. Higher feeding intensity was observed during pre-spawning and post-spawning seasons. The breeding season of *R. rita* appears to coincide with the rainy season and ranges from May to August as evident from higher GSI values during this period. Histological examination of fish gonads clearly reveals the difference between the immature, maturing, mature, and spent phases of fish gonads. The fecundity of *R. rita* ranges from 9464-72,678. Fecundity was linearly correlated with body length, body weight, and ovarian weight. This study can improve our knowledge about the changes in food, feeding habits, and reproductive biology of the *R. rita* population, which can then be utilized for its sustainable fishery management and conservation.

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