



Research Paper

Population dynamics of catfish *Sperata seenghala* Sykes, 1839 with special reference to physico-chemical water quality parameters in Gomati River of Tripura

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Abstract

The present study analyses the population dynamics of *Sperata seenghala* Sykes, 1839 by evaluating sex ratio, length–weight relationship, and reproductive traits, with special reference to the physico-chemical parameters of water in the upper and lower reaches of the Gomati River in Tripura, Northeast India. A total of 357 specimens were examined, with females predominating over males (67.5:32.5). Significant length–weight relationships were observed across different developmental stages, with females generally attaining greater size than males. Gonadal development progressed from February to July, with peak GSI and spawning activity occurring in July, while fecundity ranged from approximately 10,000 to 22,000 eggs per fish. Water-quality conditions were comparatively favourable in the upper reach, which supported higher fish abundance, and several physicochemical parameters showed significant associations with population density. The study highlights the immediate need for conservation measures, such as the closure of unscientific sand mining, seasonal fishing closures, and the declaration of some sites as no-fishing zones, to ensure the long-term sustainability of this fish species in the Gomati River of Tripura.

1. Introduction

Sperata seenghala (Sykes, 1839) is a large-sized catfish, locally known as guchi aor, and a member of the family Bagridae under the order Siluriformes. The distribution of this species extends across several countries, such as Afghanistan, Bangladesh, Nepal, and Pakistan, including India (Talwar and Jhingran, 1991). Even though the global conservation status of this fish is reported as “Least Concern,” many current reports at the regional level highlight a declining trend in population size in many parts of the world, including Tripura, in the northeastern part of India (Das and Banik, 2021). Lotic ecosystems are dynamic with respect to biotic and abiotic factors. Riverine ecosystems are fragile in terms of habitat degradation due to anthropogenic activities such as industrial pressure, pollution, overexploitation, and illegal fishing activities, which are resulting in rapid biodiversity loss in many indigenous fish species (Jokar and Subbey, 2026). For effective management of a species, it is necessary to identify the reasons for its decline and obtain knowledge of the biometric growth

parameters of the target species (Javaid *et al.*, 2026).

Fish population dynamics is the scientific study of how fish numbers change over time and the core factors driving these fluctuations, including reproduction, growth, and mortality (Datta *et al.*, 2023; Kumar *et al.*, 2025). Jatoi *et al.* (2013) reported positive allometric growth for females, while isometric growth was reported for males and combined sexes of *Sperata seenghala* in the Indus River. Sani *et al.* (2010) reported negative allometric growth for combined sexes from the Betwa and Gomti rivers, respectively. Fish populations are integral to global biodiversity, food security, and livelihoods; therefore, implementing effective conservation strategies is essential for ensuring their sustainability and the health of freshwater environments (Sarkar *et al.*, 2013). Fish populations are influenced by a complex interplay of natural and human-induced factors, which can lead to fluctuations in abundance and diversity over time (Suman *et al.*, 2025).

In the present study area, *S. seenghala* fetches a higher price in the local fish market than carps due to its good taste and protein content (Saini et al., 2010). However, the lack of standardized induced breeding technology has hindered the expansion of *S. seenghala* culture (Rahman, 2005). Thus, the entire demand for this fish is met by natural populations through capture, which may lead to population depletion or extirpation. Due to high market demand and the lack of fully standardized aquaculture, leaving wild fisheries as the sole source of supply poses a serious threat of overexploitation and habitat degradation. Despite its commercial importance, baseline data regarding its population parameters, such as length–weight relationship, sex ratio, reproductive traits, etc., remain scarce or unassessed for the Gomati River in particular and Tripura as a whole. Therefore, studying the population dynamics of *Sperata seenghala* in the Gomati River of Tripura provides vital baseline data on its reproductive traits, growth, and stock health. This insight helps protect wild populations from overfishing and guides local conservation efforts.

2. Materials and Methods

2.1 Study Area and Sampling

The studied fish fauna, *Sperata seenghala*, was sampled from the Gomati River of Tripura, which is identified as a wild habitat for this fish species. Geographically, the Gomati River lies at a latitude of 23°31'59.99" N and a longitude of 90°42'59.99" E, at an elevation of 67.00 m above MSL. Collections of fish fauna as well as water samples were carried out from the upper and lower reaches of the Gomati River. The upper reach of the Gomati River (Fig. 1) has three different sampling locations, namely Tirthamukh, Jatanbari, and Amarpur.



Figure 1: Upper reach of Gomati river

Similarly, the lower reach (Fig. 2) also has three different sampling locations, namely Maharani, Kakraban, and Sonamura. The fish population of *Sperata seenghala* was sampled during the early morning from the littoral zone of different sampling

locations of the Gomati River with the help of traditional cast nets and drag nets. Sample collection was carried out during 2020–2023.

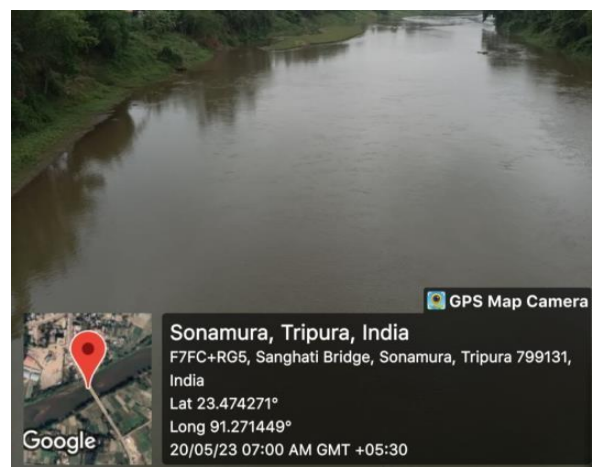


Figure 2: Lower reach of Gomati river

2.2 Sex ratio

The sex of adult males and females was determined by examining their external genital characteristics. The sex ratio was determined using the following formula:

$$\text{Sex ratio} = \text{Number of females} / \text{Number of males}$$

2.3 Length weight relationship

The length-weight relationship of the fish under study was calculated using the formula given by Le Cren (1951).

$$W = aL^b$$

where 'W' is body weight (g), 'L' is total length (cm), 'a' is a coefficient related to body form, and 'b' is an exponent indicating isometric growth when equal to 3.

2.4 Gonado-somatic index (GSI)

It was calculated month-wise by applying the formula suggested by Parameswaran et al. (1974).

$$\text{GSI} = \text{Weight of gonad} / \text{Weight of fish} \times 100$$

2.5 Gonadal maturity stages

The gonadal maturity of each specimen was identified using a 5-point maturity scale suggested by Wudneh (1998). Based on morphological observations, the maturity stages were categorized into five stages, viz. immature (Stage I), maturing (Stage II), mature (Stage III), fully mature or ripe (Stage IV), and spent (Stage V).

2.6 Absolute Fecundity

Absolute fecundity was estimated using the following formula:

$$F = nG/g$$

where F = fecundity, n = number of eggs in the subsample, G = total weight of the ovary, and g = weight of the subsample.

2.7 Water Quality Analysis

Water quality parameters were analyzed following the standard methods recommended by APHA (2005).

2.8 Statistical Analysis

The data obtained from the study were compiled and analyzed using appropriate statistical methods. Descriptive statistics were used to summarize the observations, and the results were expressed as mean $\pm$ standard deviation (SD). The relationships between the measured biological parameters were evaluated using appropriate statistical analyses. Statistical significance was considered at $p < 0.05$. The statistical analyses were performed using Microsoft Excel and appropriate statistical software.

3. Results

3.1 Sex ratio

Sex ratio is an important indicator for assessing the reproductive viability of fish. A total of 357 fish specimens were sampled, including 241 females and 116 males, with a female-to-male percentage ratio of 67.5:32.5. Monthly variations in the sex ratio were recorded during the study period and are presented in Figure 3. Among the total fish population of *Sperata seenghala*, females were found to be quantitatively dominant over males. The female-to-male ratio was approximately 2:1. Monitoring the sex ratio helps us understand reproductive potential, fish stock size, overexploitation of one sex leading to population decline, and genetic bottlenecks. The findings of the present study indicate that the sex ratio in the Gomati River of Tripura is unbalanced, as it deviates from the expected 1:1 ratio. This variation may be due to differences in maturity, mortality, and habitat preference.

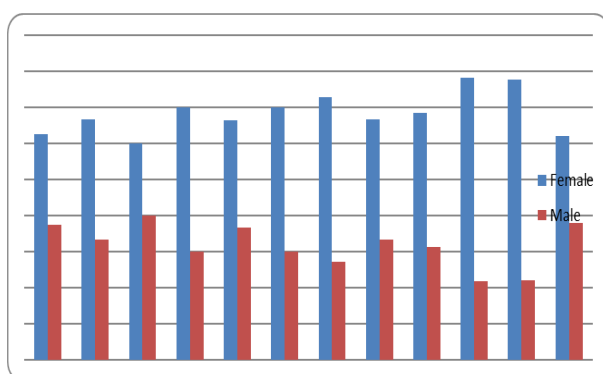


Figure 3: Monthly variation of male-female sex ratio of *Sperata seenghala* during study period

3.2 Length-weight relationship

The length-weight data are presented in Figure 4 and Fig. 5. The results show that the female fish specimens were relatively larger in both length and weight compared to the male fish specimens.

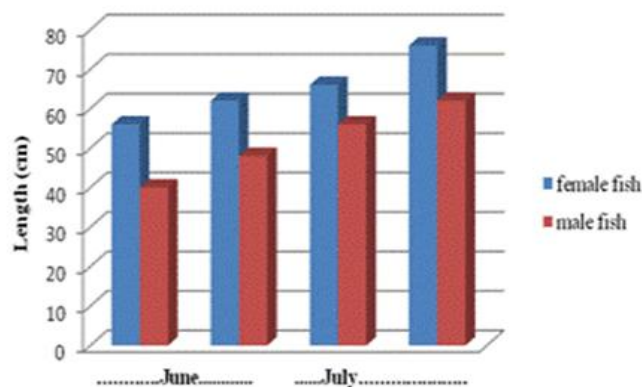


Figure 4: Variation of length in adult female and male

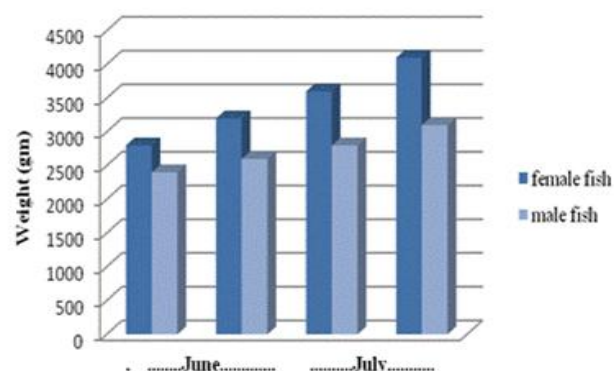


Figure 5: Variation of weight in adult female and male

The regression equations of *Sperata seenghala* were prepared in relation to its different life-cycle stages, such as the post-fingerling, pre-adult, and adult stages, and are presented in Fig. 6, 7, 8, 9, 10, and 11. The regression equation presented in Fig. 7 shows a regression coefficient (R^2) of 0.971, indicating a significant correlation between the length and weight parameters during the post-fingerling stage in male fish samples, whereas Fig. 6 shows an R^2 value of 0.975, indicating a significant correlation between the length and weight parameters of *Sperata seenghala* in post-fingerling female fish samples.

In *Sperata seenghala*, during the pre-adult stage, the regression equations for both female and male fish samples showed a linear relationship between length and weight parameters. Figs. 10 and 11 also show a significant correlation between length and weight parameters, indicating a linear relationship between these two biological parameters. The fry stage of *Sperata seenghala* observed in the Gomati River of Tripura showed a higher occurrence during the pre-monsoon season. Among the two sexes, female fish samples showed relatively greater density than male

fish samples.

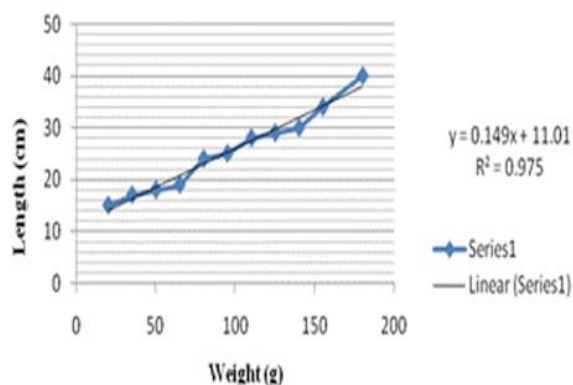


Figure 6: Regression analysis on length weight relationship in post fingerling female

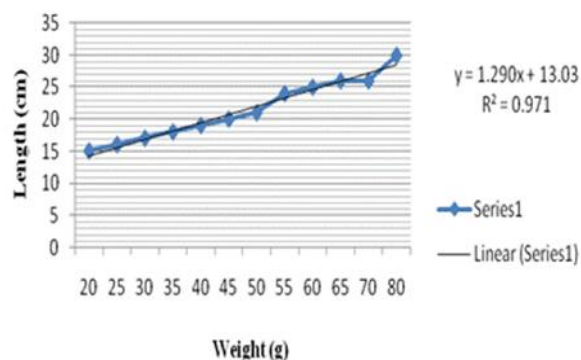


Figure 7: Regression analysis on length weight relationship in post finger ling male

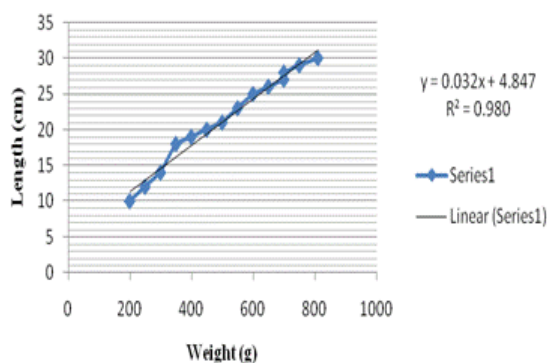


Figure 8: Length weight relationship in pre-adult female

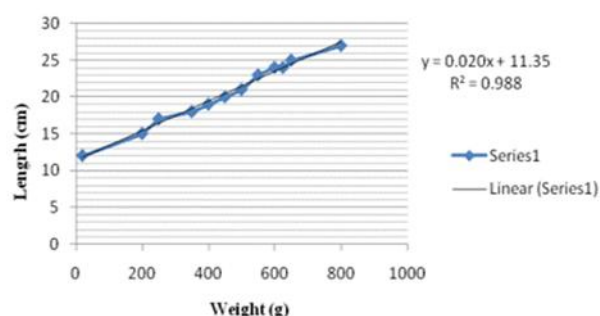


Figure 9: Length weight relationship in pre-adult male

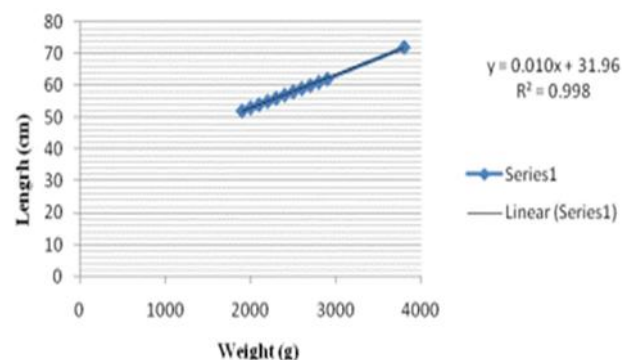


Figure 10: Length weight relationship in adult female

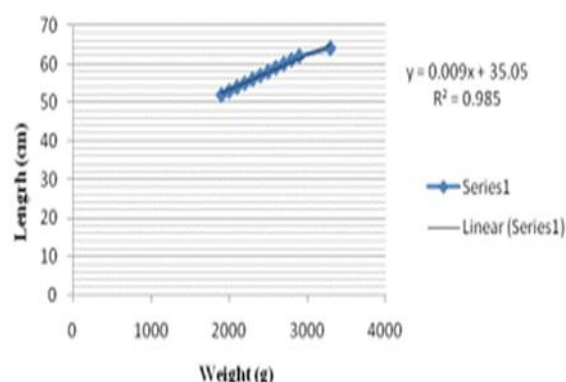


Figure 11: Length weight relationship in adult male

3.3 Maturity stage

Maturity stages in the studied fish species, *Sperata seenghala*, were identified in both females and males, showing different stages of gonadal maturity from Stage I to Stage V. Stage I was observed in February, while Stage V was noticed during July (Figure 12 and 13). Thus, both female and male fish samples exhibited an immature stage in February, when the gonads were first visually observed (Stage I). During March, the gonads of females and males could be distinguished from each other (Stage II). In May, mature ovaries in females were noticeably observed (Stage III). By the end of June, enlarged ovaries and testes were observed (Stage IV). In both females and males, the fully mature gonadal stage (Stage V) was observed during the third to fourth week of July.

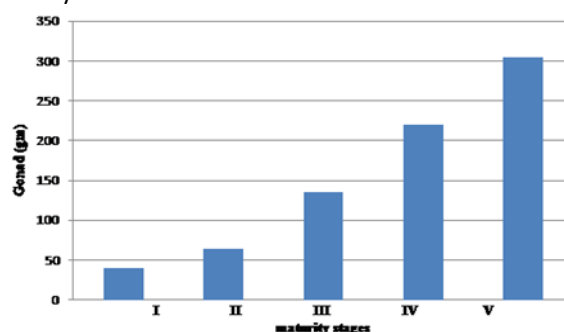


Figure 12: Maturity stages in female

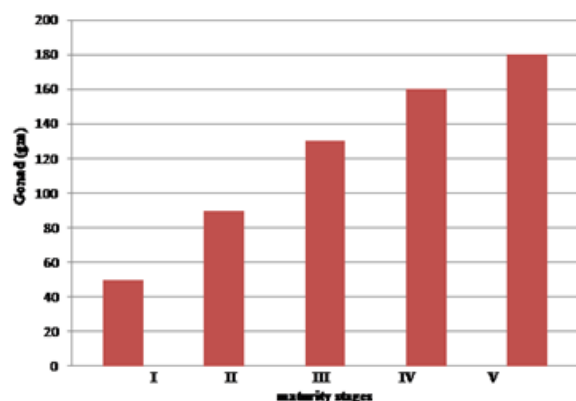


Figure 13: Maturity stages in male

3.4 Gonado-Somatic Index (GSI %)

This index in both sexes depicts gonadal maturity during May to June, with peak maturity occurring in July. The GSI value in females becomes low from August to October, whereas in males, low values are observed from August to September. The GSI value could not be assessed in female fish samples from November to January and in males from October to February. The GSI values of females were consistently higher than those of males. The GSI (%) gradually declined in both female and male fish samples from August onwards.

Thus, it is presumed that in *Sperata seenghala*, the pre-spawning stage occurs from February to May in females and from March to May in males. Evaluation of GSI can be carried out from February in females, whereas in males, it begins in March and continues until June–July. In female fish, low GSI (%) values were observed from February to April, while in males, the GSI (%) was relatively low during March to April. The pre-spawning period develops from February to March in females and from March to April in males, whereas the peak spawning period in this species was observed during July in both females and males (Figure 14, 15, and 16).

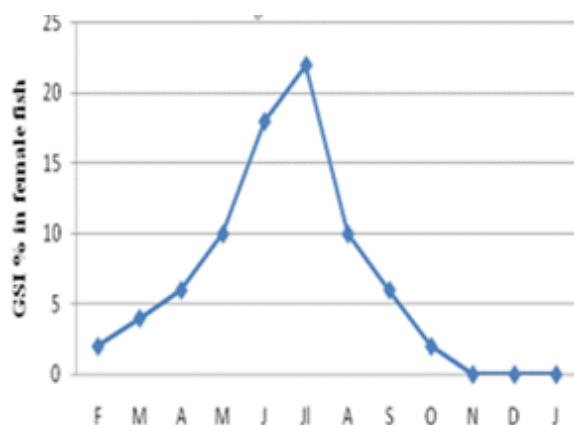


Figure 14: GSI (%) in female during different months

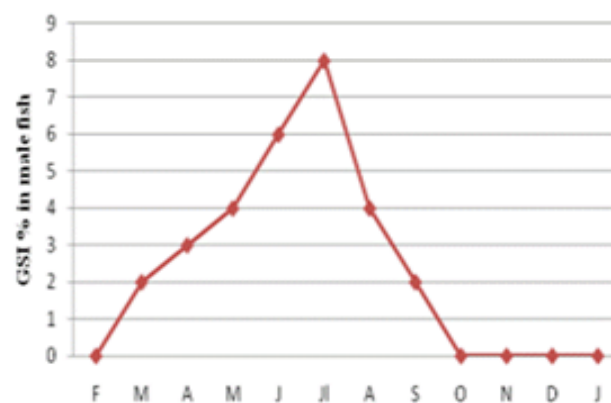


Figure 15: GSI (%) in male during different months

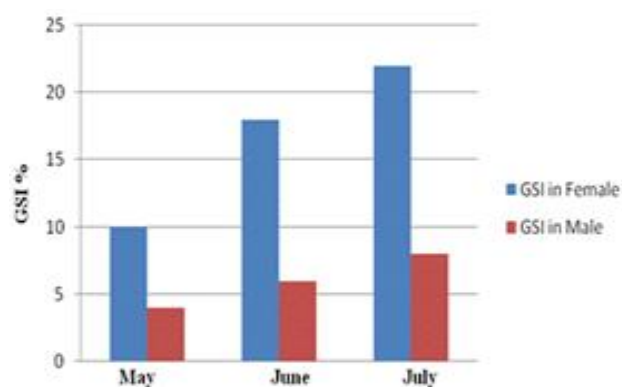


Figure 16: Peak GSI (%) during May to July

3.5 Fecundity and Breeding Aspects

In nature, *Sperata seenghala* showed fecundity values ranging from approximately 10,000 to 22,000 eggs per fish during the period from June to July. The numerical density of eggs per gram of ovary varied from a minimum of 10,000 in May to a maximum of 22,000 in July. The diameter of mature eggs gradually increased during the spawning period from May to July, while it decreased during the post-spawning period from August to September (Figure 19). The diameter of mature eggs was found to be larger during June to July (Fig. 18). Regression analysis of fecundity (i.e., the number of eggs in an ovary) in relation to ovary weight showed a linear relationship between fecundity and ovary weight in the present study (Figure 16). The R^2 value of 0.990 indicated a significant correlation between these two biological parameters during May (Figure 17).

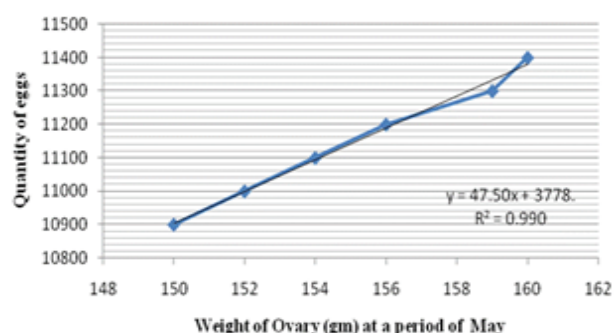


Figure 17: Relation between Fecundity and ovary during month of May

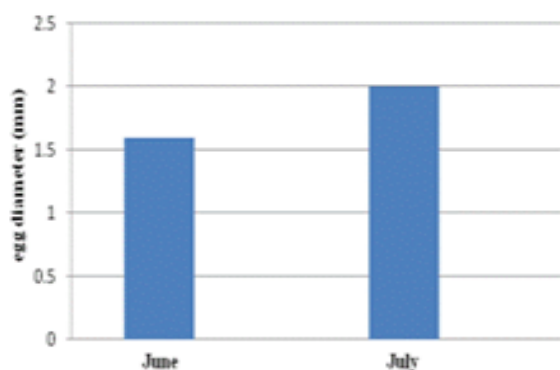


Figure 18: Diameter of mature egg during peak spawning period

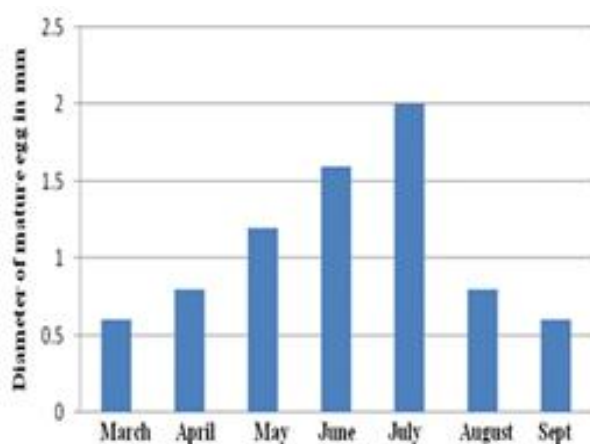


Figure 19: Diameter of egg during pre-spawning and spawning period

The month of July represents the peak period of development, with a larger quantity of mature eggs. Hence, July appears to be a suitable spawning season for the studied fish, *Sperata seenghala*. Regression analysis depicting the relationship between fecundity and ovary weight in *Sperata seenghala* during the peak spawning period in July showed an R^2 value of 0.989. Thus, a significant correlation exists between fecundity and ovary weight during July (Figure 20 and Figure 21).

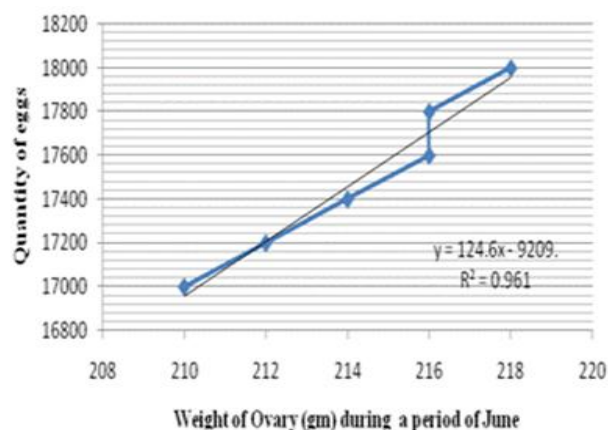


Figure 20: Relationship between fecundity and weight of ovary(gm) during June

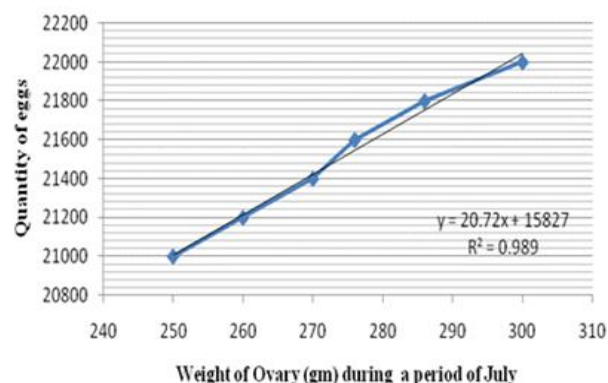


Figure 21: Relationship between fecundity weight of ovary(gm) during July

3.6 Water quality Analysis

The Gomati River ecosystem of Tripura, which serves as a habitat for the studied fish species, *Sperata seenghala*, was investigated for several important physicochemical parameters of the lotic water. The parameters analyzed included water turbidity, CO_2 , HCO_3^- , $\text{PO}_4\text{-P}$, $\text{NO}_3\text{-N}$, and dissolved organic matter.

The results showed that the physicochemical parameters of the upper-reach area of the Gomati River indicated more suitable water quality characteristics than those of the lower-reach area. Probably for this reason, the upper-reach area showed a relatively greater density of the fish population of *Sperata seenghala* during both the monsoon and winter periods (Figure 22, 23, and 24).

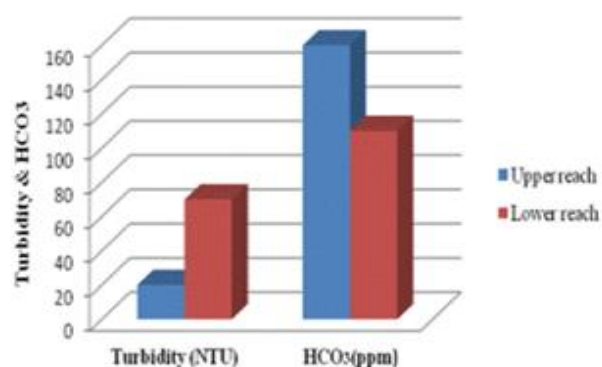


Figure 22: Turbidity and bicarbonate in upper and lower reach

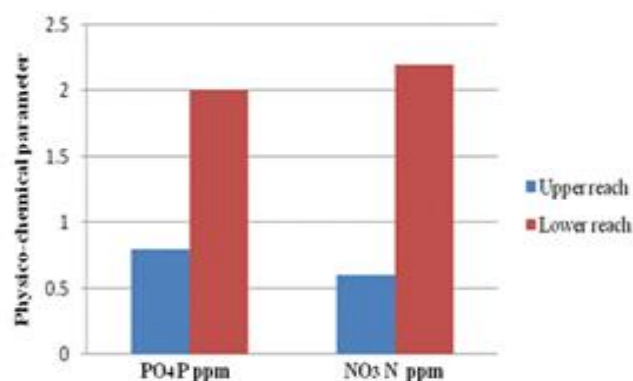


Figure 23: Concentration of PO_4P and NO_3N in upper and lower reach

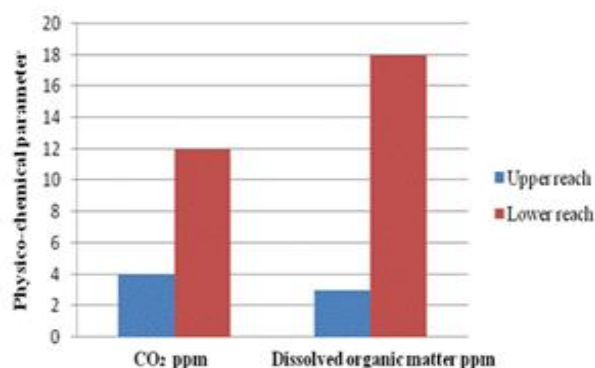


Figure 24: Concentration of CO_2 and DOM in upper and lower reach

The population density of *Sperata seenghala* during the fry and fingerling stages was relatively higher during the pre-monsoon season. Females were also found to be quantitatively dominant during this period. In contrast, male fish showed a relatively lower population density (Figure 25 and 26).

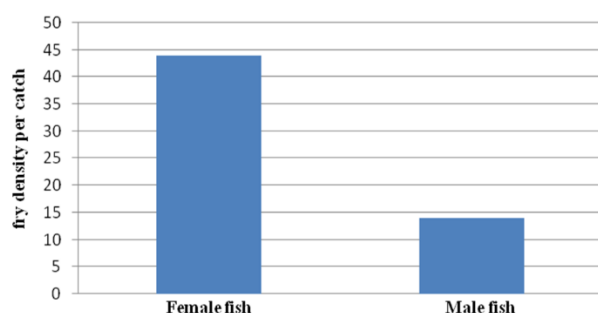


Figure 25: Population density of *Sperata seenghala* in fry stage during pre-monsoon period

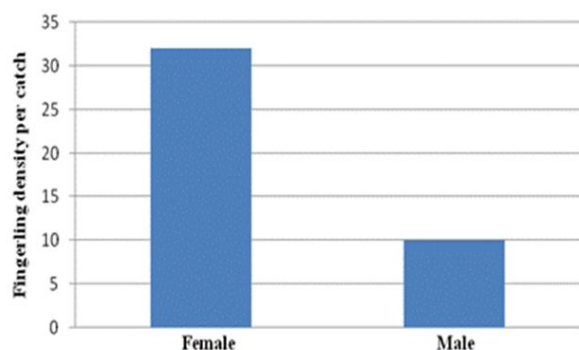


Figure 26: Population density of *Sperata seenghala* in fry stage during pre-monsoon period

During the adult stage, *Sperata seenghala* depicted a relatively higher population density during the monsoon period (Fig. 27). The adult fish samples from the Gomati River ecosystem during this season showed an increasing trend in population density from the initial sampling location, i.e., Tirthamukh, to the

maximum density at the Amarpur sampling location. The areas from Tirthamukh to Amarpur fall under the upper reach of the Gomati River, whereas the areas from Maharani to Sonamura fall under the lower reach. In the upper-reach area, an increasing trend in fish population density was observed, while in the lower-reach area, a decreasing trend in fish population density was noticed (Fig. 28). Furthermore, between female and male fish, the quantitative population density was relatively higher in females.

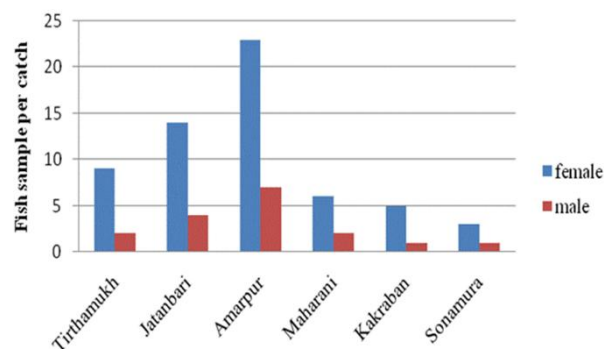


Figure 27: Population density of both female and male in adult condition during monsoon period

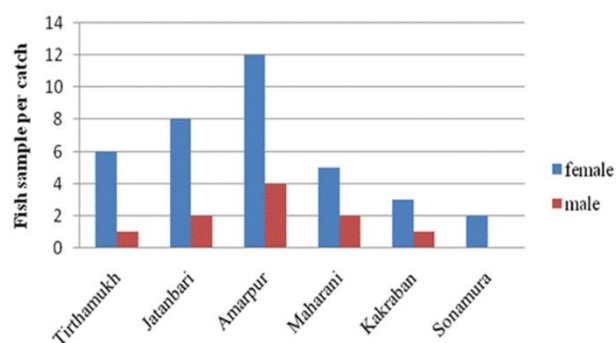


Figure 28: Population density of both female and male in adult condition during winter period

The brood stage of *Sperata seenghala* showed a gradual increase in population density during the monsoon period from June to July. During this period, the peak density of the brood fish population was observed in July, which represents the peak breeding period for this fish species (Figure 29).

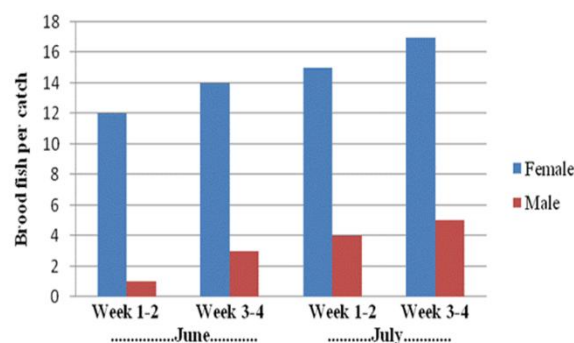


Figure 29: Population density of brood stage with female and male fish samples during monsoon period

4. Discussion

The present study provides information on the reproductive biology, growth characteristics, seasonal abundance, and spatial distribution of *Sperata seenghala* in the Gomati River of Tripura. The female-biased sex ratio observed in the present study, with a female-to-male ratio of approximately 2:1, indicates a greater representation of females in the sampled population. Variation in sex ratio among fish populations may be associated with differences in habitat preference, mortality, maturity, fishing pressure, and seasonal distribution. A female-biased population has also been reported for *S. seenghala* from the Gomti River in central India (Kumar et al., 2025).

The length–weight analysis showed a strong relationship between length and weight, particularly during the post-fingerling stage. Similar strong relationships have been reported for *S. seenghala* from the Sutlej River, although the growth coefficient may vary among populations and habitats (Kaur et al., 2022; Rana and Kaur, 2023). Such differences may be associated with environmental conditions, food availability, size structure, season, and reproductive condition. The comparatively larger size of females observed in the present study may also be related to differences in growth and reproductive investment. The seasonal distribution of different life stages showed a clear pattern. Fry and fingerlings were more abundant during the pre-monsoon period, whereas adults showed comparatively greater population density during the monsoon season. The increasing abundance of adult fish from Tirthamukh towards Amarpur in the upper reach and the subsequent decline towards Maharani and Sonamura in the lower reach indicate spatial variation in habitat utilization. The relatively greater abundance in the upper reach may be associated with comparatively favourable physicochemical conditions observed in this part of the Gomati River. Differences in habitat quality, food availability, flow characteristics, depth, and shelter may influence the distribution of riverine fishes.

The reproductive observations revealed a distinct seasonal progression of gonadal development. Gonads progressed from immature stages in February to fully mature stages during July. The GSI pattern further supported this reproductive cycle, with increasing gonadal development before spawning and a marked decline after the peak period. The maximum reproductive activity observed during July indicates that July represents the principal spawning period of *S. seenghala* in the studied population. However, the breeding season of this species may vary geographically, as differences in reproductive timing have been reported among river systems (Memon et al., 2017; Kumar et al., 2025). Fecundity increased during the maturation period, with the highest values recorded during July. The increase in egg diameter up

to July followed by a decline during the post-spawning period further indicates active oocyte maturation and subsequent spawning. The strong relationship between fecundity and ovary weight suggests that females with larger ovaries generally possessed greater numbers of eggs. Variation in fecundity among populations may occur because of differences in female size, ovary weight, maturity stage, nutritional status, and environmental conditions (Kumar et al., 2025).

The brood-stage population gradually increased from June to July, with the highest density recorded in July. This pattern coincided with the peak gonadal maturity, GSI, fecundity, and mature egg development observed during the same period. The agreement among these reproductive indicators supports July as the major breeding period of *S. seenghala* in the Gomati River. The concentration of mature and brood fish during this period highlights the importance of protecting breeding individuals from excessive fishing pressure.

Overall, the present findings demonstrate clear seasonal and spatial variations in the population and reproductive biology of *S. seenghala* in the Gomati River. The comparatively higher abundance in the upper reach and the concentration of mature and brood fish during June–July indicate important periods and areas for population management. Protection of mature fish during the breeding season and conservation of suitable riverine habitats may contribute to maintaining the natural population of this economically important catfish.

5. Conclusion

From the present study, it is concluded that the Gomati River of Tripura experiences seasonal low-flow periods and poor water quality, which act as major ecological bottlenecks. The correlation between biological and water quality parameters clearly indicates that both the upper and lower stretches of the Gomati River are experiencing environmental stressors. These conditions reduce fish habitat availability and adversely affect native fish species. It is suggested that immediate restoration of riverbanks and natural flow paths would help rejuvenate the river ecosystem.

6. Statements and Declarations

Ethical Approval: Not applicable

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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