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Studies on gonado-somatic index (GSI) of selected fishes in tons barrage, Satna, Madhya Pradesh

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Abstract
A research study was conducted to analyze seasonal variations in the gonadosomatic index of certain fish species in Tons barrage, Satna district, Madhya Pradesh. The highest mean GSI values were recorded during the monsoon season, while the lowest mean values were observed during the post-monsoon period for *Cirrhinus mrigala*, *Labeo rohita* and *Catla catla*. However, in the case of *Labeo rohita*, the maximum mean GSI value was actually observed during the pre-monsoon period in June, while the minimum was during the monsoon period in July-August, due to its single spawning period in June-July. The GSI is a measurement of the gonadal mass relative to the total body mass and serves as an important indicator of fish maturity and spawning patterns. This study aimed to identify the spawning season of key fish species in Tons barrage by analyzing the Gonadosomatic index, which can be beneficial for selective breeding programs, conservation efforts, and sustainable fishery management in natural water bodies.

Keywords: GSI, tons barrage, fishes, spawning season

Introductions
Carp farming is the most extensive form of animal aquaculture globally (Desilva, 2003) [1]. The fecundity of a fish refers to the number of eggs it carries in its ovary, representing its egg production capacity or the amount of mature eggs it produces in one spawning season. Understanding fecundity is crucial for assessing the productivity and commercial viability of a fish population. To effectively manage fish farming operations, it is essential to determine the fecundity of the fish (Mian and Dewan, 1984) [2]. Studies have also looked into fecundity and gonadosomatic index in species like *Mystus gulio* (Sarker, *et al.* 2002) [3], *Anabas testudineus* (Ala and Pathak, 2010) [4] and *Labeo rohita* (Marimuthu *et al.* 2009) [5]. The gonadosomatic index (GSI) is a key indicator in fish biology, providing insights into reproductive patterns and breeding periods. It measures changes in gonad weight relative to the total body weight and helps identify spawning seasons. Knowledge of GSI and fecundity is vital for evaluating the reproductive potential of fish and predicting their spawning times accurately. Monitoring gonad weight offers a straightforward way to track changes in gonad condition over time.
Gonadosomatic index (GSI) is one of the important parameters of the fish biology, which gives a detailed idea regarding the fish reproduction, reproductive status of the fish species and help in ascertaining breeding period of fish (Sindhe and Kulkarni, 2004) [6]. Production of eggs and milt is greatly influenced by the environmental changes among different species and within the same species also. Fish populations are more vulnerable as they are the direct recipient of virtually every form of human as well as animal wastes. Water pollution is the biggest contributor to this decline. The breeding success of a fish depends on the quality of the gametes it produces. Moreover, a fish under stress will be subject to physiological and hormonal changes, unable to divert energy for gonadal maturity on time, thus delaying the breeding season.
The determination of breeding season is an essential part of biological investigation of fishes (Saksena, 1987) [7]. The use of gonadosomatic index and volume of gonad as indicators of gonadal state has been used by several researchers to determine the breeding season of different fish species (Shailja and Saksena, 2012) [8].
The breeding success is affecting the fishery resources and is causing a decline in the endemic fish species. It is therefore very important to study gonadal development indexes

like GSI, which can give first-hand information about the breeding season. Keeping this in view, the present study was devised with an aim to determine the spawning season of commercially important fishes of Tons barrage and to assess the effect of pollution if any on the same.

Materials and Methods

Study site

Tons barrage located in village Bakiya Bailo, (24°42'19.3"N 81°09'03.0"E) district Satna (MP). The barrage is connected with all-weather Rewa-Semariya Road. The samples (Fish) were collected from Tons barrage.

Study period

The study was conducted for 180 days (from June 2023 – December 2023) covering three seasons *viz*. pre-monsoon (June-July), monsoon (August-September) and post-monsoon (October –December) and samples were collected in triplicate on two monthly intervals.

Fish species selected for the present study

Commercially important food fishes of Tons barrage *i.e. Cirrhinus mrigala*, *Labeo rohita* and *Catla catla*, were selected for the present study.

Sample collection and GSI estimation

The fish samples were collected in plastic zippers and brought under iced conditions in insulated corrugated boxes to the College of Fisheries, Govt. Model Science College, Rewa (M.P.). The samples were examined in the laboratory immediately after collection. Total lengths (in cm) of fishes were measured by using fish measuring band whereas total weights (in g) were recorded for each fish specimen with the help of electronic balance. The sex of each specimen was identified by visual examination and confirmed after dissection and examination of the gonads following standard protocol. The gonads were dissected and weighed by digital electronic weight balance nearest to 0.01mg. The GSI was calculated by formula (Reddy, 1979) [9].

Gonadosomatic index (GSI)

It is defined as the calculation of the gonad mass as a proportion of the total body mass. It is represented as:

$$GSI\% = \frac{\text{Gonad weight}}{\text{Total body weight}} \times 100$$

Statistical analysis

One way ANOVA and Duncan Multiple range test was applied to find out the significant differences in the seasonal variations in Gonadosomatic index (GSI) of selected fishes. Statistical analysis was performed on MS-Excel and SPSS-16 software package (p<0.05).

Results

Results GSI (Female) of *Cirrhinus mrigal, Labeo rohita and Catla catla* were estimated seasonally and values are expressed as percentage (Table 1). In the present study, GSI values were highest during monsoon period (July-August) for all the fish species except for *Labeo rohita* because of its only one spawning period (June-July). Different studies have suggested seasonal variation in the value of GSI, ascribed to the corresponding changes in the reproductive activities (gonadal development) of the species.

Table 1: Seasonal variations in gonadosomatic index (%) of commercial fishes during the study period (June, 2023-December, 2023)

Fishes	Pre-monsoon	Monsoon	Post-monsoon
Cirrhinus mrigala	$18.42^{b,2}$±0.67	$29.10^{a,1}$±0.36	$1.78^{c,3}$±0.12
Labeo rohita	$21.66^{b,2}$±1.23	$35.21^{a,1}$±2.45	$1.84^{c,3}$±0.10
Catla catla	$20.43^{b,2}$±0.88	$34.55^{a,1}$±0.22	$2.65^{c,3}$±0.55

*Values (mean ± standard error) in a row with different alphabetical superscripts (a, b, c …) differ significantly within seasons and with different numerical superscripts (1, 2, 3 …) differ significantly between sites (p<0.05)

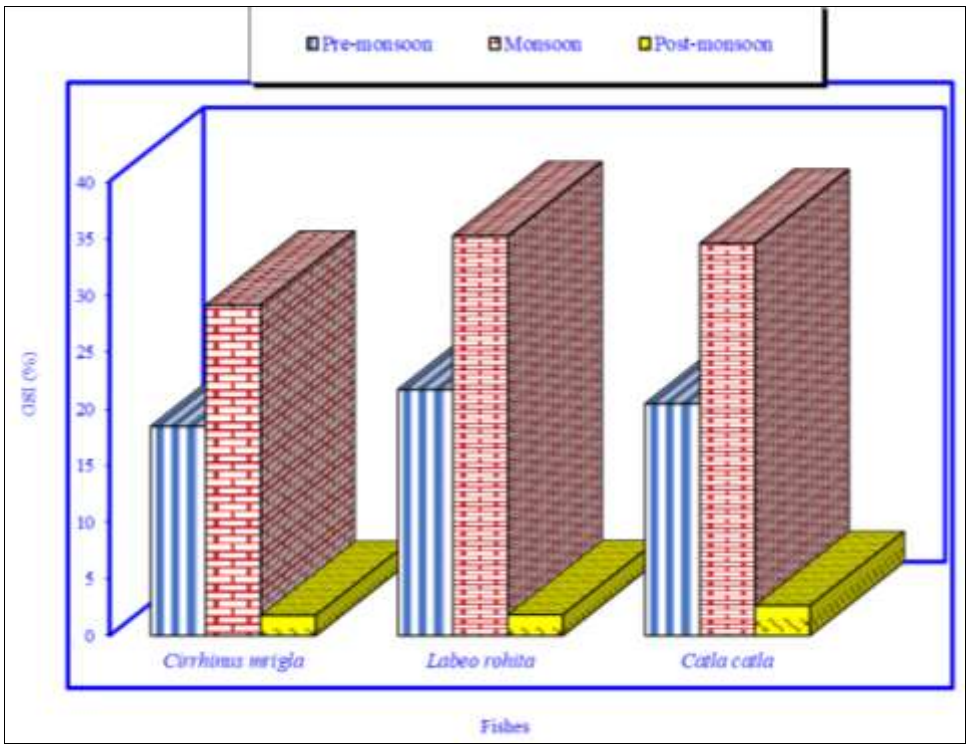

Fig 1: Seasonal variations in gonadosomatic index (%) of commercial fishes during the study period

Cirrhinus mrigala

Body moderate, elongate, Head short, Mouth wide, transverse. Lower jaw sharp, dorsal fin inserted ahead of pelvic fins. Anal fin short. Caudal fin forked or lunate. Scales of varying sizes. Lateral line complete. It breeds in confined waters with the onset of rainy season. During the present study, maximum mean GSI (%) values for *Cirrhinus mrigala* (29.10) was observed during monsoon whereas minimum mean GSI (%) values (1.78) was observed during post-monsoon period respectively (Table 1 & Fig. 1).

Labeo rohita

Body moderate sized deep with rounded abdomen. Head fairly large. Snout more or less swollen, rounded projecting behind mouth. Mouth moderate, inferior jaws with a sharp margin and with soft movable horny covering. Barbels always present. Dorsal fin inserted above anterior to origin of pelvic fins. Anal fin short. Caudal fin deeply forked. Scale large. Lateral line complete or little curved. The food of *Labeo rohita* consisted of plant (algae and macrophytes) and animal matter (Protozoa, rotifers, cladocerans, copepods, molluscs, annelids and insects) besides unidentified matter (UM), sand/mud and detritus. Spawning occurs in flooded rivers in the monsoon period. During the present study, maximum mean GSI (%) values for *L. rohita* (35.21) was observed during monsoon whereas minimum mean GSI (%) values (1.84) was observed during post-monsoon period respectively (Table 1 & Fig. 1).

Catla catla

Body deep, Abdomen rounded, Head broad, very large, snout bluntly rounded. Mouth wide. Eye large Dorsal fin long. Anal fin short. Caudal fin forked. Scale moderate, Lateral line complete. *Catla catla* is plankton feeder and feeds primarily on zooplanktons. During the present study, maximum mean GSI (%) values for *Catla catla* (34.55) was observed during monsoon whereas minimum mean GSI (%) values (2.65) was observed during post-monsoon period (Table 1 & Fig. 1).

Discussion

GSI provides information on fish reproduction and is a crucial factor in assessing ovary maturity. It serves as a useful tool in understanding the reproductive patterns of organisms and developing appropriate breeding strategies for endangered fish species or impacted water habitats.

During different seasons, the significant differences were found in the mean GSI values for all the fish species observed as (Monsoon>Pre-monsoon>Post-monsoon) within the Tons barrage, except for *Labeo rohita* in which the mean GSI values does not differed significantly during monsoon and post monsoon seasons (Pre-monsoon>Post-monsoon>Monsoon).

Furthermore, there were no notable variances found in the average GSI values among the sites for all of the fish species observed, with the exception of *Labeo rohita*, where the GSI values showed significant differences during the monsoon season. In the same way, several studies have verified the highest GSI in other *Channa* species like *C. punctatus*, typically seen during the early and mid-rainy season, from May to August (Sunita *et al*. 2011 and Mian *et al*. 2017) [10-11].

In the current research, it was discovered that GSI values were elevated during the monsoon season for all fish species, confirming them as monsoon breeders, with the exception of *Labeo rohita*. *Labeo rohita* exhibited higher GSI values during the pre-monsoon period, suggesting spawning activity during the dry season. The average GSI values decreased during the post-monsoon period for all fish species except *Labeo rohita*, which experienced a decrease during the monsoon period, signifying the end of spawning. Therefore, higher GSI values serve as an indication of the spawning season in line with previous research findings (Abuzinadah, 2001) [12].

Lower values of GSI during the present study indicate that fish is not ready to spawn in conformity with the other findings who also reported that the GSI range between 0 - 2 values means that fishes are not preparing to spawn (Sindhe and Kulkarni, 2004) [13]. Value of GSI is affected by the weight through temporary changes in the visceral mass caused by feeding and different workers have tried to address this problem and have been subtracting gonad weight from the body weight (Tracey *et al.* 2007) [14] or using eviscerated body weight.

The present findings are in close agreement with the findings of other scientists. Similar observations were recorded in *Cirrhinus mrigala* (Snyder, 1983 and Brewer *et al.* 2008) [15-16] and *Rasbora towarensis* (Muchlisin *et al.* 2010) [17].

Conclusion

The study highlights the importance of continuous monitoring of Gonadosomatic Index to assess their trends and potential impacts. The findings provide valuable information for high organic pollution, less gonadal weight as the fish might have been under physiological stress which lead to late maturity of gonads. This might be also due to the fact that during stress the fish might be using its own body reserves for metabolic needs and less channelization of energy towards gonadal development. Further studies are needed on histological level to rule effect if any of Tons barrage pollution on the gonadal maturity of fish species harbouring. The observations of the present study also helpful for selective breeding programme, conservation and sustainable fishery management of commercially important fishes in its natural water bodies.

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