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Comparative studies on the physiology of Bagrid cat fish, *Mystus cavasius* in Tunga and Bhadra rivers, Karnataka

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Abstract
The present study deals with the comparative study on physiology (GSI, HSI, protein content of ovary, testis and liver) of *Mystus cavasius* in Tunga and Bhadra rivers, Karnataka was studied during July to October 2017. In Tunga river, the GSI values increases was almost linear during September there was marked fall in GSI value and continued to be low during remain period. The GSI value is maximum in August and September indicates that for is engaged in spawning activity from August to September. Higher values of HSI was found in October and minimum during July. The HSI value is more in male than find then also observed his was high at beginning of the gonadal development their after the value decreased to low level in mature stage. Monthly variation in protein content of the testies and ovary shows the inverse relationship in both the rivers i.e. increases the protein content in testes and over as during in July on the contain the liver and muscle protein decreases during July indicates their inverse relationship. The protein content in ovary, muscle and liver is more in female compared to male testis, muscle and liver. The biochemical contents are higher in females because they contain large weight and length than male. In Bhadra river, GSI value was maximum in July for female and October for male and minimum in August for males and October for females. Higher values of HSI was found during the resting and preparatory month of July in both the sexes. The minimum HSI was found during September (Female) and October (Male) months. The HSI value is more in male than female due to beginning of the gonadal development their after the value decreased to low level in mature stage. In males, protein content in liver, testes and muscles ranged from 1.10-1.41, 1.03-1.99 and 2.20-4.14. However, in females protein content in liver, testes and muscles ranged 1.21-1.31, 1.07-1.93 and 3.45-5.53. GSI and HSI varies during the reproductive cycles. Liver is strongly correlated to vitellogenic activity. Changes in the HSI indicates that liver undergo more or less parallel changes in weight. HSI and GSI also exhibit that the liver supports to spermatogenic and organic activity.

Keywords: GSI, HSI, Physiology, *Mystus cavasius*, Tunga and Bhadra rivers

Introduction
In the world about 22,000 species of fish have been recorded of which 24.73% belongs to fresh water, 6.5% back water and 65.45% of marine ecosystem. India has huge inland water resource interview of 29,000 km of rivers. India is home for more than 10% of global fish diversity.
Mystus cavasius is widely distributed siloroid fish found throughout the India and Burma in rivers canals, irrigation, channels, ponds and inundated field. It belongs to family Bagridae, *Mystus cavasius* is a commercially important fishery along Bhadra river. This genera comprises same species *Mystus seenghala*, *Mystus tengara*, *Mystus montanus* etc. These fishes are differ from each other. The economic value of any fish depends upon relationship between its length and weight. The ratio of length to weight of fish is known to be a useful index to demonstrate the well being of the fish. It plays a vital rave in the fishery. It helps in establishing the yield and also in comforting, one variable into the other as is often required in during monitoring field operations.
The method of studying spawning season is to followed seasonal changes in gonadal weight in relation to body weight expressed as the GSI. Gonad undergo regular seasonal cyclic changes in weight practice in female indicates the spawning season. It is one of important parameter of fish biology. It gives the detail idea regarding the fish reproduction and reproductive stages of the species and helps in ascertaining breeding period of fish. Studying seasonal changes in liver weight decreases relation to body weight expressed as the HSI. Liver undergo regular seasonal cyclic changes in weight in both male and female indicate the spawning season. It is also one of the important parameter of biology.
The biochemical composition of fish tissues is of great interest to assess the specificity in the nutritional value of fish and their physiological needs at different life stages. Several researchers have studied the disruptive effects of maturation and spawning on the chemical composition of fish (Appa Rao, 1967 [1]; Pandey *et al*., 1976 [21]; Piska & Prasad, 1991 [22]; Kiran & Puttaiah, 2005) [16]. The seasonal bio-chemical variations correlation tests, ovaries, muscle and liver have not been given much attention of *Mystus cavasius* of the rivers. Hence, keeping in view of the commercial importance of fish, an attempt have been made to study the storage and utilization of liver contents for testicular growth spermatogenesis and oogenesis.
The main objectives of the present includes identifying character of *Mystus cavasius*, study the protein content in the liver, gonads and muscles. Also to study the GSI and HIS and length and weight relationship of the *Mystus cavasius*.

Materials and Methods
Study area
The Tunga river is in Karnataka state of Southern India (Fig 1 and 1A). The river is originated born in the Western Ghats at a place called Gangamoola. From here, the river flows through two districts like Chikmagalur and Shimoga

District. Tunga river is about 147 km long and merge with the Bhadra river at Koodli Sangama, a small town near Shivamogga of Karnataka. The Tungabhadra flows towards East and merges with the Krishna river in Andhra Pradesh, India. Tunga dam is built at Gajanur,

The Bhadra river is in Karnataka state of Southern India (Fig 2 and 2 A). The river is originated in the Western Ghats at a place called Gangamoola. From here, the river flows through Shivamogga district. Tunga river is about 147 km long and merge with the Bhadra river at Koodli Sangama, a small town near Shivamogga of Karnataka. The Tungabhadra flows towards East and merge with the Krishna river in Andhra Pradesh, India. Bhadra reservoir is built near Lakkavalli of Chikmagalur district.

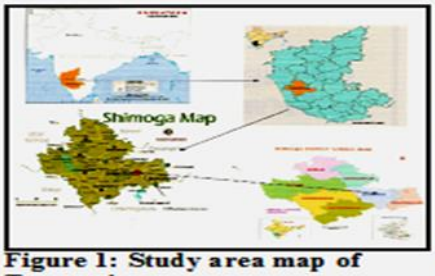

Figure 1: Study area map of Tunga river


Figure 1A: Fish sampling in Tunga river


Figure 1B: Views of *Mystus cavasius*


Figure 2: Study area map showing location of Bhadra river

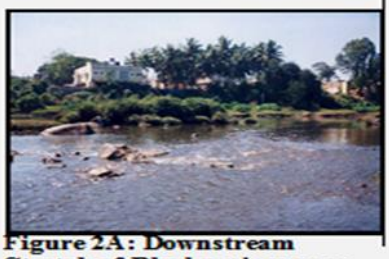
Figure 2A: Downstream Stretch of Bhadra river near Bhadravati town


Figure 2B: Testis and ovary of *Mystus cavasius*

Methodology

During the study period (July to October 2017) specimens of *Mystus cavasius* were collected monthly from the local fisherman. The fish were measured and weighed in the fresh condition with the help of measuring board and weighing balance the length weight relationship was estimated by using the formula: Log W = Log a + b logl

Where, W =Weight; L = Length; a = multiplying constant; b = exponent of length.

According to the statistical analysis, The values of an average total length were platted against their respective weights. The departure from cubic law has been tested and correlation co-efficient has also been computed to test whether regression co-efficient depart significantly from the cubic value C.

The fish *Mystus cavasius* (Fig 2) were collected several time per month from Tunga river during July to October and were obtained from fisherman. They were brought in to the lobaratory and then scarified for further studies. The tissue was processed from protein estimation- GSI and HSI. The protein was estimated as method described by Lory method and to study the Gonadosomatic Index and Hepatosomatic Index. Two fishes were examined per month in 4 mounted duration. The weight of liver and gonads of individual fish was recorded and GSI and HSI was calculated by using formula.

GSI =Weight of Gonad/Weight of fish x 100; HSI = Weight of Liver /Weight of fish x 100

Results and Discussion

Tunga river

Results are depicted in Table 1-4 and Figs 3-5. *Mystus cavasius* is a fresh water fish. This fish is commercially important as it consumed by large population. Although the reproductive biology of this fish has received attention in other areas by many workers. Systematic study pertaining to the biochemical changes in response to different mounts. Hence in the present investigation observation on aspects such as length weight relationship condition changes in to GSI. HSI biochemical changes during the four month reproductive cycle has been studied.

The study of length weight relationship of primary importance in setting up yield equation in estimating the number of fish landed and in comparing population in time and space. The study of length weight relationship also gives an idea of their growth rate generally the length of fish increases. The weight also increases. Showing that the width of the fish is a function of its length.

Maximum length reported = Male = 20cm; Female = 21.3cm

Weight of *Mystus cavasius* = Male = 75g; Female = 232.1 g

Comparatively, female have more weight and length than male. There was a fare degree of correspondence between maturity stages. GSI values and historical events. The GSI values increases gradually and marked enhancement of index occurred from idly. The increases was almost linear during September there was marked fall in GSI value and the index continued to be low during remain period. The GSI value is large in August and September indicates that for is engaged in spawning activity from August to September.

The breeding season of the animals can be determined by several methods such as by GSI measuring gonadal weight, Ganado somatic index is a function of the breeding cycles of fishes. The gonadosomatic index involves determination of the ratio of gonadal weight to the body weight. Compare to male and female the female as high value of GSI than male.

Because the female have high value of gonad and weight compared to male. The HSI also known as the hepatosomatic index. Like GSI, HSI also varies during the reproductive cycle in fishes. Because of involvement of liver is strongly correlated to vitellogenic activity. Seasonal changes in the HSI indicates that liver undergo went more or less parallel changes in weight in 4 months. HSI and GSI also exhibit inverse relationship suggesting that the liver supports to spermatogenesis and organic activity. Higher values of HSI was found during the resting and preparatory month of October. The minimum HSI was found during in July month. The HSI value is more in male than find then also observed his was high at beginning of the gonadal development their after the value decreased to low level in mature stage.

Protein is necessary for the physiology of the cell. In the present study, the monthly variation in protein content of the testies, ovary over to increase shows the inverse relationship i.e. increases the protein content in testes and over as during in July on the contain the liver and muscle protein decreases during July indicates their inverse relationship. The protein content in ovary, muscle and liver in more in female compared to male teties, muscle and liver.

The protein content in ovary is more in October in August and in tests also protein content more in October and less in August, month. And the protein content in muscle more in September and less in July compare t o male and female the protein content in more in female. The protein content in liver is more in October and less in July both in male and female and the protein content more in female to male.

Norman has reported that the stage of gonads may play a great role in the biochemical composition of a fish. Hence, the observation made here is in agreement with Norman (1962); Singh *et al*., 1993 [27]; Dhawan and Sexena (1998) [4]; Kiran & Puttaiah (2005) [16]; Kour and Kour (2006), Joseph Marykuttu *et al*., (2011), Shendge *et al*., (2012) [26]; Ashashree *et al* (2013) [2]. The proteins in the flesh of fish are important for the tissue building activity of those who consume them. Protein cycle does not show any relationship with intensity of feeding. Low value of protein content in winter or post-monsoon season may be a consequence of greater utilization of protein for energy requirements in the season.

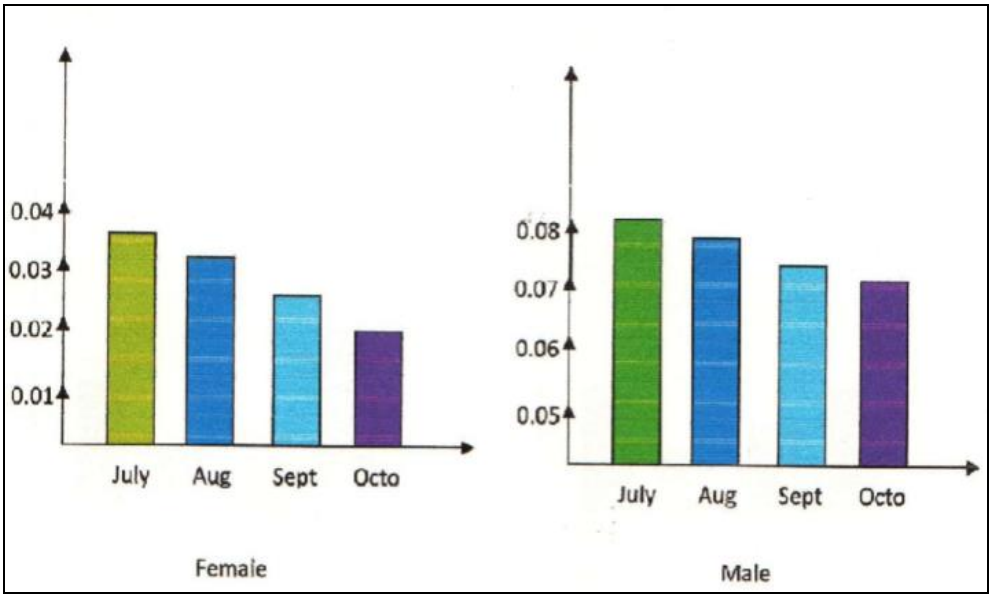

Fig 3: Monthly GSI of *Mystus cavasius* in Tunga river

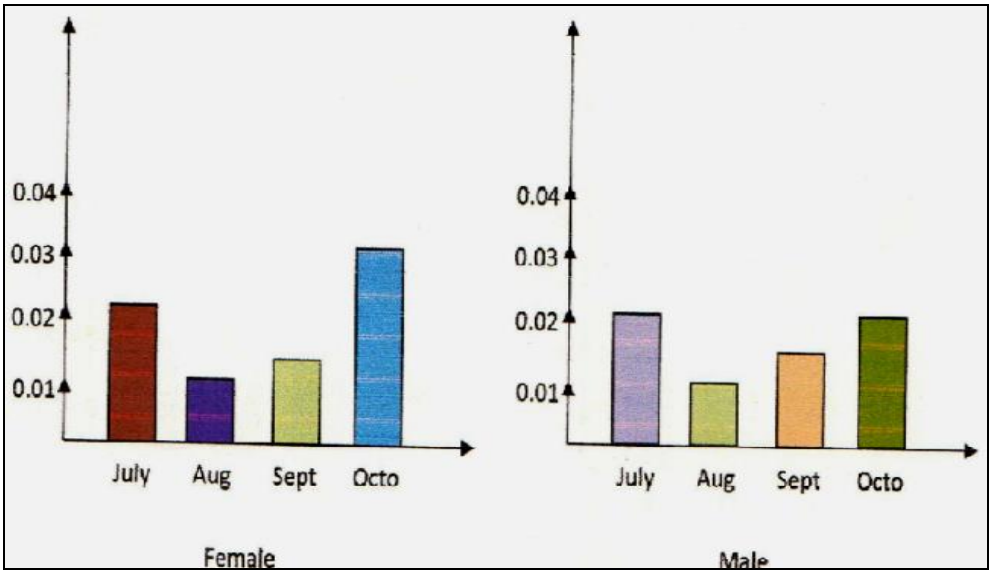

Fig 4: Monthly protein in the Ovaries and testis of *Mystus cavasius* in Tunga river

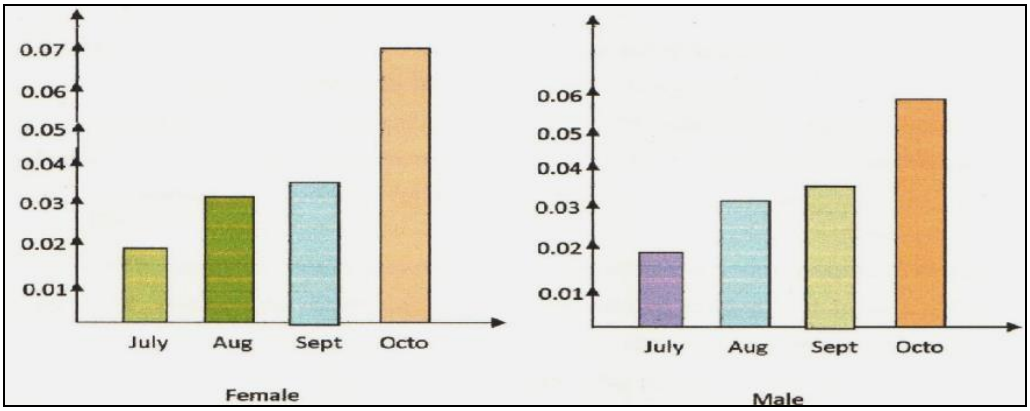

Fig 5: Monthly protein content of liver of *Mystus cavasius* in Tunga river

Water quality in Tunga river

Mystus cavasius requires pH around 7-8. That mean, it requires the pH which is slightly basic or neutral. As in this study Tunga river show the pH values of 7.2 to 7.8. *Mystus cavasius* required temperature 16°-25° in the present study the observed the water temperature is around 16.4 to 17.2.The present investigation reveals the dissolved oxygen content was range from 6.8 to 8.8mg/l. The total hardness in the Tunga river was 124.2 to 132.6mg/l. Fishes are the Valuable source of the high grade protein and other organic products.

of countries located in tropical region. Flesh of fish is highly nutritive with 60-80% water 13-20% protein and greater or less amount of fat. It also contain phosphorous and vitamins.

Physiology of *Mystus cavasius*-Bhadra river

The results are depicted in Tables 5-6 and Fig 6 to 9. Length of male fishes varied from 14.5 cm to 20.0 cm and females with 19.5cm to 26 cm respectively. However, weight of male fishes fluctuated from 29.6 gm to 40.20 gm and that of female fishes varied 39.60 gm to 54.80 gm respectively. Female fishes have more weight and length than males.

The GSI values increases gradually and marked enhancement of index occurred from idly. The GSI values were maximum in July for female and October for males indicate that it is engaged in spawing activity. GSI of males fluctuated between 2.82 and 6.35 and in females GSI values varied from 4.27 to 11.59. Female fishes have higher GSI than males. Because the female has high value of gonad weight compared to male.

The HSI is also known as the hepato-somatic index. Like GSI, HSI also varies during the reproductive cycle in fishes. Because of involvement of liver is strongly correlated with vitellogenic activity. Seasonal changes in the HSI indicates that liver undergo more or less parallel changes in weight. HSI and GSI also exhibit inverse relationship suggesting that the liver supports to spermatogenic and organic activity. Higher values of HSI was found during the resting and preparatory month of July in both the sexes. The minimum HSI was found during September (female) and October (male) months (Table 3).The HSI value is more in male than female due to beginning of gonadal development. Their after the value decreased to low level in mature stage.

Proteins are concerned with the physiology of the cell. Total protein of the muscle, liver, ovary and testes showed fluctuations during the reproductive cycle. They exhibit well marked trend of build up and utilization in order to meet the needs of reproductive metabolism.

In males, protein content in liver, testes and muscles ranged from 1.10-1.41, 1.03-1.99 and 2.20-4.14 respectively. However, in females protein content in liver, testes and muscles ranged from 1.21-1.31, 1.07-1.93 and 3.45-5.53 correspondingly (Table 6). The protein content in liver, ovary and testes were maximum in July for both the sexes and less in August (males) and October (females) months for the gonads. The protein content in muscle was maximum in October for both male and females (Table 6).

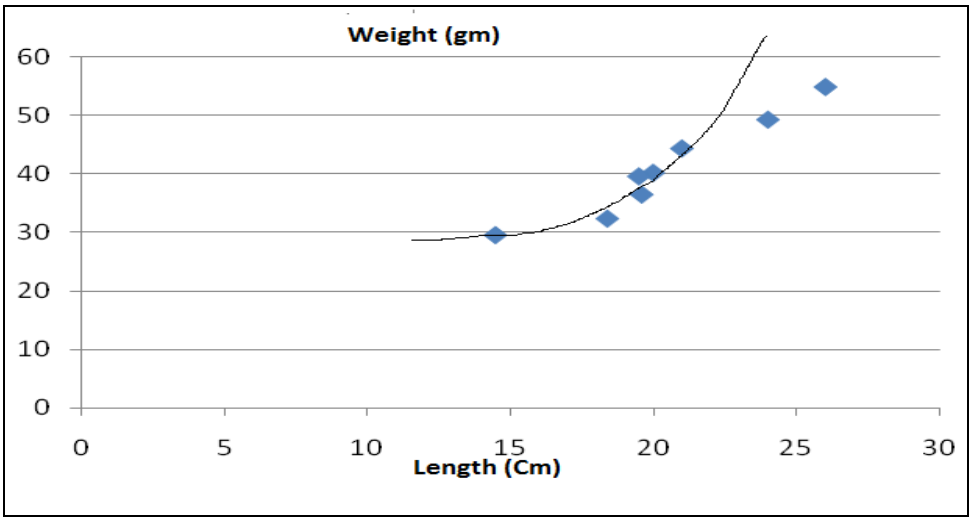

Fig 6: Parabolic relation between length and weight (Both the sexes combined) of *Mystus cavasius* in Bhadra river

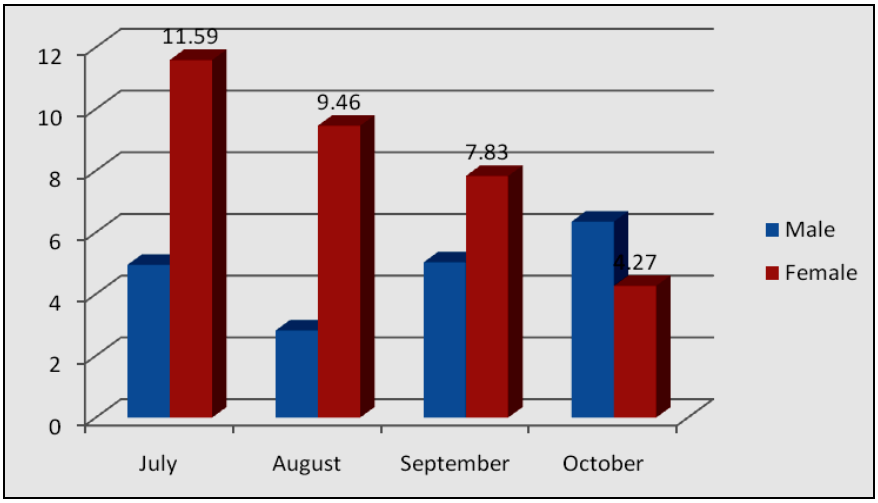

Fig 7: Monthly GSI of *Mystus cavasius* in Bhadra river

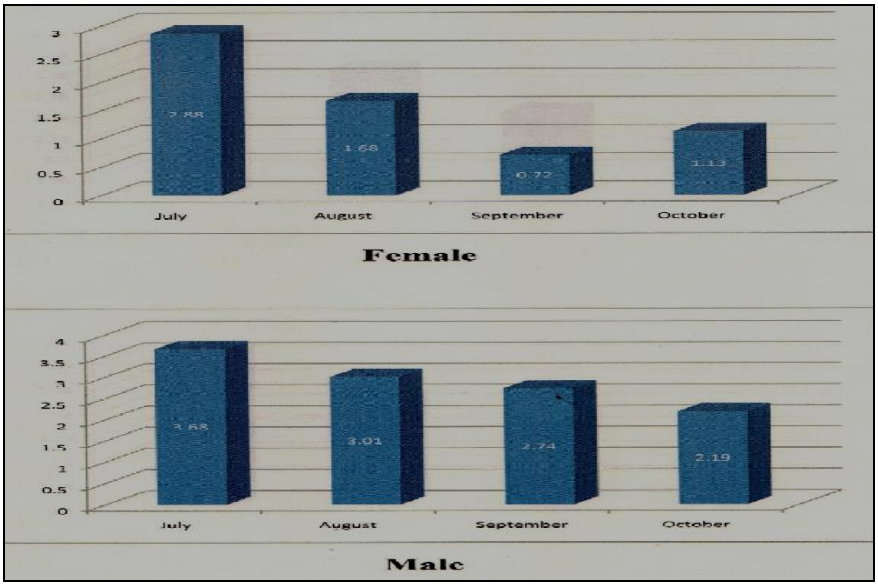

Fig 8: Monthly HSI of *Mystus cavasius* in Bhadra river

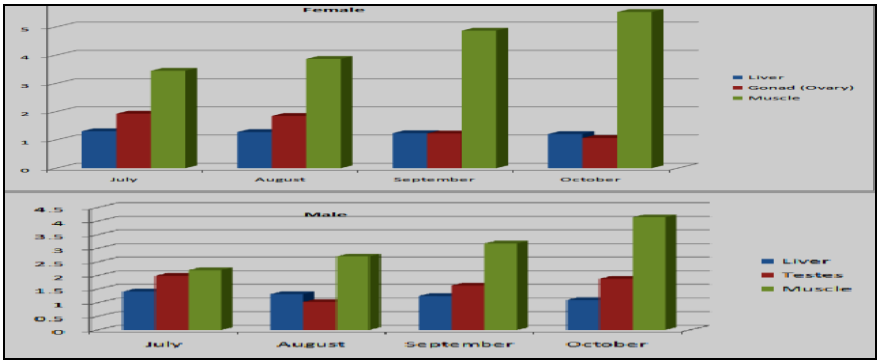

Fig 9: Monthly proteins in the organs of *Mystus cavaius* (mg/gm) in Bhadra river

Table 1: Length and weight of the fishes in Tunga river

Sex	July	August	September	October	Sex	July	August	September	October
Female (L)	21.3 cm	20 cm	19 cm	16.2 cm	Male (Wt.)	75g	68g	52g	35g
Male(L)	20 cm	19.6 cm	18.4 cm	14.5 cm	Female (Wt)	232.1g	228.1g	206g	114.3g

Table 2: Hepato Somatic Index of *Mystus cavasius* in Tunga river

Sex	July	August	September	October
Female	0.0019	0.0029	0.0032	0.0033
Male	0.0069	0.0066	0.0073	0.0077

Table 3: Weight of the organs of the fish (grams) in Tunga river

Description	July	August	September	October
Liver	1.86	3.13	3.45	6.83
Ovary	2.13	1.27	1.84	1.97
Muscle	0.12	0.23	0.69	0.19

Table 4: Monthly variations of protein in different organs for females in Tunga river

Description	July	August	September	October
Liver	1.75	2.94	3.25	6.47
Ovary	1.99	1.03	1.63	1.88
Muscle	0.14	0.18	0.22	0.20

Table 5: Length -Weight of both sexes of *Mystus cavasius* in Bhadra river

Male	July	August	September	October	Female	July	August	September	October
Length	20 cm	19.6cm	18.4cm	14.5cm	Length	26 cm	24cm	21cm	19.5cm
Weight	40.20g	36.50g	32.40g	29.60g	Weight	54.80g	49.24g	44.34g	39.60g

Table 6: Monthly proteins in the organs of *Mystus cavasius* (mg/gm) in Bhadra river

Female	July	August	September	October	Male	July	August	September	October
Liver	1.31	1.28	1.24	1.21	Liver	1.41	1.32	1.25	1.10
Ovary	1.93	1.85	1.23	1.07	Testes	1.99	1.03	1.63	1.88
Muscle	3.45	3.87	4.87	5.53	Muscle	2.20	2.70	3.18	4.14

Water quality in Bhadra river

If the turbidity of water is high the fishes cannot survive in that region. This is because the mud particles present in the water results in clotting of bladder or gills. The water with low turbidity is suitable for the existence of *Mystus cavasius*. *Mystus cavasius* requires pH around 7 to 8. This mean, it requires the pH which is slightly basic or neutral. The river water has pH of 7.2 that means it is slightly basic. *Mystus cavasius* require a temperature of 16°-25°C. In the present study, the observed water temperature is around 16.5 to 18.5^{O}C.

All the living organisms are dependent on dissolved oxygen to maintain metabolic process to produce energy, for growth and reproduction. In the present investigation, average dissolved oxygen content in the Bhadra river was 8.8mg/1. The carbon dioxide content in river was 24 mg/l and total hardness was 132.6mg/l.

Discussion

Jothi Srigowri (2007) [12] investigated on length weight relationship, seasonal changes in the GSI, HSI, gonadal morphology, spawning, minimum size at spawning, seasonal histological changes and biochemical changes during the annual reproductive cycle of female fish *Mystus cavasius*. Monthly variation of protein contents of liver with testes shows an inverse relationship suggests the involvement of hepatic protein for testicular growth and spermatogenesis. Such observations have been made in *Channa punctatus* and *Heteropneustes fossilis* (Verma *et al*., 1985) [30] and *Labeo rohita* (Manohar Patil & Kulkarni, 1994) [18]. Norman has reported that the gonad stage may play a major role in the biochemical composition of fish.. Hence, the observation made here is in agreement with Singh *et al* (1993) [27]; Dhawan and Sexena (1998) [4]; Kiran & Puttaiah (2005) [16]; Kour and Kour (2006), Joseph Marykuttu *et al*., (2011), Shendge *et al*., (2012) [26] and Ashashree *et al*. (2013) [2].

Sadguru Prakash (2022) [23] in his study reported that industrial wastewater may have toxic effects on gonads, leading to a decrease in GSI of *Channa punctatus* collected from contaminated Sawan Nallaha site. Changes in HSI showed higher HIS values during resting periods and during the adult phase, and lower HSI values were observed when the gonads were in the adult phase, suggesting liver supports vitellogenic activity (Thirumala and Kiran, 2020 [28]; Sadguru Prakash, 2022) [23]. The results are consistent with these findings Dewi and Probowo (2017) [3].

Conclusion

The length and weight gives the relationship of length and weight. If the fishes length increases the weight also increases. The weight is depends on length of fish and the females *Mystus cavasius* is largest than male. It indicates that the female is target than male. The GSI value in female fish is larger than male. The protein content in the testes, ovary, liver, muscles are larger in female than male. The biochemical contents are higher in females because they contain large weight and length than male.The present investigation gives information about the GSI, HSI, protein content in the gonads, muscles, and liver of *Mystus cavasius*. If the fish's length increases the weight also increases. The weight is depends on length of fish and the female *Mystus cavasius* is larger than male. The GSI (Gonado-somatic index) gives a relationship between weights of fish. The GSI value in female fish is higher than male. The protein content in the testes, ovary, liver, muscles are higher in female than male fishes. The biochemical contents are higher in females because they contain higher weight and length than males.

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