Chapter 06: Anatomical

Chapter – 06

Anatomical

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6.1 INTRODUCTION

Air-breathing fishes live in diversified environmental conditions. There is a need of systematic study of anatomical as well as index values to know the food values and other physiological aspect of different life stages in different season. Indigenous air-breathing fishes like *Heteropneustes fossilis, Clarias batrachus* and *Anabas testudineus* have a greater potentiality in utilizing shallow, swampy, marshy and derelict water bodies for aquaculture. There are enormous numbers of derelict water bodies lying unattended and involve massive cost for reclamation for traditional carp culture practices. These fishes have long been regarded as valuable food fish in terms of consumer preference with high market demands and have report of medicinal values. Population of these species in the wild has been declining for various reason and cultivation of these fish species has not been achieved perhaps due to the lack of complete knowledge about different life stages. So, there is a need to explore every means of increasing fish production to meet the gap of demand and supply of fish by diversifying the spectrum of cultivable species and attempts at optimal utilization of aquatic resources with efficiency. Different aspects of air-breathing fishes are very scanty and considering its importance and attempt is made to study the different aspects of gastrosomatic index (GaSI),

gonadosomatic index (GSI) (ovary and testis) and hepatosomatic index (HSI) of this species. Weight of fish body and weight of stomach give the gastrosomatic index (GaSI), weight of fish body and weight of gonad give the gonadosomatic index (GSI). It is the ratio of fish gonad weight and body weight. It is particularly helpful in identifying seasons of spawning as the ovaries of gravid females swiftly increase in size just prior to spawning. Gonadosomatic index is related to spawning and reproduction of fish. Air-breathing fishes are a good source of food for poor people and hence they must be reproduced in large number. So they are easily available to poor people and hence the study of GSI is important and essential. So generally during the breeding season of air-breathing fishes show maximum GSI value and after spawning it is reduced. When GSI of both sexes are compared, we came to know that maximum values of GSI occurred almost at the same time in both sexes and after spawning it is recorded that there is a great decrease in GSI values. On the other hand, study of hepatosomatic index of air-breathing fishes is also carried out simultaneously. Increase in the weight of the body is related to the increase in the HSI value and it is observed that HSI depends upon seasonal cycle. HSI value reaches its peak value in spawning season and then starts to decrease after spawning (Schreck, 1981). In poor environment, fishes usually have a smaller liver with less energy reserved in the liver. HSI values are indirect indices of energy status on a seasonal basis of the HSI values and are variable. Condition factor basically represents the quality of fish and their effect on the physiological condition and sexual maturity, (Sharma et al., 2011).

6.2 MATERIALS AND METHODS

The present study was carried out to determine the morphological and anatomical character of three freshwater air-breathing fishes of *Heteropneustes fossilis*, *Clarias batrachus* and *Anabas testudineus.* In this study 960 (nine hundred sixty) fish samples are collected from a cultural ponds located at Hotar, Magrahat, South 24-Parganas, West Bengal, India during November,

2014 to October, 2016 for the determination of gastrosomatic index, gonadosomatic index, hepatosomatic index and condition factor. Fishes were caught by traditional fishing gears Jhaki Jal (Cast net), Tar Jal (square lift net) and dug hair (Conical trap) (Kibria and Ahmed, 2005).The ponds ware chosen considering tropical climate and the physico-chemical features of ponds water were analysed as per APHA (2005). They were classified as suggested by Bhattacharya et al., (2005) into two stages young and adult. Morphometric measurement is the measurement of different external body parts of an organism, total length**,** standard length, body weight and sex were recorded Talwar and Jhingran, 1991. Morphometric measurement of nine hundred sixty fishes of young and adult that the total length is the maximum elongation of the body from end to end**.** Thus from the most anterior projection part of the head to the posterior most tip of caudal fin is included in total length (Biswas, 1985). Standard length is the distance from the anterior most part of the head (snout) to the end of the vertebral column (caudal fin). The weight of body increases as the weight of liver also increases condition factor is used for obtaining information on seasonal variation of the condition of fish in relation to its environment. The morphometric features like total length (TL) and standard length (SL). Total body weight, gut, liver and gonads (ovary/testis) weight are measured by Aafcoset Electronic Balance, Koli et al., (2012).

After pressing the anal zone of a fish, if it oozes out a brownish milt, it is sure to be a mature male fish. But, in case of a young but premature male fish, the milt looks whitish. On the other hand, when the anal zone of an adult and mature female fish is pressed, a good number of brownish eggs come out. In case of young but immature female fish, the eggs should be greenish in colour (Jhingran, 1975).

Anatomical

Culture pond

1. *Heteropneustes fossilis*

2. *Heteropneustes fossilis* (Male)

3. Ovary, *Heteropneustes fossilis* (Female)

4. Testis, *Heteropneustes fossilis* (Male)

5. Liver *Heteropneustes fossilis*

6. Stomach, *Heteropneustes fossilis*

7. Liver, *Heteropneustes fossilis*

Photo plate no. VI

Anatomical

1. *Clarias batrachus*

2. *Clarias batrachus* (Male)

3. Ovary, *Clarias batrachus* (Female)

4. Testis, *Clarias batrachus* (Male)

5. Liver, *Clarias batrachus*

6. Stomach, *Clarias batrachus*

Photo plate no. VII

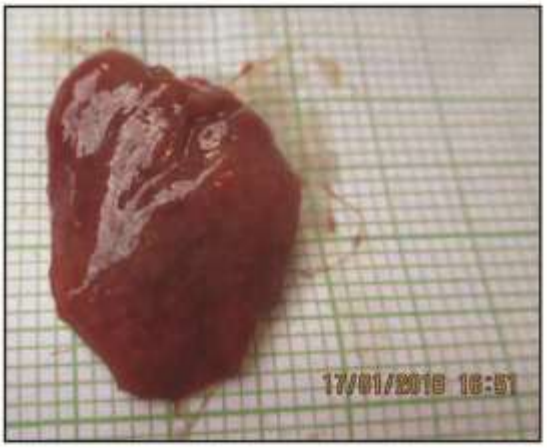
Anatomical

1. Anabas testudineus

2. *Anabas testudineus* (Male)

3. *Anabas testudineus* (Female)

4. Teatis, *Anabas testudineus* (Male)



5. Liver, *Anabas testudineus*

6. Ovary, *Anabas testudineus* (Female)

7. Stomach, *Anabas testudineus*

Photo plate no. VIII

Procurement of fish dissection and analysis, (Talwar and Jhingran, 1991)

Fish samples were brought to the laboratory and they were blotted by blotting papers and their body weights were recorded to the nearest value of milligram. The fishes are being brought to Laboratory and identification keys described by Talwar and Jhingran, (1991), Ghosh (2006). Before dissection, the total length, standard length and total weight of all the sampling fishes were recorded using one foot long scale, divider and thread. Thus total length from the anterior protecting part of the head to the poster most tip of the caudal fin was included in total length. Standard length was the distance from the anterior most part of the head to the end of the vertebral column (caudal peduncle).

Sterile biological stainless steel equipment's like bone cutter, scissors, forceps were used for dissection. The internal organs like stomach, intestine, liver; ovary and testis were exposed carefully and detached from main body. Moisture of the gut, gonads and liver were removed with the help of blotting paper. The weight of gut, gonads and liver recorded in grams in laboratory electronic balance.

The gastrosomatic index, gonadosomatic index and hepatosomatic index value were calculated from the ratio of total body weight and gut weight, gonadal weight, liver weight for the determination of gastrosomatic, gonadosomatic and hepatosomatic index whereas condition factor (K) was determined to make the relationship between standard length and its weight of the fish.

The gastrosomatic index of the fish was determined by the use of equation cited by Parameswaran (1975). It revealed that the weight of gut divided by total body weight of fish as percentage, (Desai, 1970). It is calculated using the following formula:

$$\text{GaSI} = \frac{\text{Weight of the gut (gm)}}{\text{Total weight of the fish (gm)}} \times 100$$

The gonadosomatic index of the weight of testis of male fish and the weight of ovary of female fish were determined by equation cited by Parameswaran (1975). The development of gonad is estimated by determining its weight related to the body weight of the fish (Hopkins, 1979). The body mass (gm.) and gonad mass (gm.) were recorded and the data were used to calculate the gonadosomatic index according to the formula of Roff (1983). This is calculated using the following formula:

$$GSI = \frac{\text{Weight of the gonad (Testis / ovary) (gm)}}{\text{weight of the fish body (gm)}} \times 100$$

Similarly, the hepatosomatic index of the fish was determined by the use of equation cited by Parameswaran (1975) and Htun – Han (1978). Thus index is determined by the ratio of liver weight and body weight of fish as percentage.

$$HSI = \frac{\text{weight of the liver (gm)}}{\text{weight of the fish body (gm)}} \times 100$$

Condition factor (K) was calculated by using on the cube law in order to compare the condition of fishes under various cultural regions in numeral terms by using the following formulaic of (Beckman, 1948) and Bagenal et al., (1987).

$$\text{Where, Condition factor (K)} = \frac{\text{weight of the fish body (gm)}}{\text{Standard length of the fish (cm) } L^3} \times 100$$

$$= \frac{W}{L^3} \times 100$$

Whereas, 'K' is the coefficient of condition

'W' is the weight of fish (in gm.)

'L^3' is the standard length of the fish (in cm) to the cube

In such a way, weight of gut, gonads male / female, liver and condition factor (K) of every fish per season was recorded and the value of the gut, gonads, testis /ovaries, liver and condition factor (K) of 120 (one hundred twenty) fishes per season was given in 1st annual cycle and 2nd annual cycle was given also in the table (18 to 23). The mean values of the gut, gonads, liver and condition factor (K) of every season of the year 2014 to 2015 and 2015 to 2016 give an

idea about the condition of the gut and liver of the fish and maturity of the fish. So the good condition of the liver is the indication of good health of the fish. Similarly the good and healthy condition of the gonad is the indication of maturity of fish for the breeding season.

Statistical Analysis

The significant correlation (r) between physico-chemical parameters and biological parameters has been done using with the help of stat plus 2009 software and Microsoft Excel Data Analysis (2007).

The Statistical analysis of the data set under study, consists of 12 sections where each section provides the analysis of observation on each of four categories of fishes (Adult male, Adult female, Young male and Young female) falling under the three species (*Heteropneustes fossilis*, *Clarias batrachus* and *Anabas testudineus*)**.**

Each section has three parts – Part A, Part B and Part C.

In Part A, study has been made in pair-wise correlations between physico-chemical parameters of the cultural ponds, index values (GaSI, GSI and HSI) condition factor (K) and physiological measurements of them. The significant correlation coefficients along with p-values are furnished through tables for each category.

In Part B, it is presented the time series plots of eight seasons over 2 years for each category of fish data set, for 10 variables [1. Body weight (gm.), 2.Total Length (cm), 3.Standard Length (cm), 4. Weight of stomach (gm.), 5. Weight of liver (gm.). 6. Weight of testis (gm.), weight of ovary (gm.), 7 Condition factor (K), 8. GaSI, 9. GSI and 10. HSI]. It is also performed statistical tests to check for the significant effect of seasons on the index value, condition factors (K) and different physiological measurements of fishes of each category. Part C contains the results and findings of the tests.

6.3 RESULT

Three air-breathing fishes are studied. It had been observed that there exist some variations in the structure of stomach, total body weight, total length, standard length and other internal organs of liver, ovary and testis in the value of biological parameters, gastrosomatic index (GaSI), gonadosomatic index (GSI), hepatosomatic index (HSI) and condition factor (K).

All the specimens of *Heteropneustes fossilis* (Bloch) collected during the study period were classified into four seasons based on young male and female and adult male and female. The proportion of individuals belonging to different weight and size present in the samples collected from the study ponds. Different morphometric characters (body weight, total and standard length, weight of stomach, liver, ovary / testis) were measured separately for each species of *Heteropneustes fossilis* in (Table-18 & 19, Pl. VI).

The features of each of the fishes have been discussed individually for each season and total four seasons like winter, summer, monsoon and post-monsoon seasons. Three hundred twenty specimens of *Heteropneustes fossilis*, the total body weights of young male (30.77 to 50.79 gm), young female (34.64 to 58.6 gm.) and adult male (38.68 to 119.8 gm.) and adult female (42.95 to 98.7 gm.) respectively. (Table-18 &19) shows the data of *Heteropneustes fossilis* collected for the study and represent the value of biological parameters of gastrosomatic index, gonadosomatic index, hepatosomatic index and condition factor (K) of the fish. Liver (Pl. IV) of this fish is brownish, well-built and triangular shaped. The ovary (Pl. IV) of specimen was red in colour, cylindrical, covering more than half of the length of abdominal cavity and ovary is clearly visible. Pyloric stomach is with a thick muscular and a masticatory gizzard.

Heteropneustes fossilis (Bloch)

1st year – November, 2014 to October, 2015

Table No- 18 Index Values and condition factor of *Heteropneustes fossilis* of four Season – Winter, Summer, Monsoon and Post Monsoon

Sl. No.	Descriptive	Winter				Summer				Monsoon				Post Monsoon			
		Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female
1	Body weight (gm)	30.77 ±0.02	34.64 ±0.02	119.8 ±0.01	96.54 ±0.01	38.82 ±0.02	50.07 ±0.02	44.23 ±0.01	70.47 ±0.01	40.41 ±0.02	48.15 ±0.01	49.48 ±0.02	57.28 ±0.02	38.94 ±0.02	35.79 ±0.02	38.68 ±0.02	46.97 ±0.01
2	Total length (cm)	19 ±1.09	19.5 ±0.17	29.1 ±0.1	26.8 ±0.27	20 ±1.09	22 ±1.09	21 ±2.93	23.9 ±0.17	21.03 ±0.01	21.07 ±0.02	23 ±1.73	24 ±0.77	19.07 ±0.02	19 ±1.09	20.04 ±0.03	23.4 ±0.13
3	Standard length (cm)	13.8 ±0.21	15.4 ±0.15	23.3 ±0.23	21 ±1.09	19.1 ±0.26	21.1 ±0.26	19.5 ±0.18	22 ±1.09	19.5 ±0.19	20 ±1.09	20.5 ±0.19	22.1 ±0.26	18.03 ±0.02	17.01 ±0.01	18.06 ±0.02	21.2 ±0.17
4	Weight of stomach (gm)	0.33 ±0.02	0.05 ±0.02	0.41 ±0.03	0.41 ±0.03	0.52 ±0.02	0.56 ±0.01	0.43 ±0.02	0.79 ±0.02	1.02 ±0.02	0.77 ±0.02	0.6 ±0.13	1.23 ±0.01	0.42 ±0.02	0.85 ±0.01	0.97 ±0.01	0.92 ±0.02
5	Weight of liver (gm)	0.15 ±0.01	0.21 ±0.01	3.41 ±0.02	1.2 ±0.15	0.25 ±0.02	0.4 ±0.08	0.32 ±0.01	0.44 ±0.02	0.48 ±0.03	0.37 ±0.03	0.35 ±0.02	0.69 ±0.02	0.16 ±0.02	0.37 ±0.03	0.28 ±0.02	0.46 ±0.01
6	Weight of ovary (gm)	X	0.25 ±0.02	X	0.42 ±0.01	X	5.31 ±0.02	X	5.62 ±0.01	X	4.21 ±0.02	X	3.29 ±0.02	X	0.12 ±0.02	X	0.42 ±0.02
7	Weight of testis (gm)	0.16 ±0.01	X	0.8 ±0.17	X	0.17 ±0.02	X	0.33 ±0.02	X	0.86 ±0.03	X	1.39 ±0.02	X	0.05 ±0.02	X	0.18 ±0.02	X
8	Gastrosomatic index (GaSI) (%)	1.08 ±0.01	1.46 ±0.01	0.34 ±0.02	0.43 ±0.01	1.36 ±0.02	1.13 ±0.05	0.98 ±0.02	1.13 ±0.02	2.59 ±0.06	1.63 ±0.02	1.23 ±0.01	2.19 ±0.03	1.09 ±0.02	2.43 ±0.02	2.57 ±0.01	2 ±0.03
9	Gonadosomatic index (GSI) (%)	0.52 ±0.01	0.73 ±0.01	0.67 ±0.03	0.44 ±0.02	0.44 ±0.02	11.86 ±0.01	0.75 ±0.02	8.67 ±0.01	2.17 ±0.02	9.58 ±0.09	2.89 ±0.02	6.09 ±0.01	1.3 ±0.15	0.34 ±0.02	0.47 ±0.01	0.9 ±0.21
10	Hepatosomatic index (HSI) (%)	0.49 ±0.03	0.61 ±0.02	2.93 ±0.02	1.26 ±0.01	0.65 ±0.02	0.81 ±0.01	0.73 ±0.01	0.62 ±0.02	1.2 ±0.14	0.77 ±0.01	0.71 ±0.01	1.22 ±0.02	0.41 ±0.01	1.04 ±0.01	0.73 ±0.01	0.99 ±0.04
11	Condition factor (K)	1.17 ±0.01	0.95 ±0.02	0.95 ±0.02	1.04 ±0.01	0.56 ±0.01	0.27 ±0.01	0.6 ±0.19	0.66 ±0.02	0.58 ±0.01	0.6 ±0.14	0.57 ±0.01	0.53 ±0.02	0.64 ±0.01	0.72 ±0.01	0.6 ±0.14	0.49 ±0.02

2nd year – November, 2015 to October, 2016

Table No- 19 Index Values and condition factor of *Heteropneustes fossilis* of four Season – Winter, Summer, Monsoon and Post Monsoon

Sl. No.	Descriptive	Winter				Summer				Monsoon				Post Monsoon			
		Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female
1	Body weight (gm)	36.7 ±0.14	40.63 ±0.02	110.4 ±0.26	98.7 ±0.14	50.7 ±0.14	58.6 ±0.13	49.2 ±0.3	73.6 ±0.1	47.73 ±0.02	53.18 ±0.02	58.3 ±0.02	42.95 ±0.02	43.65 ±0.02	40.81 ±0.03	48.13 ±0.02	52.38 ±0.02
2	Total length (cm)	21.2 ±0.17	22.1 ±0.26	28.2 ±0.27	27.7 ±0.14	22 ±1.41	23.3 ±0.16	22.1 ±0.28	24 ±0.77	22.2 ±0.17	23.1 ±0.24	24.5 ±0.2	22.6 ±0.13	22.5 ±0.13	21.8 ±0.17	22 ±1.41	22.2 ±0.17
3	Standard length (cm)	15.7 ±0.11	17.5 ±0.11	22.4 ±0.17	21.8 ±0.22	19.7 ±0.12	20.9 ±0.33	19.4 ±0.15	22.6 ±0.15	20.7 ±0.14	20.8 ±0.22	21.6 ±0.17	20.7 ±0.25	20.6 ±0.18	19.9 ±0.3	19.3 ±0.30	18.7 ±0.26
4	Weight of stomach (gm)	0.34 ±0.01	0.7 ±0.13	0.37 ±0.03	0.35 ±0.02	0.54 ±0.02	0.61 ±0.02	0.44 ±0.02	0.79 ±0.02	1.33 ±0.02	0.78 ±0.02	0.62 ±0.02	1.19 ±0.02	0.17 ±0.02	0.86 ±0.03	0.32 ±0.01	0.51 ±0.02
5	Weight of liver (gm)	0.17 ±0.02	0.23 ±0.02	2.52 ±0.02	1.19 ±0.03	0.26 ±0.03	0.48 ±0.03	0.33 ±0.02	0.45 ±0.02	0.49 ±0.04	0.38 ±0.02	0.37 ±0.02	0.6 ±0.09	0.18 ±0.02	0.38 ±0.02	0.31 ±0.01	0.53 ±0.01
6	Weight of ovary (gm)	X	0.26 ±0.03	X	0.43 ±0.02	X	0.61 ±0.02	X	5.63 ±0.02	X	1.38 ±0.01	X	2.38 ±0.02	X	0.15 ±0.01	X	0.45 ±0.02
7	Weight of testis (gm)	0.18 ±0.02	X	0.7 ±0.03	X	0.19 ±0.02	X	0.36 ±0.02	X	0.88 ±0.02	X	1.42 ±0.01	X	0.6 ±0.09	X	0.2 ±0.08	X
8	Gastrosomatic index (GaSI) (%)	0.94 ±0.02	1.75 ±0.02	0.34 ±0.02	0.36 ±0.01	1.08 ±0.02	1.05 ±0.02	0.9 ±0.22	1.09 ±0.03	2.86 ±0.02	1.49 ±0.03	1.07 ±0.02	2.85 ±0.03	0.39 ±0.02	2.15 ±0.02	0.67 ±0.02	0.98 ±0.03
9	Gonadosomatic index (GSI) (%)	0.47 ±0.01	0.64 ±0.02	0.71 ±0.01	0.44 ±0.01	0.38 ±0.03	1.05 ±0.04	0.74 ±0.02	8.28 ±0.03	1.88 ±0.02	2.66 ±0.02	2.5 ±0.24	5.87 ±0.01	1.39 ±0.02	0.37 ±0.02	0.42 ±0.01	0.87 ±0.01
10	Hepatosomatic index (HSI) (%)	0.49 ±0.02	0.57 ±0.03	2.34 ±0.03	1.22 ±0.02	0.52 ±0.01	0.83 ±0.02	0.68 ±0.03	0.62 ±0.02	1.04 ±0.02	0.72 ±0.02	0.64 ±0.02	1.42 ±0.02	0.41 ±0.01	0.94 ±0.02	0.65 ±0.02	1.02 ±0.01
11	Condition factor (K)	0.95 ±0.02	0.76 ±0.01	0.98 ±0.01	0.95 ±0.02	0.66 ±0.02	0.64 ±0.02	0.67 ±0.01	0.64 ±0.02	0.53 ±0.03	0.59 ±0.04	0.58 ±0.02	0.48 ±0.02	0.5 ±0.23	0.52 ±0.02	0.67 ±0.01	0.8 ±0.21

Study of gastrosomatic index (GaSI)

Gastrosomatic index of male and female, young and adult of *Heteropneustes fossilis* were determined separately in (Table-18 & 19). The mean GaSI values of young and adult male observed to be highest value (15.22±0.14, 1.62±0.09) in monsoon and post-monsoon and lowest value (0.74±0.04, 0.34±0.02) in the season of post-monsoon and winter. Similarly, adult and young female observed to be highest value (2.52±0.03, 2.29±0.14) in the season of monsoon and post-monsoon seasons and lowest value (0.40±0.04, 1.09±0.05) in the season of winter and summer.

The GaSI value gradually increased from monsoon to post-monsoon respectively whereas gradually decreased in winter and summer in (Table-20 and Fig. 30). In present study, the higher GaSI value in female than the male indicates that the female growth is faster than male during breeding period. Generally GaSI is low during the spawning season of fish species Rahman et al., (2002).

Mean seasonal variation of gastrosomatic index (GaSI) of *Heteropneustes fossilis* during the study period

Table- 20

	Adult male	Young male	Adult female	Young female
Winter	0.34±0.02	1.01±0.07	0.40±0.04	1.61±0.14
Summer	0.94±0.04	1.22±0.14	1.11±0.03	1.09±0.05
Monsoon	1.15±0.08	15.22±0.14	2.52±0.03	1.56±0.07
Post-monsoon	1.62±0.09	0.74±0.04	1.49±0.05	2.29±0.14

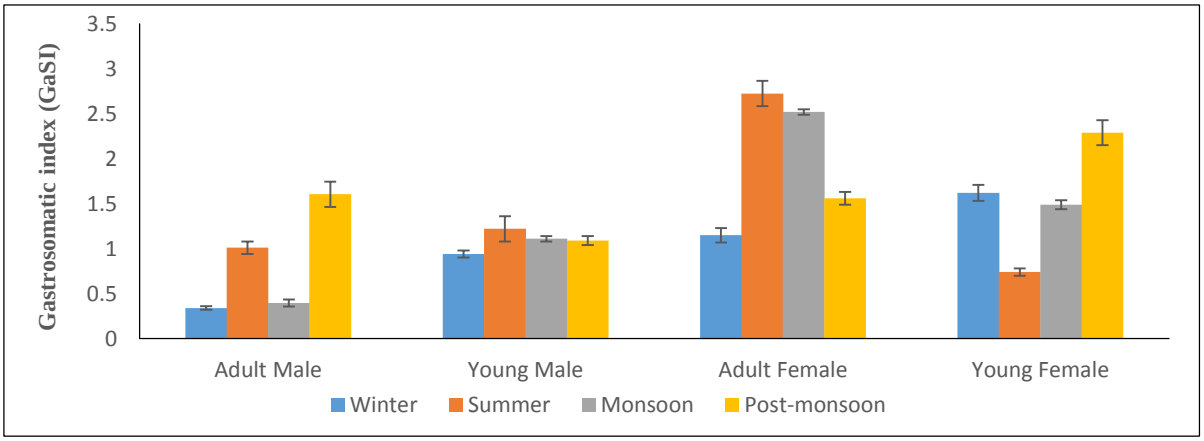


Fig. 30 Comparison of graphical representation showing gastrosomatic index (GaSI) of *Heteropneustes fossilis*, (two annual cycles)

Study of gonadosomatic index (GSI)

Mean gonadosomatic index values attained its peak value (2.70±0.03, 2.03±0.02) of adult and young male observed in monsoon and lowest value (0.45±0.03, 0.41±0.04) in the season of post-monsoon and summer. Similarly, adult and young female observed highest value (8.48±0.02, 6.12±0.05) in the season of summer and lowest value (0.44±0.02, 0.36±0.02) in the winter and post-monsoon. The GSI value of adult and young male was observed to be highest value in the season of summer to monsoon and lowest values in the season of post-monsoon to winter of both male and female in (Table- 21 and Fig. 31).

Mean seasonal variation of gonadosomatic index (GSI) of *Heteropneustes fossilis* during the study period

Table- 21

	Adult male	Young male	Adult female	Young female
Winter	0.69±0.03	0.50±0.03	0.44±0.02	0.69±0.05
Summer	0.75±0.02	0.41±0.04	8.48±0.02	6.12±0.05
Monsoon	2.70±0.03	2.03±0.02	5.98±0.11	9.12±0.04
Post-monsoon	0.45±0.03	1.35±0.11	0.89±0.14	0.36±0.02

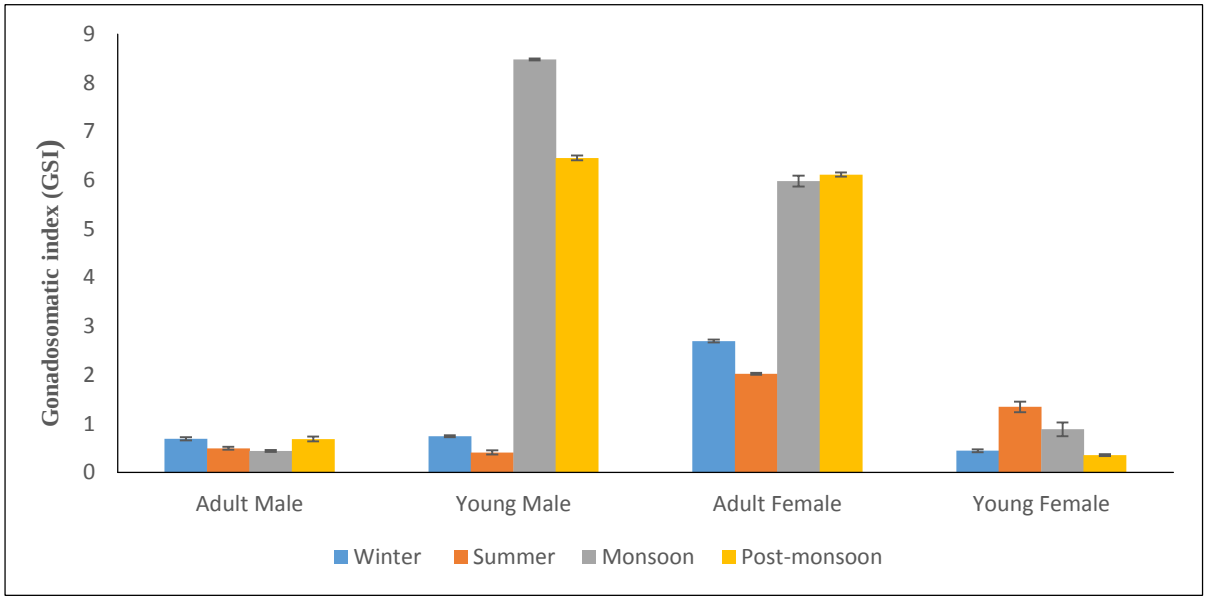


Fig. 31 Graphical representation showing gonadosomatic index (GSI) of *Heteropneustes fossilis* (two annual cycles)

Study of hepatosomatic index

Hepatosomatic index of males and females of *Heteropneustes fossilis* was determined separately in (Table-18 & 19). In male young and adult HSI value attained its peak value (1.12±0.13, 2.64±0.03) in monsoon and winter whereas the lowest value (0.41±0.01, 0.68±0.04) in post-monsoon and monsoon. HSI of adult and young female attains its highest value (1.32±0.1, 0.99±0.05) in monsoon and post-monsoon and lowest value (0.62±0.02, 0.59±0.03) in summer and winter in (Table-22 and Fig. 32).

The analysis of result shows that HSI value increased as the increasing of GSI. The highest value of HSI of young and adult male was observed in the monsoon season and winter whereas the highest value of female in monsoon and post-monsoon. In male, the lowest value of HSI was observed in the monsoon and post-monsoon season whereas the lowest value of female in winter and summer.

Mean seasonal variation of hapatosomatic index (HSI) of *Heteropneustes fossilis* during the study period

Table- 22

	Adult male	Young male	Adult female	Young female
Winter	2.64±0.03	0.49±0.03	1.24±0.02	0.59±0.03
Summer	0.71±0.03	0.59±0.07	0.62±0.02	0.82±0.02
Monsoon	0.68±0.04	1.12±0.13	1.32±0.1	0.75±0.03
Post-monsoon	0.69±0.04	0.41±0.01	1.01±0.04	0.99±0.05

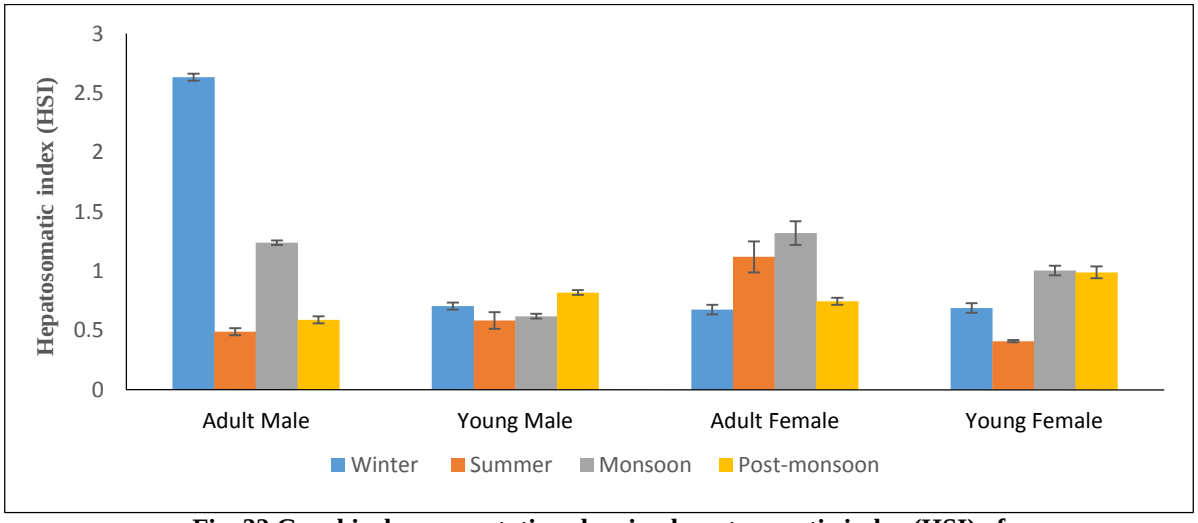


Fig. 32 Graphical representation showing hapatosomatic index (HSI) of *Heteropneustes fossilis* (two annual cycles)

Condition factor (K)

Information on condition factor (K) can be vital to cultural system because they provide the producer with information of the specific condition under which organism is developing. The value of condition factor (K) recorded in the present study of male and female, young and adult of *Heteropneustes fossilis* determined separately in (Table-18 &19). The mean condition factor (K) of young and adult male was observed and highest value (1.06±0.11, 0.97±0.02) in winter season and lowest value (0.56±0.02, 0.64±0.11) in the monsoon and post-monsoon whereas in the case of young and adult female observed highest value (0.86±0.09, 1.00±0.04) of winter and lowest value (0.46±0.08, 0.51±0.03) in summer and monsoon in table-23 and fig. 33.

Mean seasonal variation of condition factor (K) of *Heteropneustes fossilis* during the study period

Table- 23

	Adult male	Young male	Adult female	Young female
Winter	0.97±0.02	1.06±0.11	1.00±0.04	0.86±0.09
Summer	0.64±0.14	0.61±0.05	0.65±0.02	0.46±0.08
Monsoon	0.58±0.02	0.56±0.02	0.51±0.03	0.60±0.1
Post-monsoon	0.64±0.11	0.57±0.07	0.65±0.02	0.62±0.1

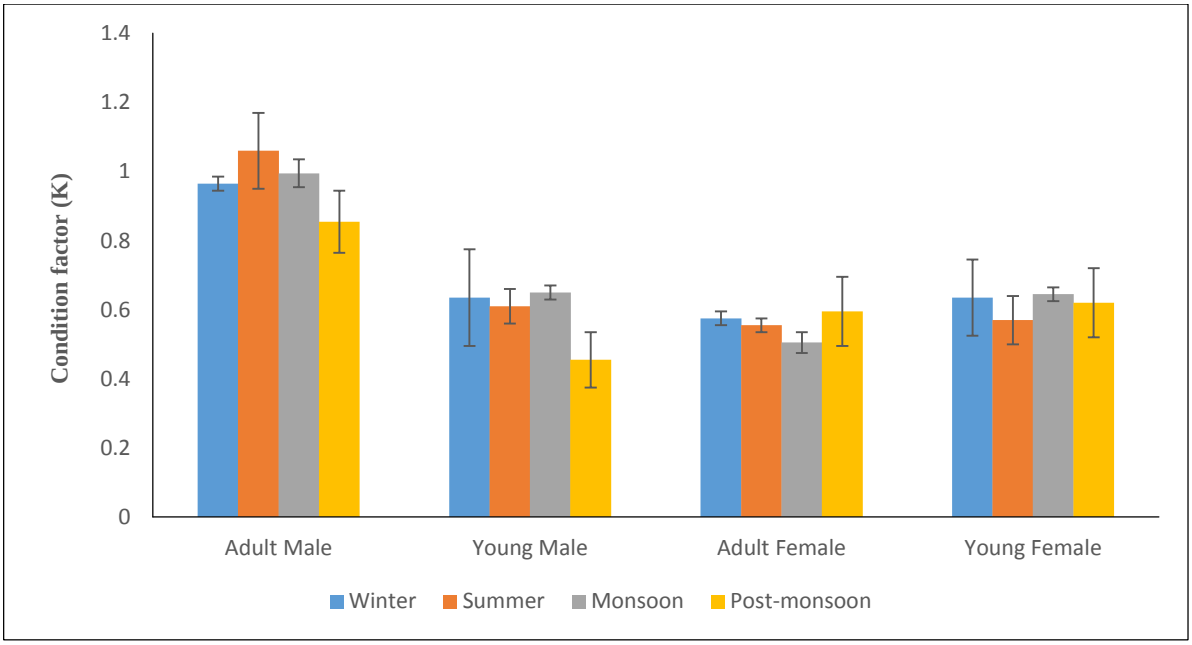


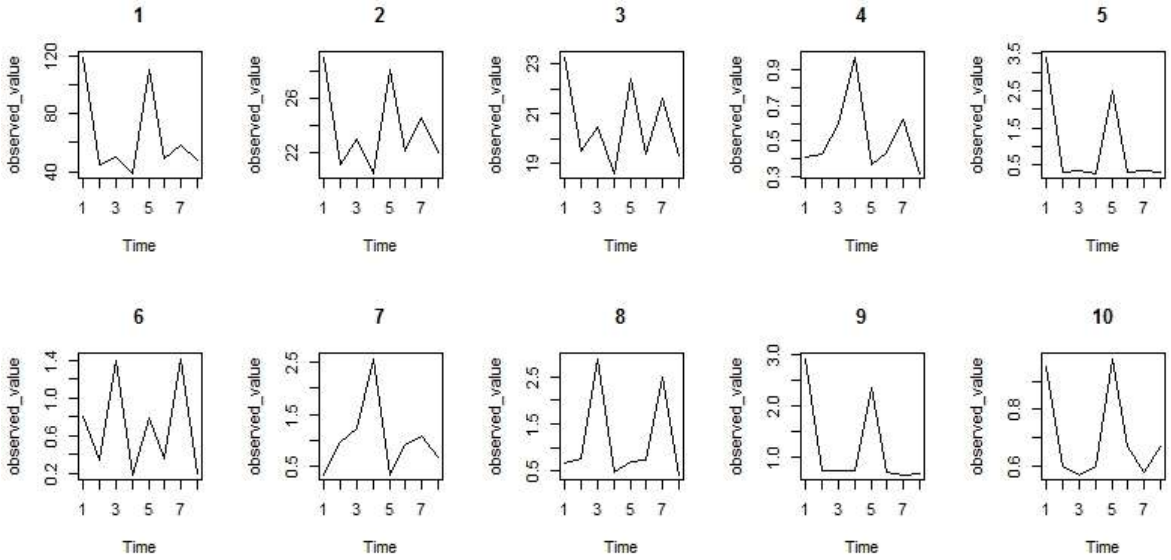
Fig. 33 Graphical representation showing condition factor (K) of *Heteropneustes fossilis* (two annual cycles)

Section 1 *Heteropneustes fossilis* (Adult Male)

Part A: Table of significant correlations among the different factors

Table-24	**Significant Correlations–*Heteropneustes fossilis***		
Adult Male			
Var – 1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Total length (cm)	0.975	0
Body weight (gm.)	Standard length (cm)	0.913	0.002
Body weight (gm.)	Weight of liver (gm.)	0.982	0
Body weight (gm.)	Hepatosomatic index (HSI) (%)	0.975	0
Body weight (gm.)	Condition factor (K)	0.947	0
Total length (cm)	Body weight (gm.)	0.975	0
Total length (cm)	Standard length (cm)	0.971	0
Total length (cm)	Weight of liver (gm.)	0.927	0.001
Total length (cm)	Hepatosomatic index (HSI) (%)	0.911	0.002
Total length (cm)	Condition factor (K)	0.871	0.005
Standard length (cm)	Body weight (gm.)	0.913	0.002
Standard length (cm)	Total length (cm)	0.971	0
Standard length (cm)	Weight of liver (gm.)	0.856	0.007
Standard length (cm)	Hepatosomatic index (HSI) (%)	0.835	0.01
Standard length (cm)	Condition factor (K)	0.742	0.035
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.942	0
Weight of liver (gm.)	Body weight (gm.)	0.982	0
Weight of liver (gm.)	Total length (cm)	0.927	0.001
Weight of liver (gm.)	Standard length (cm)	0.856	0.007
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.999	0
Weight of liver (gm.)	Condition factor (K)	0.944	0
Weight of testis (gm.)	Gonadosomatic index (GSI) (%)	0.903	0.002
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.942	0
Gonadosomatic index (GSI) (%)	Weight of testis (gm.)	0.903	0.002
Hepatosomatic index (HSI) (%)	Body weight (gm.)	0.975	0
Hepatosomatic index (HSI) (%)	Total length (cm)	0.911	0.002
Hepatosomatic index (HSI) (%)	Standard length (cm)	0.835	0.01
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.999	0
Hepatosomatic index (HSI) (%)	Condition factor (K)	0.947	0
Condition factor (K)	Body weight (gm.)	0.947	0
Condition factor (K)	Total length (cm)	0.871	0.005
Condition factor (K)	Standard length (cm)	0.742	0.035
Condition factor (K)	Weight of liver (gm.)	0.944	0
Condition factor (K)	Hepatosomatic index (HSI) (%)	0.947	0

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

- Winter has significant effect at 5% level of GaSI adult male of *Heteropneustes fossilis* whereas rest of the seasons do not exhibit any significant effect.
- Winter and post-monsoon are significant at 5% level for "GSI" but monsoon and summer do not significant effect.
- The seasonal effects of summer and winter are significant at 5% level on HSI.
- Winter and summer are significant at 5% level on condition factor (K) whereas rest of the seasons do not exhibit significant effect.
- The seasonal effects of winter, summer, monsoon and post-monsoon on weight of testis are significant at 5% level.
- Only summer has significant effect at 5% level on weight of liver whereas rest three seasons do not exhibit any significant effect.

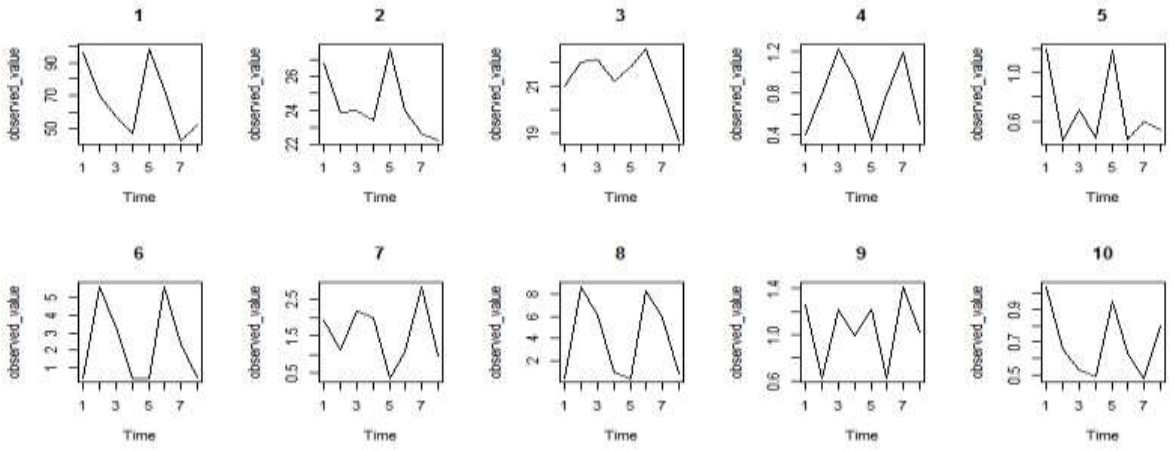
- Winter, summer, monsoon and post-monsoon seasons do not exhibit any significant effect on weight of stomach.
- The effects of winter and summer on standard length are significant at 5% level of standard length.
- The seasonal effects of winter and summer on total length are significant at 5% level.
- Winter, summer and post-monsoon are significant at 5% level on body weight whereas the monsoon do not exhibit significant seasonal effect.

Section 2 *Heteropneustes fossilis (*Adult Female)

Part A: Table of significant correlations among the different factors

Table-25	**Significant Correlations-*Heteropneustes fossilis***		
Adult Female			
Var -1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Total length (cm)	0.931	0.001
Body weight (gm.)	Weight of stomach (gm.)	0.747	0.033
Body weight (gm.)	Weight of liver (gm.)	0.782	0.022
Body weight (gm.)	Condition factor (K)	0.852	0.007
Total length (cm)	pH	0.789	0.02
Total length (cm)	Body weight (gm.)	0.931	0.001
Total length (cm)	Weight of liver (gm.)	0.886	0.003
Total length (cm)	Condition factor (K)	0.744	0.034
Weight of stomach (gm.)	Body weight (gm.)	0.747	0.033
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.74	0.036
Weight of stomach (gm.)	Condition factor (K)	0.921	0.001
Weight of liver (gm.)	Body weight (gm.)	0.782	0.022
Weight of liver (gm.)	Total length (cm)	0.886	0.003
Weight of liver (gm.)	Condition factor (K)	0.79	0.02
Weight of ovary (gm.)	Gonadosomatic index (GSI) (%)	0.971	0
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.74	0.036
Gonadosomatic index (GSI) (%)	Weight of ovary (gm.)	0.971	0
Condition factor (K)	Body weight (gm.)	0.852	0.007
Condition factor (K)	Total length (cm)	0.744	0.034
Condition factor (K)	Weight of stomach (gm.)	0.921	0.001
Condition factor (K)	Weight of liver (gm.)	0.79	0.02

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

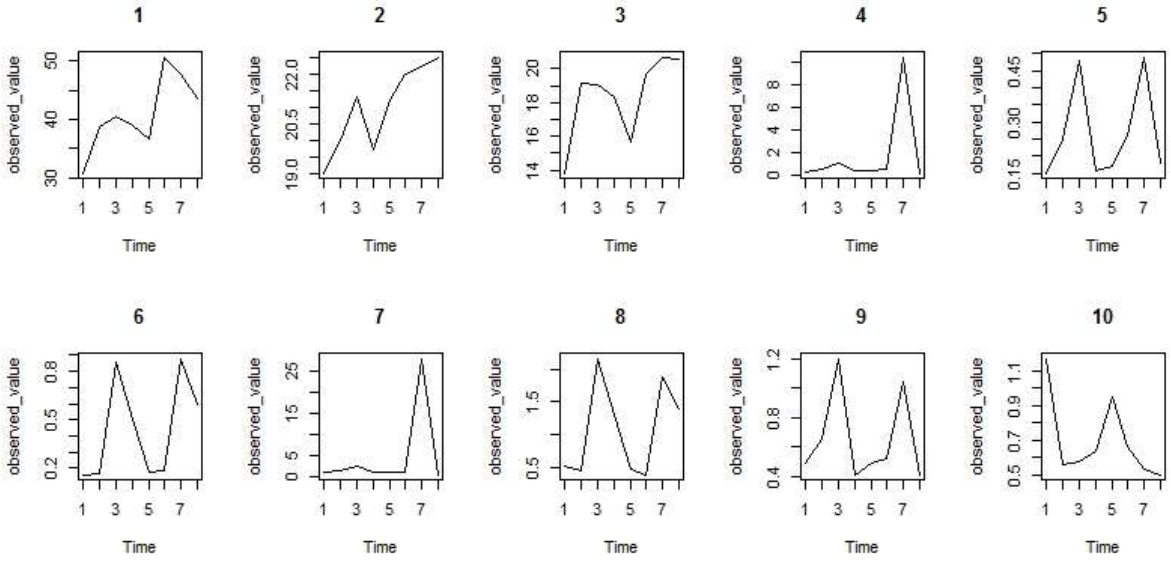
- Winter has significant effect at 5% level on GaSI of adult female of *Heteropneustes fossilis* whereas rest of the seasons do not exhibit any significant effect.
- All four seasons i.e. winter, summer, monsoon and post-monsoon are significant effect on GSI at 5% level.
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level for HSI.
- The seasonal effects of winter and summer on condition factor (K) are significant at 5% level whereas rest of the seasons do not exhibit any significant effect.
- Monsoon and post-monsoon have significant effect at 5% level on the weight of ovary but winter and summer do not exhibit any significant.
- For the weight of liver, the seasonal effects of winter, summer and post-monsoon are significant at 5% level for weight of liver.
- Winter and post-monsoon have significant effect on weight of stomach at 5 % level.
- Winter has significant effect on the standard length at 5% level on weight of stomach of adult female.
- Winter and summer are significant effect on Total length at 5% level whereas rest of the seasons do not exhibit any significant effect.
- Winter, summer, monsoon and post-monsoon seasons do not exhibit any significant on body weight.

Section 3 *Heteropneustes fossilis* (Young Male)

Part A Table of significant correlations among the different factors10

Table-26	**Significant Correlations-*Heteropneustes fossilis***		
Young Male			
Var -1	**Var -2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Total length (cm)	0.905	0.002
Body weight (gm.)	Standard length (cm)	0.891	0.003
Total length (cm)	Body weight (gm.)	0.905	0.002
Total length (cm)	Standard length (cm)	0.923	0.001
Standard length (cm)	Body weight (gm.)	0.891	0.003
Standard length (cm)	Total length (cm)	0.923	0.001
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.979	0
Weight of liver (gm.)	Salinity (ppt.)	–0.821	0.013
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.833	0.01
Weight of testis (gm.)	Gonadosomatic index (GSI) (%)	0.934	0.001
Weight of testis (gm.)	Condition factor (K)	–0.872	0.005
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.979	0
Gonadosomatic index (GSI) (%)	Weight of testis (gm.)	0.934	0.001
Weight of testis (gm.)	Condition factor (K)	–0.872	0.005
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.979	0
Gonadosomatic index (GSI) (%)	Weight of testis (gm.)	0.934	0.001
Gonadosomatic index (GSI) (%)	Condition factor (K)	–0.760	0.029
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.833	0.01
Condition factor (K)	Weight of testis (gm.)	–0.872	0.005
Condition factor (K)	Gonadosomatic index (GSI) (%)	–0.760	0.029

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

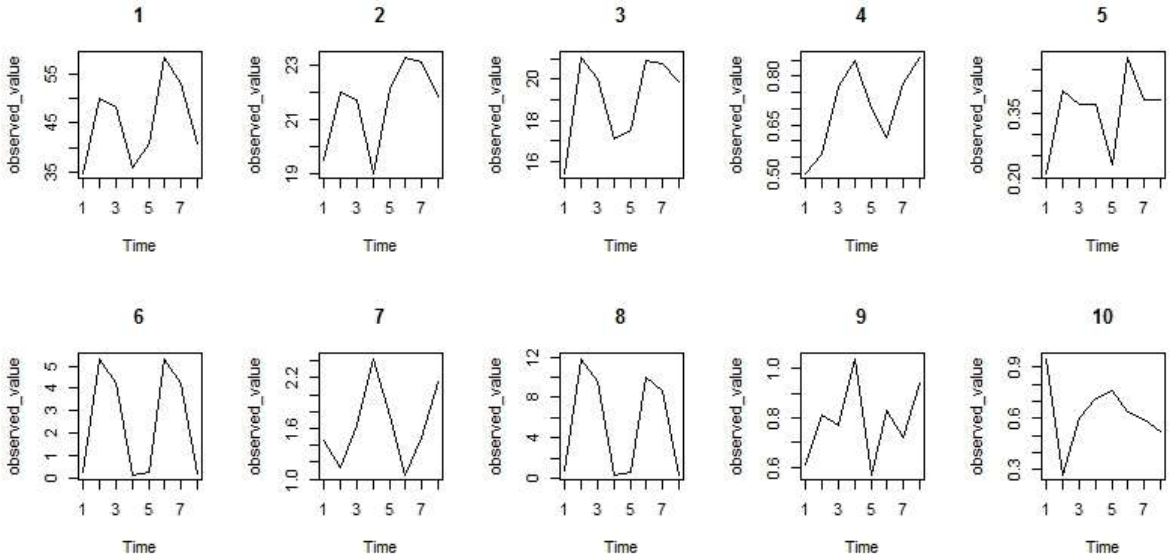
- All the four season winter, summer, monsoon and post-monsoon do not exhibit any significant effect on GaSI.
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level on GSI.
- Winter and post-monsoon have significant effect on HSI at 5% level but the summer and monsoon has no significant effect.
- The effects of the winter and summer are significant on condition factor (K) at 5% level whereas rest of the seasons do not exhibit any significant effect.
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level for weight of testis.
- The seasonal effects of winter, monsoon and post-monsoon are significant at 5% level on the weight of liver while summer do not exhibit any significant effect.
- There is no significant seasonal effect of any of four seasons on weight of stomach.
- Winter has significant effect at 5% level on standard length whereas rest three seasons do not have any significant effect.
- The seasonal effect of winter is only significant at 5% level for total length whereas rest of the seasons do not exhibit any significant effect.
- The winter and summer have significant effect on body weight but the other two seasons do not exhibit any significant effect.

Section 4 *Heteropneustes fossilis* (Young Female)

Part A: Table of significant correlations among the different factors

Table-27	**Significant Correlations –*Heteropneustes fossilis***		
Young Female			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P - Value**
Body weight (gm.)	Total length (cm)	0.886	0.005
Body weight (gm.)	Standard length (cm)	0.872	0.005
Body weight (gm.)	Weight of liver (gm.)	0.743	0.035
Body weight (gm.)	Weight of ovary (gm.)	0.921	0.001
Body weight (gm.)	Gonadosomatic index (GSI) (%)	0.879	0.004
Total length (cm)	Body weight (gm.)	0.866	0.005
Total length (cm)	Standard length (cm)	0.815	0.014
Standard length (cm)	Body weight (gm.)	0.872	0.005
Standard length (cm)	Total length (cm)	0.815	0.014
Standard length (cm)	Weight of liver (gm.)	0.822	0.012
Standard length (cm)	Weight of ovary (gm.)	0.81	0.015
Standard length (cm)	Gonadosomatic index (GSI) (%)	0.799	0.017
Standard length (cm)	Condition factor (K)	0.835	0.01
Weight of stomach (gm.)	Mg (mg/l)	0.752	0.031
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.782	0.022
Weight of liver (gm.)	Body weight (gm.)	0.743	0.035
Weight of liver (gm.)	Standard length (cm)	0.822	0.012
Weight of ovary (gm.)	Body weight (gm.)	0.921	0.001
Weight of ovary (gm.)	Standard length (cm)	0.81	0.015
Weight of ovary (gm.)	Gastrosomatic index (GaSI) (%)	–0.769	0.026
Weight of ovary (gm.)	Gonadosomatic index (GSI) (%)	0.993	0
Gastrosomatic index (GaSI) (%)	Salinity (ppt.)	0.786	0.021
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.782	0.022
Gastrosomatic index (GaSI) (%)	Weight of ovary (gm.)	–0.769	0.026
Gastrosomatic index (GaSI) (%)	Gonadosomatic index (GSI) (%)	–0.751	0.032
Gonadosomatic index (GSI) (%)	Body weight (gm.)	0.879	0.004
Gonadosomatic index (GSI) (%)	Standard length (cm)	0.799	0.017
Gonadosomatic index (GSI) (%)	Weight of ovary (gm.)	0.993	0
Gonadosomatic index (GSI) (%)	Gastrosomatic index (GaSI) (%)	–0.751	0.032
Condition factor (K)	Standard length (cm)	–0.835	0.01

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

- All seasons have significant effect at 5% level on 'GaSI' of young Female of *Heteropneustes fossilis.*
- The effects of the monsoon and post-monsoon are significant at 5% level for GSI whereas rest of two seasons do not exhibit any significant effect.
- The seasonal effect of winter, summer, monsoon and post-monsoon are significant at 5% level for HSI.
- Winter has significant effect on condition factor (K) at 5% level whereas rest of the seasons do not exhibit any significant effect.
- Winter, summer, monsoon and post-monsoon have significant effect at 5% level on weight of ovary.
- The effects of the winter, summer and monsoon are significant at 5% level on weight of liver while post-monsoon do not have any significant effect.

- The seasonal effects of winter, summer and monsoon are significant at 5% level on weight of stomach whereas the post-monsoon do not exhibit any significant effect.
- Only the seasonal effect of winter is significant at 5% level but rest of the seasons do not exhibit any significant effect.
- Winter has significant effect at 5% level on total length whereas rest of the seasons do not exhibit any significant effect.
- Winter has significant effect at 5% level on body weight whereas rest of the seasons do not have any significant effect.

Clarias batrachus

1st year – November, 2014 to October, 2015

Table No-28 Index Values and condition factor of *Clarias batrachus* of four

Season – Winter, Summer, Monsoon and Post Monsoon

Sl. No.	Descriptive	Winter				Summer				Monsoon				Post Monsoon			
		Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female
1	Body weight (gm)	77.6 ±0.2	46.85 ±0.02	117.79 ±0.03	100.58 ±0.02	112.29 ±0.03	106.84 ±0.02	120.58 ±0.03	190.41 ±0.03	82.9 ±0.28	91.41 ±0.03	141.31 ±0.02	130.6 ±0.28	59.02 ±0.02	60.48 ±0.02	61.89 ±0.03	67.65 ±0.01
2	Total length	22.6 ±0.26	18.9 ±0.23	24.7 ±0.30	23 ±0.77	24.9 ±0.21	24.6 ±0.24	26.2 ±0.15	29.7 ±0.18	24.01 ±0.01	24.5 ±0.17	29.9 ±0.22	28.5 ±0.20	20.01 ±0.01	21.05 ±0.03	23 ±0.77	23.2 ±0.15
3	Standard length (cm)	14.5 ±0.23	12.9 ±0.23	16.9 ±0.24	15.8 ±0.26	21.9 ±0.15	21 ±0.77	24.5 ±0.17	26.2 ±0.14	20.09 ±0.02	21.7 ±0.26	27.1 ±0.24	24.5 ±0.12	18.03 ±0.02	18.09 ±0.02	20.05 ±0.04	20 ±1.09
4	Weight of stomach (gm)	1.32 ±0.02	1.43 ±0.01	2.03 ±0.01	1.02 ±0.01	1.25 ±0.02	2.13 ±0.2	2.5 ±0.024	2.61 ±0.02	0.82 ±0.01	1.12 ±0.02	1.12 ±0.02	0.77 ±0.01	1.19 ±0.02	1.44 ±0.01	2.17 ±0.02	1.94 ±0.02
5	Weight of liver (gm)	0.44 ±0.01	0.3 ±0.03	0.73 ±0.02	0.44 ±0.02	0.83 ±0.02	1.25 ±0.02	0.45 ±0.02	1.49 ±0.02	0.54 ±0.01	0.37 ±0.01	0.82 ±0.02	0.93 ±0.02	0.3 ±0.13	0.32 ±0.01	0.6 ±0.09	0.61 ±0.02
6	Weight of ovary (gm)	X	0.15 ±0.02	X	1.17 ±0.01	X	6.8 ±0.08	X	22.1 ±0.15	X	0.5 ±0.15	X	14.37 ±0.01	X	0.24 ±0.02	X	0.37 ±0.03
7	Weight of testis (gm)	0.04 ±0.02	X	0.44 ±0.02	X	0.73 ±0.02	X	0.33 ±0.02	X	0.2 ±0.1	X	0.54 ±0.01	X	0.11 ±0.02	X	0.22 ±0.02	X
8	Gastrosomatic index (GaSI) (%)	1.73 ±0.02	3.15 ±0.03	1.75 ±0.02	0.93 ±0.03	1.13 ±0.02	2.03 ±0.02	2.12 ±0.02	1.39 ±0.03	1 ±0.29	1.24 ±0.02	0.8 ±0.27	0.59 ±0.04	2.05 ±0.02	2.44 ±0.02	3.63 ±0.02	2.96 ±0.02
9	Gonadosomatic index (GSI) (%)	0.05 ±0.02	0.32 ±0.01	0.37 ±0.02	1.07 ±0.01	0.65 ±0.02	6.8 ±0.34	0.27 ±0.02	13.13 ±0.02	0.24 ±0.02	0.55 ±0.02	0.38 ±0.03	12.36 ±0.02	0.19 ±0.02	0.4 ±0.19	0.36 ±0.02	0.55 ±0.02
10	Hepatosomatic index (HSI) (%)	0.57 ±0.02	0.64 ±0.02	0.62 ±0.02	0.4 ±0.19	0.74 ±0.02	1.18 ±0.02	0.37 ±0.02	0.79 ±0.02	0.66 ±0.02	0.41 ±0.01	0.58 ±0.02	0.72 ±0.02	0.51 ±0.01	0.53 ±0.02	0.98 ±0.01	0.91 ±0.01
11	Condition factor (K)	2.55 ±0.02	2.18 ±0.01	2.44 ±0.02	2.8 ±0.13	1.07 ±0.02	1.15 ±0.02	0.82 ±0.02	1.06 ±0.02	0.91 ±0.01	0.89 ±0.02	0.71 ±0.01	0.89 ±0.02	0.97 ±0.02	0.9 ±0.17	0.72 ±0.01	0.85 ±0.03

Clarias batrachus

2nd year – November, 2015 to October, 2016

Table No- 29 Index Values and condition factor of *Clarias batrachus* of four Season – Winter, Summer, Monsoon and Post Monsoon

Sl. No.	Descriptive	Winter				Summer				Monsoon				Post Monsoon			
		Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female
1	Body weight (gm)	80.2 ±0.15	48.5 ±0.13	115.31 ±0.02	111.38 ±0.02	113.15 ±0.01	109.9 ±0.24	130.1 ±0.1	187.3 ±0.15	90.7 ±0.14	87.5 ±0.17	138.4 ±0.13	140.32 ±0.01	60.2 ±0.11	67.32 ±0.01	70.4 ±0.1	72.8 ±0.24
2	Total length (cm)	23.4 ±0.16	19.3 ±0.17	24.4 ±0.12	22.24 ±0.01	24.8 ±0.11	24.7 ±0.11	26.6 ±0.16	28.8 ±0.15	24.4 ±0.12	24.8 ±0.11	28.7 ±0.17	28.9 ±0.32	20.2 ±0.17	22.2 ±0.17	23.3 ±0.16	23.7 ±0.13
3	Standard length (cm)	14.7 ±0.14	13.4 ±0.08	16.7 ±0.15	15.6 ±0.11	21.9 ±0.17	21.2 ±0.15	24.7 ±0.11	25.5 ±0.08	20.8 ±0.18	21.9 ±0.17	26.3 ±0.17	24.7 ±0.18	18.2 ±0.29	19.3 ±0.17	20.6 ±0.13	20.8 ±0.18
4	Weight of stomach (gm)	1.33 ±0.02	1.44 ±0.02	2 ±0.77	1.3 ±0.13	1.26 ±0.01	2.14 ±0.01	2.48 ±0.02	2.51 ±0.01	0.85 ±0.01	1.13 ±0.02	1.1 ±0.1	0.8 ±0.13	1.2 ±0.15	1.45 ±0.01	2.18 ±0.02	2.1 ±0.23
5	Weight of liver (gm)	0.45 ±0.02	0.32 ±0.01	0.7 ±0.15	0.45 ±0.02	0.78 ±0.02	1.26 ±0.01	0.46 ±0.02	1.47 ±0.01	0.55 ±0.02	0.35 ±0.02	0.8 ±0.11	0.92 ±0.02	0.31 ±0.01	0.33 ±0.02	0.61 ±0.02	0.63 ±0.02
6	Weight of ovary (gm)	X	0.17 ±0.02	X	1.18 ±0.02	X	6.77 ±0.01	X	21.2 ±0.13	X	0.48 ±0.03	X	14.3 ±0.15	X	0.26 ±0.02	X	0.39 ±0.02
7	Weight of testis (gm)	0.5 ±0.15	X	0.42 ±0.02	X	0.74 ±0.02	X	0.34 ±0.02	X	0.25 ±0.02	X	0.52 ±0.01	X	0.1 ±1.39	X	0.24 ±0.02	X
8	Gastrosomatic index (GaSI) (%)	1.69 ±0.02	3.06 ±0.02	1.77 ±0.02	1.18 ±0.01	1.13 ±0.02	1.99 ±0.04	1.94 ±0.03	1.36 ±0.01	0.95 ±0.02	1.31 ±0.01	0.8 ±0.33	0.57 ±0.01	2.03 ±0.02	2.2 ±0.16	3.2 ±0.11	2.97 ±0.01
9	Gonadosomatic index (GSI) (%)	0.63 ±0.02	0.35 ±0.02	0.37 ±0.02	1.07 ±0.03	0.66 ±0.01	6.56 ±0.02	0.26 ±0.02	12.76 ±0.02	0.28 ±0.02	0.55 ±0.02	0.38 ±0.03	11.35 ±0.02	0.17 ±0.02	0.39 ±0.03	0.34 ±0.02	0.54 ±0.02
10	Hepatosomatic index (HSI) (%)	0.56 ±0.01	0.66 ±0.02	0.61 ±0.02	0.41 ±0.01	0.69 ±0.02	1.16 ±0.02	0.35 ±0.02	0.79 ±0.03	0.61 ±0.03	0.4 ±0.19	0.58 ±0.02	0.66 ±0.02	0.52 ±0.01	0.49 ±0.02	0.87 ±0.02	0.87 ±0.02
11	Condition factor (K)	2.52 ±0.02	2.02 ±0.01	2.48 ±0.03	2.93 ±0.02	1.08 ±0.01	1.15 ±0.03	0.86 ±0.02	1.13 ±0.05	1 ±0.29	0.83 ±0.02	0.76 ±0.01	0.93 ±0.01	1 ±0.29	1.12 ±0.03	0.81 ±0.04	0.81 ±0.04

Clarias batrachus

Study of gastrosomatic index (GaSI)

Gastrosomatic index (GaSI) of male and female, young and adult of *Clarias batrachus* is determined separately in (Table-28 & 29). The mean GaSI values of young and adult male are highest (2.04±0.02, 3.42±0.02) in post-monsoon and lowest (0.98±0.2, 0.8±0.3) in the season of monsoon. Similarly, young and adult female showed highest value (3.11±0.05, 2.97±0.01) in the winter and post-monsoon season and lowest value (1.28±0.04, 0.58±0.03) in the season of monsoon. In the case of both young and adult male, the GaSI has the highest value in post-monsoon and lowest value in monsoon. Similarly in the case of both young and adult female, the GaSI has highest value in winter and post-monsoon whereas lowest value in monsoon. The GaSI value have gradually increased from monsoon to winter respectively whereas gradually decreased from summer to monsoon table-30 and fig. 34.

Mean seasonal variation of gastrosomatic index (GaSI) of *Clarias batrachus* during the study period

Table- 30

	Adult male	Young male	Adult female	Young female
Winter	1.76±0.02	1.71±0.03	1.06±0.12	3.11±0.05
Summer	2.03±0.09	1.13±0.02	1.38±0.03	2.01±0.04
Monsoon	0.8±0.3	0.98±0.2	0.58±0.03	1.28±0.04
Post-monsoon	3.42±0.02	2.04±0.02	2.97±0.01	2.32±0.06

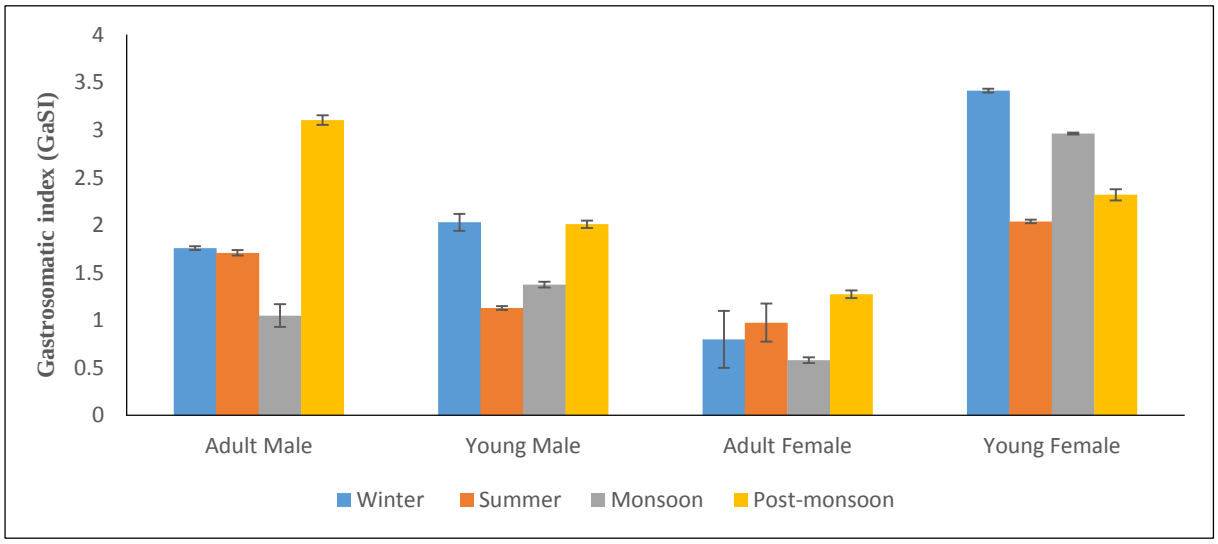


Fig. 34 Graphical representation showing gastrosomatic index (GaSI) of *Clarias batrachus* (two annual cycles)

Study of gonadosomatic index (GSI)

Mean gonadosomatic index values attains its peak value (0.38±0.03, 0.66±0.02) in case of adult and young male was observed in monsoon and summer season and lowest value (0.27±0.02, 0.18±0.03) in the season of summer and post-monsoon. Similarly, young and adult female were observed to be highest value (6.68±0.02, 12.95±0.08) in the summer and lowest value (0.34±0.02, 0.55±0.02) in the winter and post-monsoon. The gonadosomatic index value of male was observed to be highest in the season of summer and monsoon and lowest in summer and post-monsoon season. Similarly, the GSI value of female is observed highest in summer and lowest in winter and post-monsoon seasons. The present study showed that gonadosomatic index value increased as increasing of gonad present study showed that gonadosomatic index value increased as increasing of gonad development and decreasing temporarily. The result of this study was also appropriate in *Calisa fasciatus* as per

observation of Sarkar and Deepak (2009) that gradual increases in gonadosomatic index value during pre-spawning period and its peak value reached during spawning period. Similar observation were recorded by Tiwari, et al., (2014), where stated that the increasing of gonadosomatic index as the increase of gonads weight table-31 and fig. 35.

Mean seasonal variation of gonadosomatic index (GSI) of *Clarias batrachus* during the study period

Table- 31

	Adult male	Young male	Adult female	Young female
Winter	0.37±0.02	0.34±0.03	1.07±0.03	0.34±0.02
Summer	0.27±0.02	0.66±0.02	12.95±0.08	6.68±0.02
Monsoon	0.38±0.03	0.26±0.03	11.86±0.05	0.55±0.02
Post-monsoon	0.35±0.02	0.18±0.03	0.55±0.02	0.40±0.14

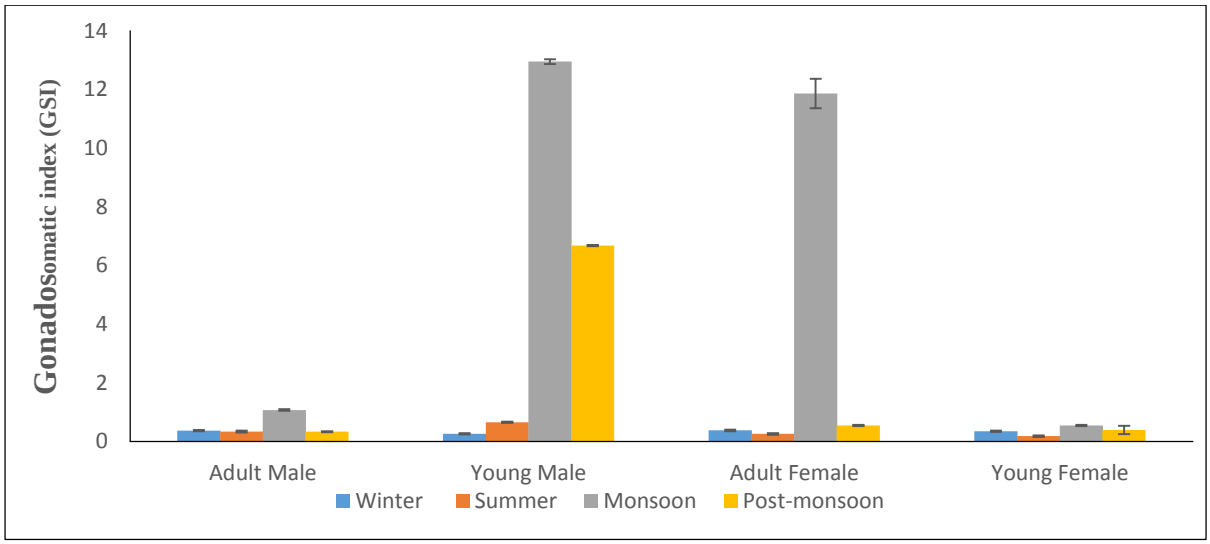


Fig. 35 Graphical representation showing gonadosomatic index (GSI) of *Clarias batrachus* (two annual cycles)

Study of hepatosomatic index

Hepatosomatic index of males and females of *Clarias batrachus* were determined separately in (Table-28 & 29). In male young and adult HSI mean values attains its peak value (0.72±0.03, 0.93±0.05) in summer and post-monsoon and lowest value (0.52±0.01. 0.36±0.02) in post-monsoon and summer. The HSI value of young and adult female attained its highest value (1.17±0.02, 0.89±0.02) in summer and post-monsoon season and lowest value (0.41±0.13, 0.41±0.13) in the winter and monsoon. The hepatosomatic index value was increased gradually from summer to post-monsoon and decreased monsoon to summer. Studies on hepatosomatic

index revealed that in female specimen, the HSI value reaches its peak value prior to spawning season and then starts to decrease after spawning. Decrease in HSI value after spawning was due to the loss of hepatic glycogen which was a common morphologic response to stress fish liver (spawning and reproduction) and enhanced consumption of glycogen as an instant source to meet the energy demand during the spawning season (Schreck, 1981). Hepatosomatic index decreased as increasing of body weight and standard length table-32 and fig. 36.

Mean seasonal variation of hapatosomatic index (HSI) of *Clarias batrachus* during the study period

Table- 32

	Adult male	Young male	Adult female	Young female
Winter	0.62±0.02	0.57±0.02	0.41±0.13	0.65±0.02
Summer	0.36±0.02	0.72±0.03	0.79±0.03	1.17±0.02
Monsoon	0.58±0.02	0.64±0.03	0.69±0.03	0.41±0.13
Post-monsoon	0.93±0.05	0.52±0.01	0.89±0.02	0.51±0.03

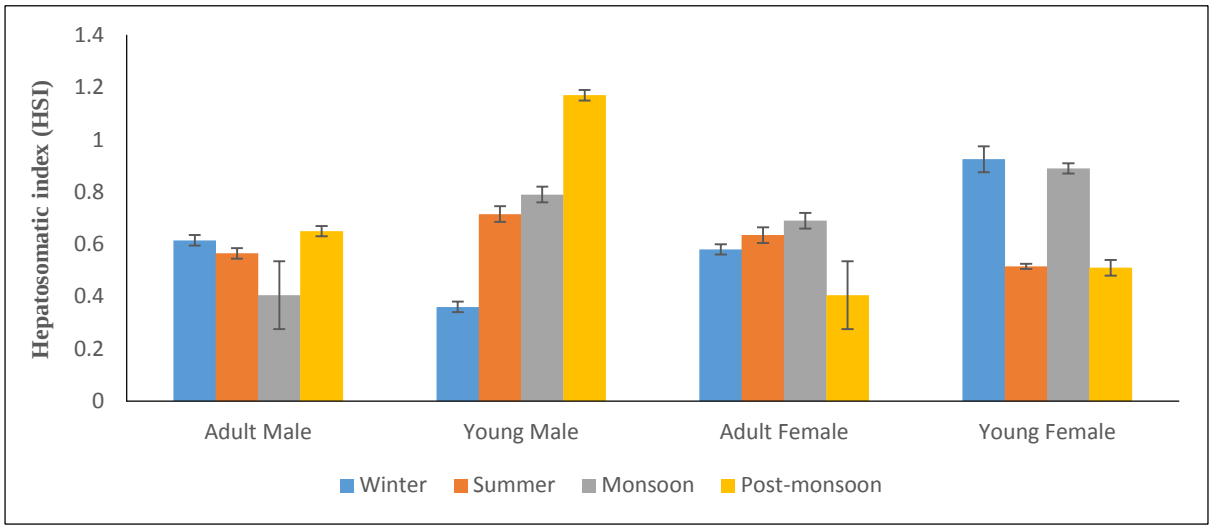


Fig. 36 Graphical representation showing hapatosomatic index (HSI) of *Clarias batrachus* (two annual cycles)

Condition factor (K)

The value of condition factor (K) recorded in the present study of male and female, young and adult of *Clarias batrachus* was determined separately in (Table-28 & 29). The mean condition factor (K) of adult and young male was showed highest value (2.46±0.03, 2.54±0.03) in the season of winter and lowest value (0.74±0.03, 0.96±0.2) in the season of monsoon whereas adult and young female were showed highest value (2.87±0.11, 2.1±0.08) in the season of

winter and lowest value (0.83±0.04, 0.86±0.04) in the season of post-monsoon and monsoon in (Table-33 and Fig. 37). The condition factor (K) was increasing in the case of both young and adult male in winter whereas in the case of female it was observed in winter and decreasing in monsoon and post-monsoon season. Observation from the present study showed that the condition factor (K) in both male and female specimens exhibit a gradual decrease before spawning season in monsoon which indicates the development of gonad occurs at the expense of somatic weight. After the spawning season, condition factor (K) starts to increase and reaches its peak value in post-monsoon. The overall low value of condition factor (K) suggested scarcity of food in the environment development of gonads and variations in feeding intensity were the probable factors which contribute to the seasonal fluctuations in condition factor (K). Hossain et al., (2006) obtained similar observations in Asian striped catfish, *Mystus vitiates.*

Mean seasonal variation of condition factor (K) of *Clarias batrachus* during the study period

Table- 33

	Adult male	Young male	Adult female	Young female
Winter	2.46±0.03	2.54±0.03	2.87±0.11	2.1±0.08
Summer	0.84±0.03	1.08±0.02	1.10±0.05	1.15±0.02
Monsoon	0.74±0.03	0.96±0.2	0.91±0.03	0.86±0.04
Post-monsoon	0.77±0.05	0.99±0.2	0.83±0.04	1.01±0.11

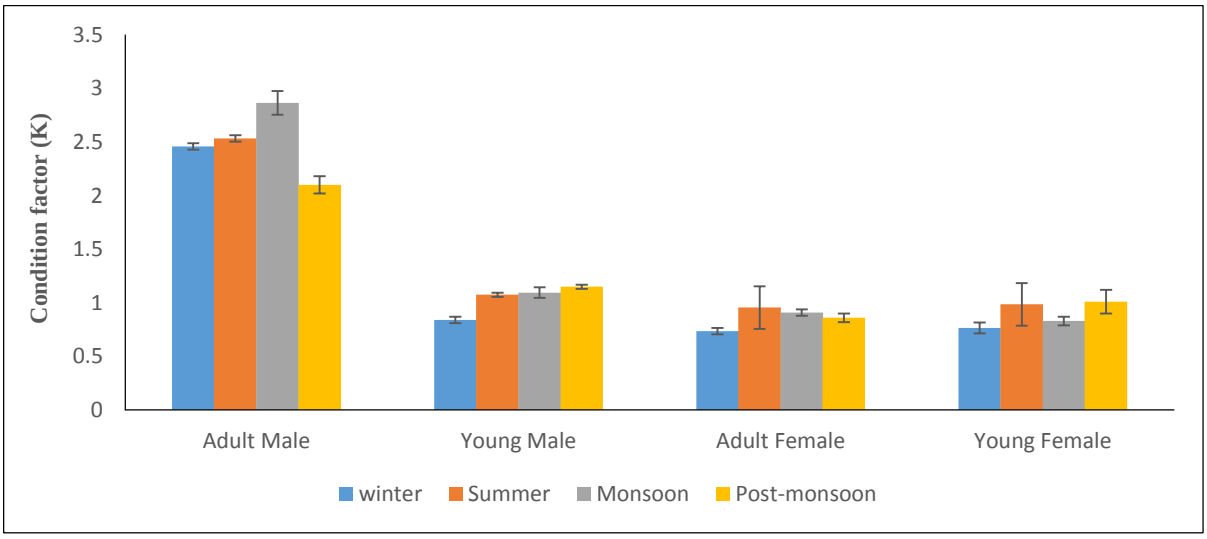


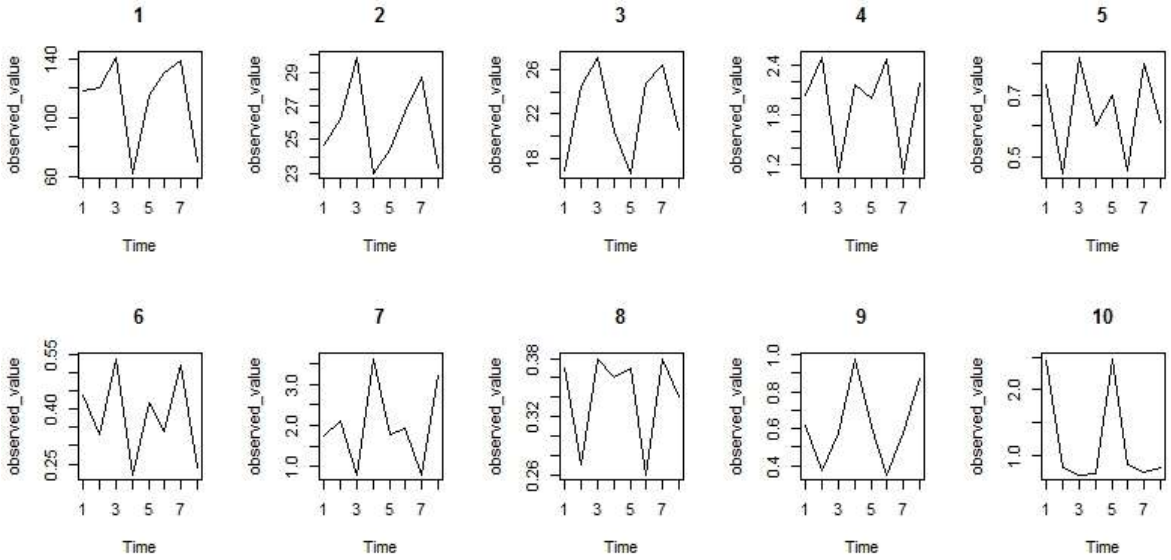
Fig. 37 Comparative Graphical representation showing Condition factor (K) of *Clarias batrachus* (two annual cycles)

Section 5 *Clarias batrachus* (Adult Male)

Part A Table of significant correlations among the different factors

Table-34	**Significant Correlations-*Clarias batrachus***		
Adult Male			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Salinity (ppt.)	–0.816	0.014
Body weight (gm.)	Total length (cm)	0.862	0.006
Body weight (gm.)	Weight of testis (gm.)	0.864	0.006
Body weight (gm.)	Gastrosomatic index (GaSI) (%)	–0.953	0
Body weight (gm.)	Hepatosomatic index (HSI) (%)	–0.83	0.011
Total length (cm)	Body weight (gm.)	0.862	0.006
Total length (cm)	Standard length (cm)	0.807	0.015
Total length (cm)	Weight of testis (gm.)	0.812	0.014
Total length (cm)	Gastrosomatic index (GaSI) (%)	–0.876	0.004
Standard length (cm)	Total length (cm)	0.807	0.015
Standard length (cm)	Condition factor (K)	–0.815	0.014
Weight of stomach (gm.)	Weight of liver (gm.)	-0.903	0.002
Weight of stomach (gm.)	Weight of testis (gm.)	-0.788	0.02
Weight of stomach (gm.)	Gonadosomatic index (GSI) (%)	-0.746	0.034
Weight of liver (gm.)	Weight of stomach (gm.)	-0.903	0.002
Weight of liver (gm.)	Weight of testis (gm.)	0.729	0.04
Weight of liver (gm.)	Gonadosomatic index (GSI) (%)	0.928	0.001
Weight of testis (gm.)	Body weight (gm.)	0.864	0.006
Weight of testis (gm.)	Total length (cm)	0.812	0.014
Weight of testis (gm.)	Weight of stomach (gm.)	-0.788	0.02
Weight of testis (gm.)	Weight of liver (gm.)	0.729	0.04
Weight of testis (gm.)	Gastrosomatic index (GaSI) (%)	-0.97	0
Gastrosomatic index (GaSI) (%)	Salinity (ppt.)	0.73	0.04
Gastrosomatic index (GaSI) (%)	Body weight (gm.)	-0.953	0
Gastrosomatic index (GaSI) (%)	Total length (cm)	-0.876	0.004
Gastrosomatic index (GaSI) (%)	Weight of testis (gm.)	-0.97	0
Gonadosomatic index (GSI) (%)	Weight of stomach (gm.)	-0.746	0.034
Gonadosomatic index (GSI) (%)	Weight of liver (gm.)	0.928	0.001
Hepatosomatic index (HSI) (%)	Salinity (ppt.)	0.743	0.035
Hepatosomatic index (HSI) (%)	Body weight (gm.)	-0.83	0.011
Condition factor (K)	Standard length (cm)	-0.815	0.014

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

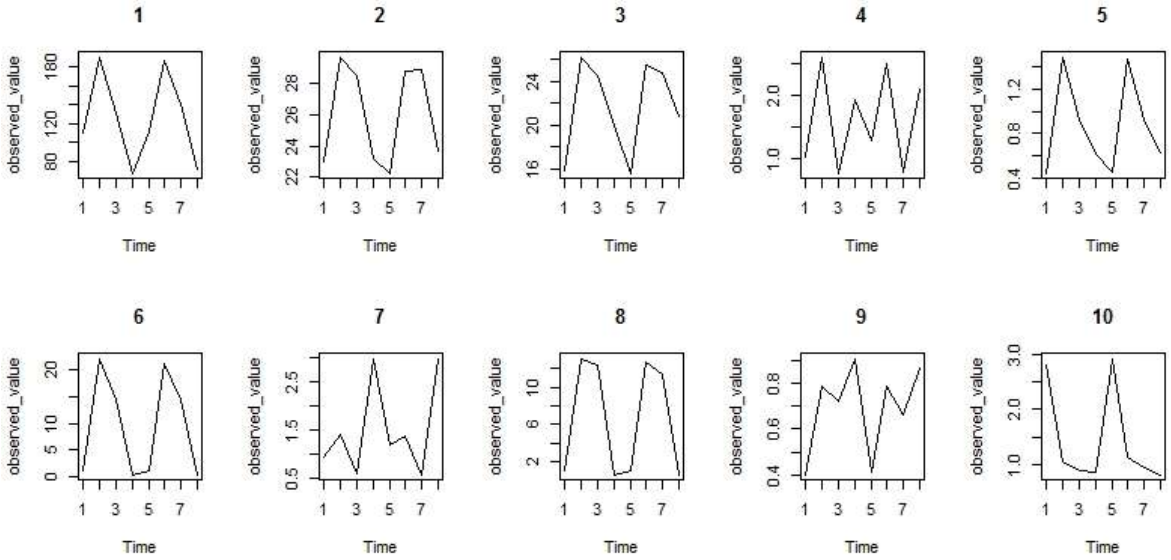
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level for GaSI.
- Winter, monsoon and post-monsoon have significant effect on GSI at 5% level.
- All the four seasons - winter, summer, monsoon and post-monsoon are significant at 5% level on HSI.
- Winter and summer are significant at 5% level whereas the other seasons do not exhibit any significant effect on condition factor (K).
- Four seasons are significant at 5% level on weight of testis.
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level on the weight of liver, weight of stomach, standard length, Total length and body weight of the adult male of *Clarias batrachus*.

Section 6 *Clarias batrachus* (Adult Female)

Part A Table of significant correlations among the different factors

Table-35	**Significant Correlations-*Clarias batrachus***		
Adult Female			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Total length (cm)	0.82	0.013
Body weight (gm.)	Weight of liver (gm.)	0.875	0.004
Body weight (gm.)	Weight of ovary (gm.)	0.932	0.001
Body weight (gm.)	Gonadosomatic index (GSI) (%)	0.866	0.005
Total length (cm)	Body weight (gm.)	0.82	0.013
Total length (cm)	Standard length (cm)	0.942	0
Total length (cm)	Weight of liver (gm.)	0.889	0.003
Total length (cm)	Weight of ovary (gm.)	0.962	0
Total length (cm)	Gonadosomatic index (GSI) (%)	0.984	0
Standard length (cm)	Total length (cm)	0.942	0
Standard length (cm)	Weight of liver (gm.)	0.888	0.003
Standard length (cm)	Weight of liver (gm.)	0.881	0.004
Standard length (cm)	Gonadosomatic index (GSI) (%)	0.89	0.003
Standard length (cm)	Condition factor (K)	-0.805	0.016
Weight of liver (gm.)	Body weight (gm.)	0.875	0.004
Weight of liver (gm.)	Total length (cm)	0.889	0.003
Weight of liver (gm.)	Standard length (cm)	0.888	0.003
Weight of liver (gm.)	Weight of ovary (gm.)	0.954	0
Weight of liver (gm.)	Gonadosomatic index (GSI) (%)	0.877	0.004
Weight of liver (gm.)	Body weight (gm.)	0.932	0.001
Weight of liver (gm.)	Total length (cm)	0.962	0
Weight of liver (gm.)	Standard length (cm)	0.881	0.004
Weight of ovary (gm.)	Weight of liver (gm.)	0.954	0
Weight of liver (gm.)	Gonadosomatic index (GSI) (%)	0.974	0
Gastrosomatic index (GaSI) (%)	Salinity (ppt.)	0.841	0.009
Gonadosomatic index (GSI) (%)	Body weight (gm.)	0.866	0.005
Gonadosomatic index (GSI) (%)	Total length (cm)	0.984	0
Gonadosomatic index (GSI) (%)	Standard length (cm)	0.89	0.003
Gonadosomatic index (GSI) (%)	Weight of liver (gm.)	0.877	0.004
Gonadosomatic index (GSI) (%)	Weight of ovary (gm.)	0.974	0
Hepatosomatic index (HSI) (%)	Condition factor (K)	-0.922	0.001
Condition factor (K)	Standard length (cm)	-0.805	0.016
Condition factor (K)	Hepatosomatic index (HSI) (%)	-0.922	0.001

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

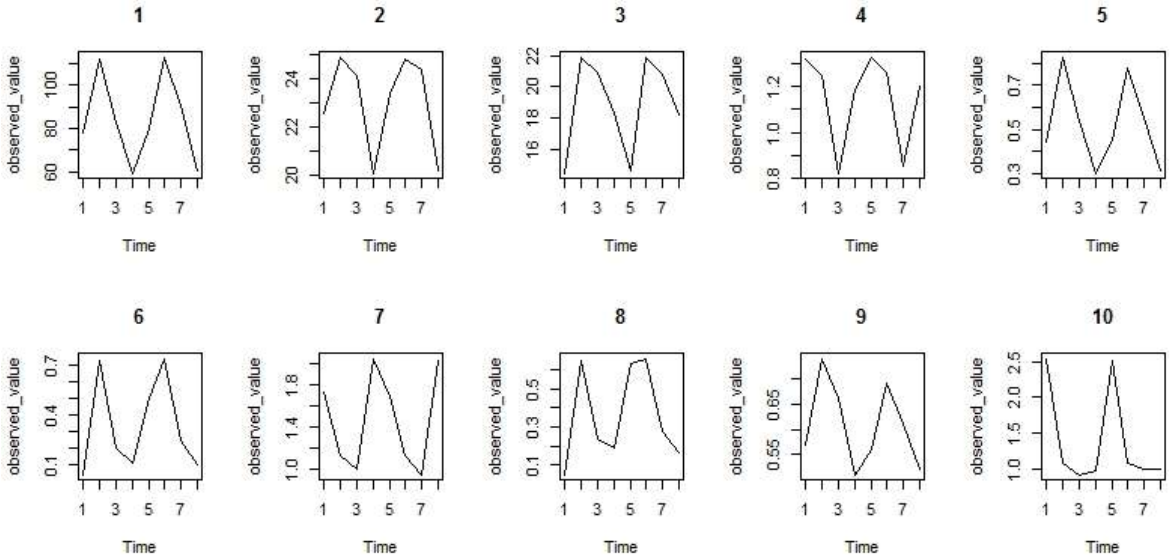
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level for GaSI.
- Monsoon and post-monsoon are only significant at 5% level on 'GSI' whereas rest of the seasons do not exhibit any significant effect.
- Winter, monsoon and post-monsoon effect of HSI are significantly at 5% level.
- Winter, summer and monsoon are significant at 5% level for condition factor (K) whereas rest of the season do not exhibit any significant effect.
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level for weight of liver, weight of stomach, standard length, total length and body weight of the adult female of *Clarias batrachus.*

Section 7 *Clarias batrachus* (Young Male)

Part A Table of significant correlations among the different factors

Table-36	**Significant Correlations –*Clarias batrachus***		
Young Male			
Var -1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Salinity (ppt.)	-0.714	0.047
Body weight (gm.)	Total length (cm)	0.909	0.002
Body weight (gm.)	Weight of liver (gm.)	0.989	0
Body weight (gm.)	Weight of testis (gm.)	0.86	0.006
Body weight (gm.)	Gastrosomatic index (GaSI) (%)	-0.798	0.018
Body weight (gm.)	Gonadosomatic index (GSI) (%)	0.74	0.036
Body weight (gm.)	Hepatosomatic index (HSI) (%)	0.931	0.001
Total length (cm)	Salinity (ppt.)	-0.818	0.013
Total length (cm)	Body weight (gm.)	0.909	0.002
Total length (cm)	Weight of liver (gm.)	0.879	0.004
Total length (cm)	Gastrosomatic index (GaSI) (%)	-0.917	0.001
Total length (cm)	Hepatosomatic index (HSI) (%)	0.873	0.005
Standard length (cm)	Hepatosomatic index (HSI) (%)	0.71	0.048
Standard length (cm)	Condition factor (K)	-0.863	0.006
Weight of liver (gm.)	Body weight (gm.)	0.989	0
Weight of liver (gm.)	Total length (cm)	0.879	0.004
Weight of liver (gm.)	Weight of testis (gm.)	0.856	0.007
Weight of liver (gm.)	Gastrosomatic index (GaSI) (%)	-0.791	0.019
Weight of liver (gm.)	Gonadosomatic index (GSI) (%)	0.726	0.042
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.968	0
Weight of testis (gm.)	Body weight (gm.)	0.86	0.006
Weight of testis (gm.)	Weight of liver (gm.)	0.856	0.007
Weight of testis (gm.)	Gonadosomatic index (GSI) (%)	0.97	0
Weight of testis (gm.)	Hepatosomatic index (HSI) (%)	0.754	0.031
Gastrosomatic index (GaSI) (%)	Body weight (gm.)	-0.798	0.018
Gastrosomatic index (GaSI) (%)	Total length (cm)	-0.917	0.001
Gastrosomatic index (GaSI) (%)	Weight of liver (gm.)	-0.791	0.019
Gastrosomatic index (GaSI) (%)	Hepatosomatic index (HSI) (%)	-0.842	0.009
Gonadosomatic index (GSI) (%)	Body weight (gm.)	0.74	0.036
Gonadosomatic index (GSI) (%)	Weight of liver (gm.)	0.726	0.042
Gonadosomatic index (GSI) (%)	Weight of testis (gm.)	0.97	0
Hepatosomatic index (HSI) (%)	Body weight (gm.)	0.931	0.001
Hepatosomatic index (HSI) (%)	Total length (cm)	0.873	0.005
Hepatosomatic index (HSI) (%)	Standard length (cm)	0.71	0.048
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.968	0
Hepatosomatic index (HSI) (%)	Weight of testis (gm.)	0.754	0.031
Hepatosomatic index (HSI) (%)	Gastrosomatic index (GaSI) (%)	-0.842	0.009
Condition factor (K)	Standard length (cm)	-0.863	0.006

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

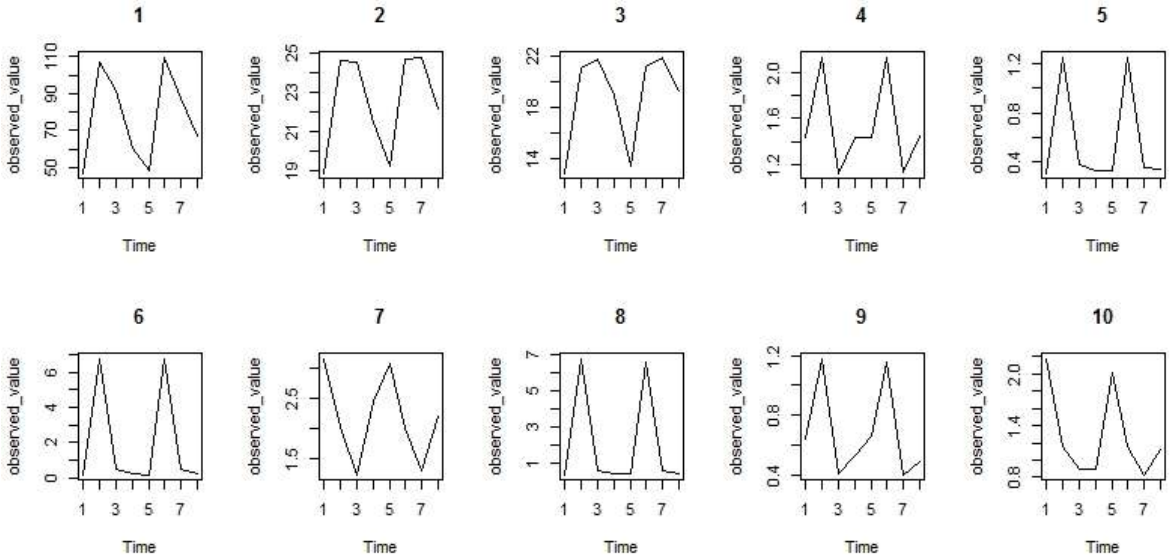
- Winter, summer, monsoon and post-monsoon are significant at 5% level for GaSI.
- The four seasons do not exhibit any significant effect on GSI.
- Winter, monsoon and post-monsoon are significant at 5% level on HSI.
- For condition factor, the seasonal effect of the winter and the summer are significant at 5% level whereas there is no significant effect of monsoon and post-monsoon on this factor.
- All the four seasons do not exhibit any significant effect on weight of testis.
- The seasonal effect of all the four seasons - winter, summer, monsoon and post-monsoon are significant at 5% level on the weight of liver, weight of stomach, standard length, total length and body weight of the young male of *Clarias batrachus*.

Section 8 *Clarias batrachus* (Young Female)

Part A Table of significant correlations among the different factors

Table-37	**Significant Correlations-*Clarias batrachus***		
Young Female			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P - Value**
Body weight (gm.)	Total length (cm)	0.94	0.001
Body weight (gm.)	Standard length (cm)	0.854	0.007
Body weight (gm.)	Weight of liver (gm.)	0.795	0.018
Body weight (gm.)	Weight of ovary (gm.)	0.792	0.019
Body weight (gm.)	Gastrosomatic index (GaSI) (%)	-0.747	0.033
Body weight (gm.)	Gonadosomatic index (GSI) (%)	0.783	0.22
Total length (cm)	Body weight (gm.)	0.94	0.001
Total length (cm)	Standard length (cm)	0.969	0
Total length (cm)	Gastrosomatic index (GaSI) (%)	-0.916	0.001
Body weight (gm.)	Condition factor (K)	-0.834	0.01
Standard length (cm)	Body weight (gm.)	0.854	0.007
Standard length (cm)	Total length (cm)	0.969	0
Standard length (cm)	Gastrosomatic index (GaSI) (%)	-0.926	0.001
Standard length (cm)	Condition factor (K)	-0.941	0
Weight of stomach (gm.)	Weight of liver (gm.)	0.921	0.001
Weight of stomach (gm.)	Weight of ovary (gm.)	0.922	0.001
Weight of stomach (gm.)	Gonadosomatic index (GSI) (%)	0.927	0.001
Weight of stomach (gm.)	Hepatosomatic index (HSI) (%)	0.977	0
Weight of liver (gm.)	Body weight (gm.)	0.795	0.018
Weight of liver (gm.)	Weight of stomach (gm.)	0.921	0.001
Weight of liver (gm.)	Weight of ovary (gm.)	1	0
Weight of liver (gm.)	Gonadosomatic index (GSI) (%)	0.999	0
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.94	0.001
Weight of ovary (gm.)	Body weight (gm.)	0.792	0.019
Weight of ovary (gm.)	Weight of stomach (gm.)	0.922	0.001
Weight of ovary (gm.)	Weight of liver (gm.)	1	0
Weight of ovary (gm.)	Gonadosomatic index (GSI) (%)	1	0
Weight of ovary (gm.)	Hepatosomatic index (HSI) (%)	0.942	0
Gastrosomatic index (GaSI) (%)	Body weight (gm.)	-0.747	0.033
Gastrosomatic index (GaSI) (%)	Total length (cm)	-0.916	0.001
Gastrosomatic index (GaSI) (%)	Standard length (cm)	-0.926	0.001
Gastrosomatic index (GaSI) (%)	Condition factor (K)	0.861	0.006
Gonadosomatic index (GSI) (%)	Body weight (gm.)	0.783	0.022
Gonadosomatic index (GSI) (%)	Weight of stomach (gm.)	0.927	0.001
Gonadosomatic index (GSI) (%)	Weight of liver (gm.)	0.999	0
Gonadosomatic index (GSI) (%)	Weight of ovary (gm.)	1	0
Gonadosomatic index (GSI) (%)	Hepatosomatic index (HSI) (%)	0.946	0
Hepatosomatic index (HSI) (%)	Weight of stomach (gm.)	0.977	0
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.94	0.001
Hepatosomatic index (HSI) (%)	Weight of ovary (gm.)	0.942	0
Hepatosomatic index (HSI) (%)	Gonadosomatic index (GSI) (%)	0.946	0
Condition factor (K)	Total length (cm)	-0.834	0.01
Condition factor (K)	Standard length (cm)	-0.941	0
Condition factor (K)	Gastrosomatic index (GaSI) (%)	0.861	0.006

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

- Winter, summer, monsoon and post-monsoon are significant at 5% level for GaSI.
- For the factor of GSI, only the seasonal effect of winter and monsoon are significant at 5% level.
- Four seasons are significant at 5% level for HSI.
- Winter and summer are significant at 5% level for condition factor (K) whereas the other two seasons do not exhibit any significant effect.
- The seasonal effects of four seasons are significant at 5% level for weight of ovary.
- Winter and monsoon are significant at 5% level but the summer and post-monsoon does not exhibit any significant effect on weight of liver.
- The seasonal effect of winter, monsoon and post-monsoon are significant at 5% level whereas the summer does exhibit any significant effect on weight of stomach.
- The seasonal effects of four seasons are significant at 5% level for standard length.

- The effect of all the four season winter, summer, monsoon and post-monsoon are significant at 5% level on total length.
- The seasonal effect of winter, summer, monsoon and post-monsoon are significant at 5% level for body weight.

Anabas testudineus

1st year – November, 2014 to October, 2015

Table No.- 38 Index Values and condition factor of *Anabas testudineus* of four Season – Winter, Summer, Monsoon and Post Monsoon

Sl. No.	Descriptive	Winter				Summer				Monsoon				Post Monsoon			
		Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female	Young Male	Young Female	Adult Male	Adult Female
1	Body weight (gm)	28.35 ±0.01	29.38 ±0.02	57.68 ±0.01	61.07 ±0.02	34.18 ±0.02	37.32 ±0.02	80.55 ±0.02	76.47 ±0.02	40.8 ±0.15	31.55 ±0.01	78.35 ±0.03	60.54 ±0.01	41.06 ±0.01	42.05 ±0.01	48.51 ±0.02	51.71 ±0.02
2	Total length (cm)	12.3 ±0.16	13 ±1.26	14.7 ±0.14	16.2 ±0.14	14.2 ±0.12	14.5 ±0.15	17 ±2.05	17 ±2.05	14.05 ±0.02	13.01 ±0.01	17 ±2.05	15.1 ±0.08	14.05 ±0.02	15.03 ±0.01	15.03 ±0.01	15.05 ±0.02
3	Standard length (cm)	10.16 ±0.02	10.5 ±0.13	12.3 ±0.16	13.7 ±0.14	11.3 ±0.13	11.5 ±0.13	15 ±1	14.9 ±0.19	12.02 ±0.01	10.01 ±0.01	13.06 ±0.02	13.05 ±0.02	11.06 ±0.01	12.02 ±0.01	12.06 ±0.01	12.05 ±0.01
4	Weight of stomach (gm)	0.15 ±0.01	0.17 ±0.02	0.68 ±0.03	0.44 ±0.02	0.15 ±0.01	0.57 ±0.01	0.6 ±0.16	1.06 ±0.01	1.16 ±0.01	0.61 ±0.02	2.53 ±0.01	1.05 ±0.01	0.74 ±0.01	0.56 ±0.01	0.77 ±0.02	0.79 ±0.03
5	Weight of liver (gm)	0.42 ±0.01	0.53 ±0.01	0.78 ±0.03	0.8 ±0.17	0.44 ±0.02	0.35 ±0.02	0.77 ±0.02	0.76 ±0.02	0.61 ±0.02	0.43 ±0.02	0.62 ±0.02	0.7 ±0.13	0.44 ±0.02	0.34 ±0.02	0.31 ±0.01	0.43 ±0.02
6	Weight of ovary (gm)	X	0.16 ±0.01	X	0.23 ±0.02	X	1.54 ±0.01	X	7.77 ±0.02	X	0.35 ±0.02	X	0.36 ±0.02	X	1.29 ±0.02	X	0.85 ±0.03
7	Weight of testis (gm)	0.14 ±0.01	X	0.08 ±0.01	X	0.36 ±0.02	X	7.6 ±0.22	X	0.14 ±0.02	X	0.18 ±0.02	X	0.08 ±0.01	X	0.81 ±0.01	X
8	Gastrosomatic index (GaSI) (%)	0.53 ±0.02	0.58 ±0.01	1.19 ±0.02	0.73 ±0.02	0.44 ±0.02	1.55 ±0.02	0.75 ±0.02	1.41 ±0.05	2.93 ±0.02	1.97 ±0.01	3.34 ±0.02	2.54 ±0.02	1.81 ±0.03	1.34 ±0.01	1.61 ±0.03	1.55 ±0.01
9	Gonadosomatic index (GSI) (%)	0.5 ±0.23	0.55 ±0.02	0.14 ±0.02	0.38 ±0.03	1.06 ±0.02	4.3 ±0.21	1.02 ±0.02	11.31 ±0.03	0.34 ±0.02	1.12 ±0.02	0.23 ±0.02	0.6 ±0.14	1.96 ±0.03	3.13 ±0.01	1.7 ±0.24	1.67 ±0.01
10	Hepatosomatic index (HSI) (%)	1.5 ±0.22	1.84 ±0.03	1.38 ±0.02	1.33 ±0.02	1.3 ±0.19	0.95 ±0.03	0.97 ±0.01	1 ±0.29	1.52 ±0.03	1.38 ±0.02	0.8 ±0.27	1.17 ±0.02	1.07 ±0.02	0.81 ±0.04	0.64 ±0.02	0.84 ±0.02
11	Condition factor (K)	2.7 ±0.21	2.54 ±0.02	3.1 ±0.24	2.38 ±0.02	2.37 ±0.02	2.45 ±0.01	2.39 ±0.02	2.31 ±0.02	2.25 ±0.02	3.06 ±0.02	3.11 ±0.03	2.46 ±0.03	2.67 ±0.03	2.34 ±0.02	2.43 ±0.02	2.65 ±0.02

Anabas testudineus

2[nd] year – November, 2015 to October, 2016

Table No.-39 Index Values and condition factor of *Anabas testudineus* of four Season – Winter, Summer, Monsoon and Post Monsoon

Sl. No.	Descriptive	Winter Young Male	Winter Young Female	Winter Adult Male	Winter Adult Female	Summer Young Male	Summer Young Female	Summer Adult Male	Summer Adult Female	Monsoon Young Male	Monsoon Young Female	Monsoon Adult Male	Monsoon Adult Female	Post Monsoon Young Male	Post Monsoon Young Female	Post Monsoon Adult Male	Post Monsoon Adult Female
1	Body weight (gm)	30.25 ±0.01	31.14 ±0.02	60.58 ±0.02	65.8 ±0.17	40.1 ±0.15	49.35 ±0.01	79.3 ±0.14	81.47 ±0.01	51.6 ±0.15	42.55 ±0.02	80.21 ±0.02	72.13 ±0.02	45.3 ±0.15	50.5 ±0.1	57.2 ±0.15	60.7 ±0.14
2	Total length (cm)	12.2 ±0.16	12.5 ±0.11	14.8 ±0.13	17.3 ±0.11	15.3 ±0.13	16.4 ±0.13	17.3 ±0.11	17.4 ±0.11	15.6 ±0.11	15.4 ±0.15	16.9 ±0.15	15.8 ±0.11	15.1 ±0.08	15.7 ±0.11	15.4 ±0.15	15.7 ±0.11
3	Standard length (cm)	10.18 ±0.02	10.3 ±0.13	12.7 ±0.15	15.1 ±0.08	13.8 ±0.21	14.2 ±0.14	15.1 ±0.08	15.3 ±0.13	13.3 ±0.14	12.8 ±0.15	14.5 ±0.08	12.7 ±0.15	11.8 ±0.15	12.3 ±0.16	12.9 ±0.15	12.8 ±0.15
4	Weight of stomach (gm)	0.18 ±0.02	0.2 ±0.08	0.7 ±0.13	0.45 ±0.02	0.17 ±0.02	0.62 ±0.02	0.6 ±0.13	1.8 ±0.13	1.8 ±0.13	0.72 ±0.02	2.54 ±0.01	1.58 ±0.02	0.76 ±0.02	0.6 ±0.13	0.78 ±0.02	0.77 ±0.02
5	Weight of liver (gm)	0.43 ±0.01	0.54 ±0.01	0.8 ±0.17	0.83 ±0.12	0.45 ±0.12	0.42 ±0.12	0.78 ±0.01	0.8 ±0.17	0.63 ±0.02	0.41 ±0.03	0.64 ±0.02	0.81 ±0.01	0.45 ±0.02	0.37 ±0.02	0.33 ±0.02	0.43 ±0.02
6	Weight of ovary (gm)	X	0.18 ±0.02	X	0.33 ±0.02	X	2.17 ±0.02	X	7.78 ±0.02	X	0.43 ±0.02	X	0.42 ±0.02	X	1.4 ±0.12	X	0.87 ±0.01
7	Weight of testis (gm)	0.15 ±0.01	X	0.1 ±0.39	X	0.43 ±0.02	X	0.8 ±0.13	X	0.15 ±0.01	X	0.19 ±0.02	X	0.1 ±1.39	X	0.73 ±0.02	X
8	Gastrosomatic index (GaSI) (%)	0.6 ±0.21	0.65 ±0.02	1.17 ±0.02	0.69 ±0.02	0.43 ±0.02	1.27 ±0.02	0.76 ±0.02	2.26 ±0.02	3.61 ±0.02	1.72 ±0.03	3.27 ±0.02	2.24 ±2.24	1.71 ±0.02	1.2 ±0.13	1.38 ±0.02	1.28 ±0.03
9	Gonadosomatic index (GSI) (%)	0.5 ±0.17	0.58 ±0.01	0.17 ±0.04	0.5 ±0.17	1.08 ±0.02	4.6 ±0.14	1.02 ±0.02	10.56 ±0.02	0.29 ±0.03	1.02 ±0.02	0.24 ±0.03	0.59 ±0.03	0.22 ±0.01	2.85 ±0.03	1.29 ±0.02	1.45 ±0.03
10	Hepatosomatic index (HSI) (%)	1.44 ±0.02	1.76 ±0.02	1.34 ±0.02	1.28 ±0.03	1.13 ±0.02	0.86 ±0.02	0.99 ±0.04	0.99 ±0.04	1.24 ±0.02	0.97 ±0.02	0.8 ±0.27	1.14 ±0.01	1 ±0.29	0.74 ±0.02	0.58 ±0.02	0.71 ±0.01
11	Condition factor (K)	2.87 ±0.03	2.85 ±0.02	2.96 ±0.02	1.91 ±0.01	1.53 ±0.02	1.72 ±0.02	2.3 ±0.14	2.27 ±0.03	2.19 ±0.03	2.03 ±0.02	2.63 ±0.02	3.52 ±0.02	2.76 ±0.02	2.71 ±0.03	2.66 ±0.03	2.89 ±0.02

Anabas testudineus

Study of gastrosomatic index (GaSI)

Gastrosomatic index of male and female, young and adult of *Anabas testudineus* were determined separately in (Table-38 & 39).The mean GaSI values of young and adult male has showed highest value (3.27±0.03, 3.31±0.04) in the monsoon and lowest value (0.44±0.02, 0.76±0.02) in the summer season. Similarly young and adult female were observed to be highest value (1.85±0.13, 2.39±0.15) in the season of monsoon and lowest value (0.62±0.04, 0.71±0.02) in the winter season. The gastrosomatic index value increased in monsoon and gradually decreases from winter to summer. Gastrosomatic index level started to increase during April to July (pre-spawning) before coming back to post-spawning (September to October), table-40 and fig. 38.

Mean seasonal variation of gastrosomatic index (GaSI) of *Anabas testudineus* during the study period

Table- 40

	Adult male	Young male	Adult female	Young female
Winter	1.18±0.02	0.57±0.15	0.71±0.02	0.62±0.04
Summer	0.76±0.02	0.44±0.02	1.84±0.04	1.41±0.14
Monsoon	3.31±0.04	3.27±0.03	2.39±0.15	1.85±0.13
Post-monsoon	1.50±0.11	1.76±0.06	1.42±0.14	1.27±0.11

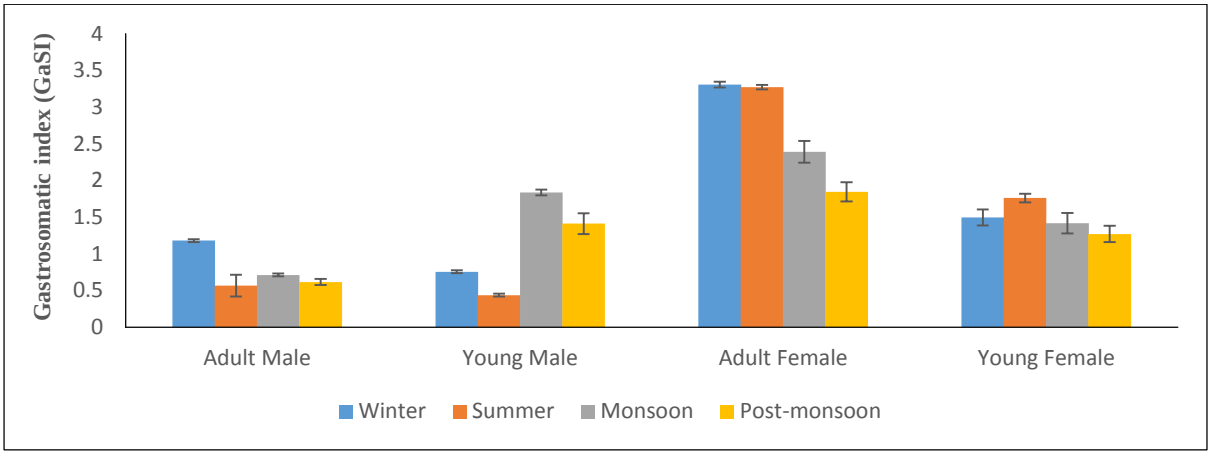


Fig. 38 Graphical representation showing gastrosomatic index (GaSI) of *Anabas testudineus* (two annual cycles)

Study of gonadosomatic index (GSI)

Mean Gonadosomatic index values attains its peak value (1.09±0.09, 1.50±0.03) in case of young and adult males in post-monsoon and lowest value (0.32±0.03, 0.16±0.03) in the season

of monsoon and winter. Similarly young and adult female showed highest value (4.45±0.03, 10.94±0.04) in the season of summer and lowest value (0.57±0.02, 0.44±0.13) in the winter season.

The highest gonadosomatic index value of male are observed in the season of post-monsoon and lowest value was observed in the monsoon and winter season. Similarly the GSI highest values of female were observed in the summer season and lowest value in the winter season. The present study shows that gonadosomatic index value increased as the increasing of gonad development. Information are available about gonadal developmental stage and its maturity and reproduction cycle throughout the year table-41 and fig. 39. Gonadosomatic index varied which depends upon length, weight and sex in present study. Hossain et al., (2002) said that GSI and HSI values were subjected to change on impact of temperature, DO, and pH values of species.

Mean seasonal variation of gonadosomatic index (GSI) of *Anabas testudineus* during the study period

Table- 41

	Adult male	Young male	Adult female	Young female
Winter	0.16±0.03	0.5±0.02	0.44±0.13	0.57±0.02
Summer	1.02±0.02	1.07±0.02	10.94±0.04	4.45±0.03
Monsoon	0.24±0.02	0.32±0.03	0.60±0.1	1.07±0.05
Post-monsoon	1.50±0.03	1.09±0.09	1.56±0.11	2.99±0.14

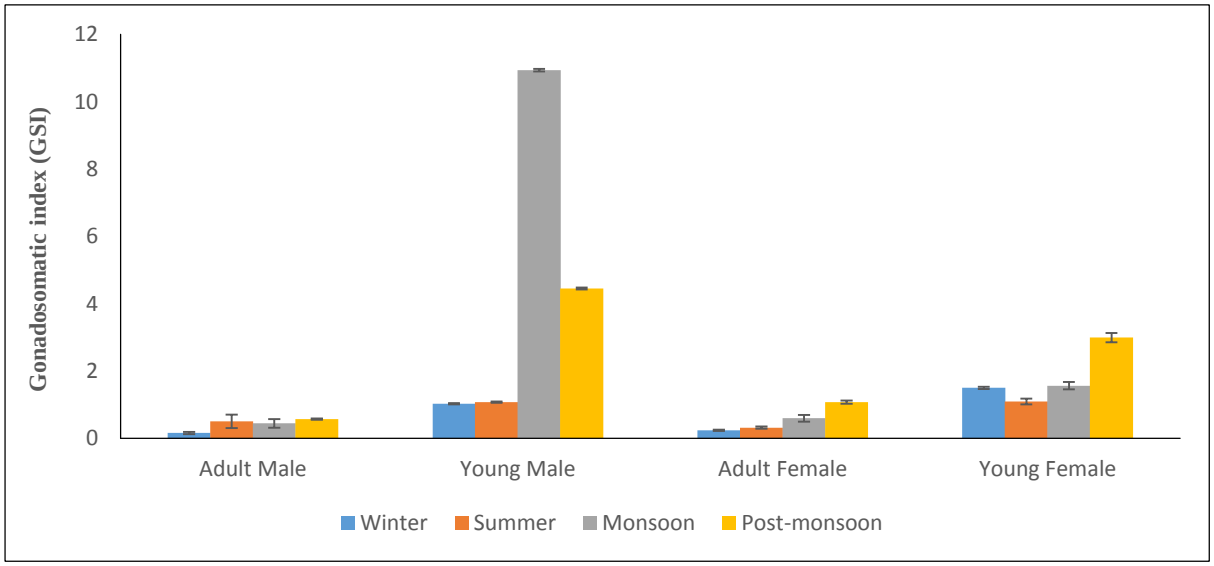


Fig. 39 Graphical representation showing gonadosomatic index (GSI) of *Anabas testudineus* (two annual cycles)

Study of hepatosomatic index (HSI)

Hepatosomatic index of males and females of *Anabas testudineus* are determined separately in (Table-38 & 39). In male young and adult the HSI mean values attained its peak value (1.47±0.11, 1.36±0.03) in winter and lowest value (1.03±0.02, 0.61±0.03) in post-monsoon. The HSI value of young and adult female attains its highest value (1.8±0.05, 1.31±0.03) in winter season and lowest value (0.78±0.05, 0.78±0.07) in the post-monsoon. The hepatosomatic index value was increased in winter season of both male and female whereas decreasing in post-monsoon table-42 and fig. 40.

Mean seasonal variation of hapatosomatic index (HSI) of *Anabas testudineus* during the study period

Table- 42

	Adult male	Young male	Adult female	Young female
Winter	1.36±0.03	1.47±0.11	1.31±0.03	1.8±0.05
Summer	0.98±0.03	1.22±0.11	1.0±0.02	0.91±0.05
Monsoon	0.8±0.03	1.38±0.14	1.16±0.02	1.18±0.02
Post-monsoon	0.61±0.03	1.03±0.02	0.78±0.07	0.78±0.05

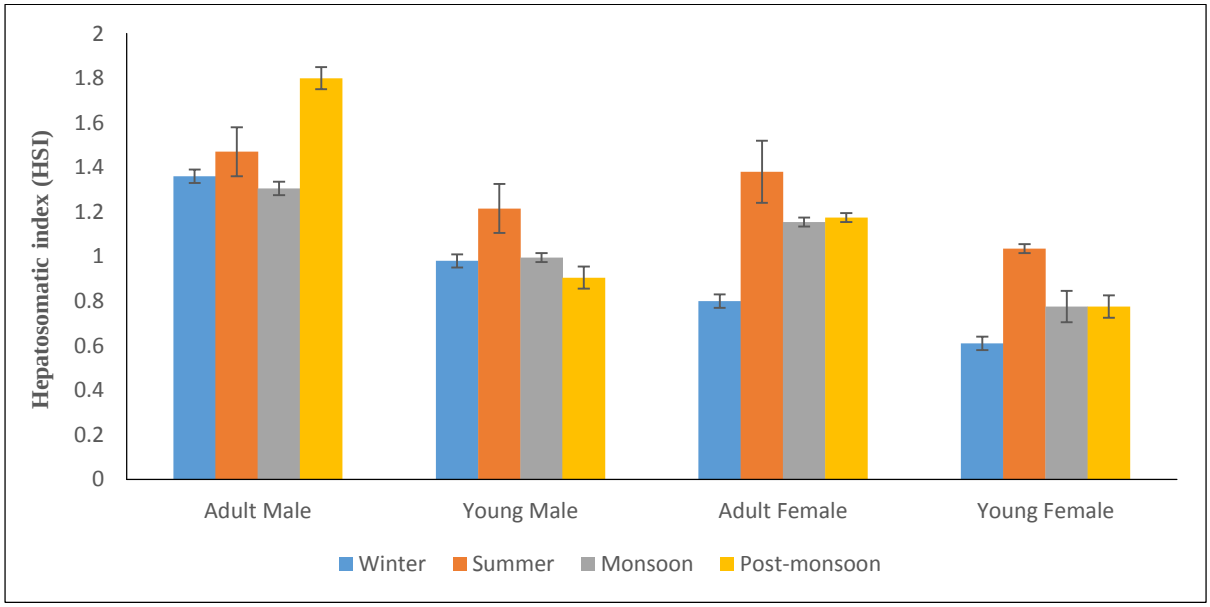


Fig. 40 Graphical representation showing hapatosomatic index (HSI) of *Anabas testudineus* (two annual cycles)

Condition factor (K)

The value of condition factor (K) recorded in the present study of male and female, young and adult of *Anabas testudineus* is determined separately in (Table-38 & 39). The mean condition

factor (K) of young and adult male are observed highest value (2.79±0.11, 3.03±0.12) in the season of winter and lowest value (1.95±0.14, 2.35±0.11) in the season of summer and young and adult female are observed highest value (2.70±0.11, 2.99±0.14) in the season of winter and monsoon and lowest value (2.09±0.12, 2.15±0.14) in the season of summer and winter in (Table-43 and Fig. 41). All the specimens of *Heteropneustes fossilis, Clarias batrachus* and *Anabas testudineus* are classified into four seasons based on male and female. The mean values of gastrosomatic index, gonadosomatic index, hepatosomatic index and condition factor (K) of the species are recorded. Information is available about gonadal developmental stage and its maturity and reproduction cycle throughout the year. It is observed that the GSI and HSI vary in common fish and they are co-related with each other.

Mean seasonal variation of Condition factor (K) of *Anabas testudineus* during the study period

Table- 43

	Adult male	Young male	Adult female	Young female
Winter	3.03±0.12	2.79±0.11	2.15±0.14	2.70±0.11
Summer	2.35±0.11	1.95±0.14	2.29±0.03	2.09±0.12
Monsoon	2.87±0.11	2.22±0.04	2.99±0.14	2.55±0.12
Post-monsoon	2.55±0.11	2.72±0.05	2.77±0.12	2.53±0.12

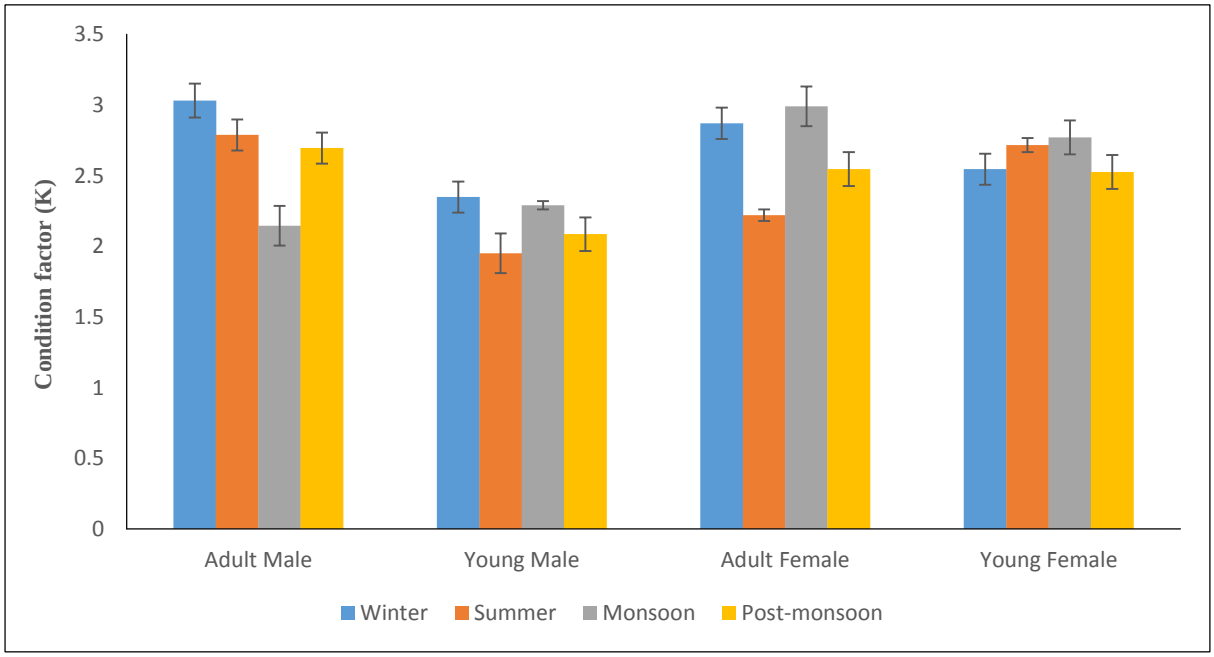


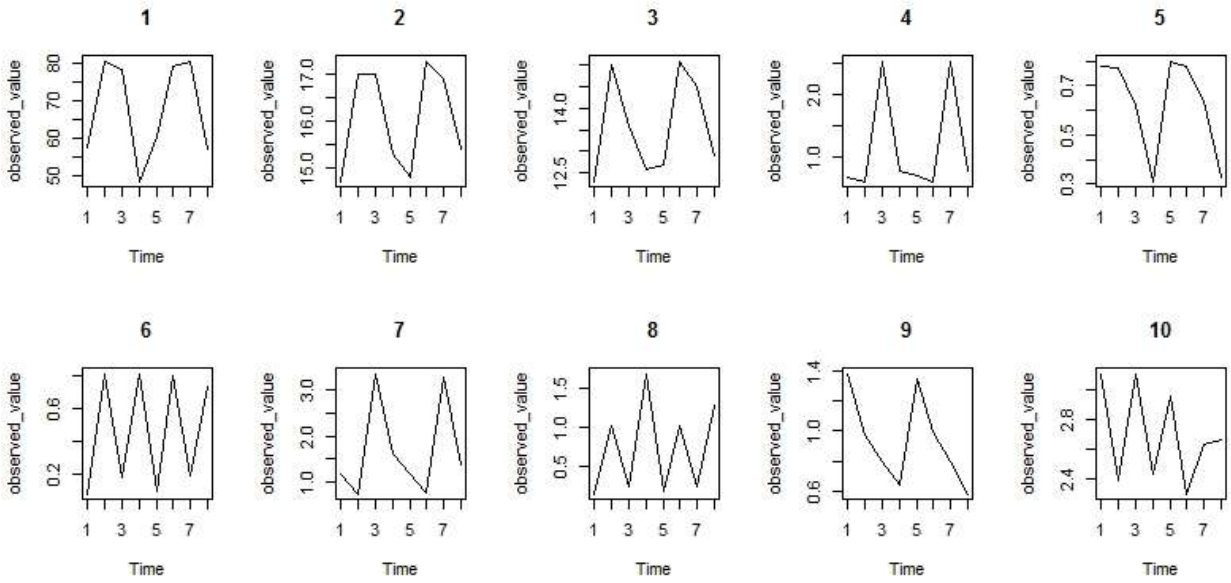
Fig. 41 Graphical representation showing condition factor (K) of *Anabas testudineus* (two annual cycles)

Section 9 *Anabas testudineus* (Adult Male)

Part A Table of significant correlations among the different factors

Table-44	**Significant Correlations - *Anabas testudineus***		
Adult Male			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P - Value**
Body weight (gm.)	Total length (cm)	0.905	0.002
Body weight (gm.)	Standard length (cm)	0.891	0.003
Total length (cm)	Body weight (gm.)	0.905	0.002
Total length (cm)	Standard length (cm)	0.923	0.001
Standard length (cm)	Body weight (gm.)	0.891	0.003
Standard length (cm)	Total length (cm)	0.923	0.001
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.979	0
Weight of liver (gm.)	Salinity (ppt.)	-0.821	0.013
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.833	0.01
Weight of testis (gm.)	Gonadosomatic index (GSI) (%)	0.934	0.001
Weight of testis (gm.)	Condition factor (K)	-0.872	0.005
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.979	0
Gonadosomatic index (GSI) (%)	Weight of testis (gm.)	0.934	0.001
Gonadosomatic index (GSI) (%)	Condition factor (K)	-0.76	0.029
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.833	0.01
Condition factor (K)	Weight of testis (gm.)	-0.872	0.005
Condition factor (K)	Gonadosomatic index (GSI) (%)	-0.76	0.029

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

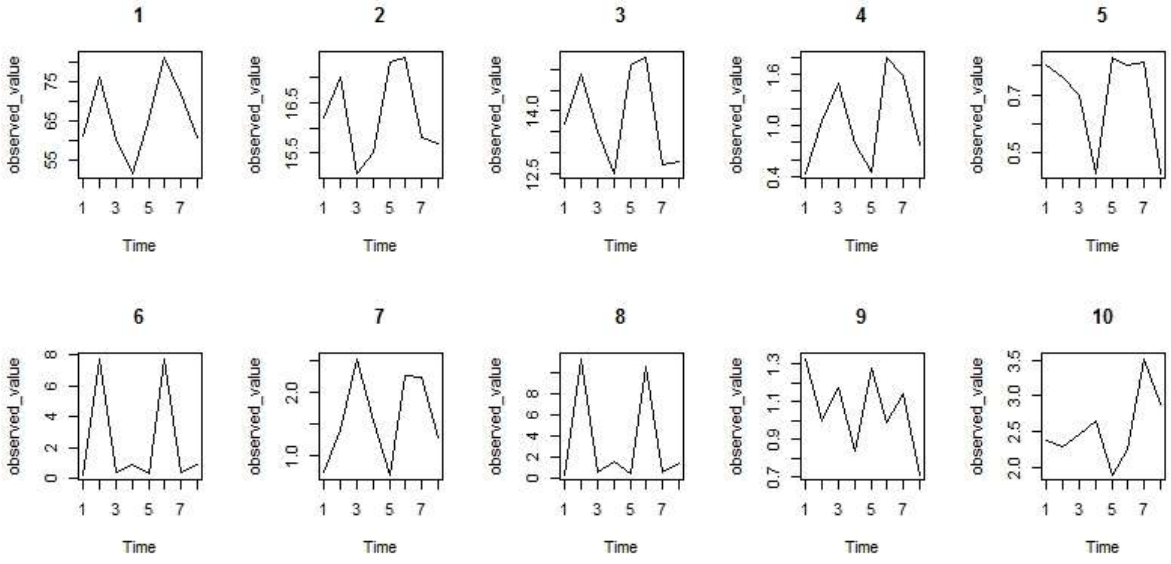
- All season winter, summer, monsoon and post-monsoon are significant at 5% level on 'GaSI' of adult male of *Anabas testudineus*.
- The seasonal effect of winter, summer, monsoon and post-monsoon are significant at 5% level for 'GSI'.
- All the four seasons are significant at 5% level on HSI.
- Winter has significant effect at 5% level whereas rest of the seasons do not exhibit any significant effect for conditioning factor.
- Winter, summer and post-monsoon are significant at 5% level but monsoon do not any significant effect on weight of testis for this species.
- Total four seasons are significant at 5% level for weight of liver.
- The seasonal effects of all season are significant at 5% level.
- Winter, monsoon and post-monsoon are significant at 5% level whereas summer do not any significant effect.
- Four seasons are significant at 5% level on total length.
- Winter, monsoon and post-monsoon are significant at 5% level whereas rest of the seasons do not exhibit any significant effect on body weight of adult male of *Anabas testudineus***.**

Section 10 *Anabas testudineus* (Adult Female)

Part A Table of significant correlations among the different factors

Table-45	**Significant Correlations-*Anabas testudineus***		
Adult Female			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Total length (cm)	0.712	0.048
Body weight (gm.)	Weight of ovary (gm.)	0.778	0.023
Body weight (gm.)	Gonadosomatic index (GSI) (%)	0.753	0.031
Total length (cm)	Body weight (gm.)	0.712	0.048
Total length (cm)	Standard length (cm)	0.896	0.003
Standard length (cm)	Total length (cm)	0.896	0.003
Standard length (cm)	Condition factor (K)	-0.775	0.024
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.944	0
Weight of liver (gm.)	Salinity (ppt.)	-0.903	0.002
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.825	0.012
Weight of ovary (gm.)	Body weight (gm.)	0.778	0.023
Weight of ovary (gm.)	Gonadosomatic index (GSI) (%)	0.999	0
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.944	0
Gonadosomatic index (GSI) (%)	Body weight (gm.)	0.753	0.031
Gonadosomatic index (GSI) (%)	Weight of ovary (gm.)	0.999	0
Hepatosomatic index (HSI) (%)	Salinity (ppt.)	-0.729	0.04
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.825	0.012
Condition factor (K)	Alkalinity (mg/l)	-0.83	0.011
Condition factor (K)	Ca (mg/l)	0.735	0.038
Condition factor (K)	Standard length (cm)	-0.775	0.024

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

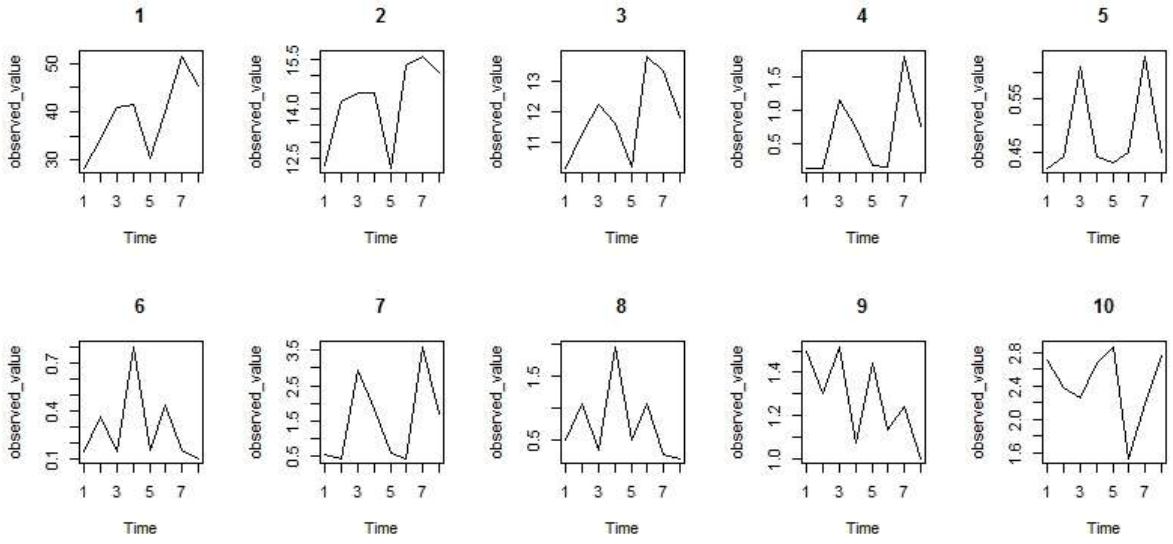
- Winter and post-monsoon have significant effect at 5% level on GaSI but summer and monsoon do not have any significant effect.
- All the four seasons' winter, summer, monsoon and post-monsoon have significant effect on GSI at 5% level.
- The seasonal effects of winter, summer, monsoon and post-monsoon are significant at 5% level for HSI.
- Only the effect of winter season is significant at 5% level on condition factor (K) whereas rest of the seasons do not exhibit any significant effect.
- All seasons are significant at 5% level on weight of testis and weight of liver.
- For the weight of stomach, winter, monsoon and post-monsoon are significant at 5%, level respectively whereas summer season does not exhibit any significant effect.
- Winter, summer and monsoon are significant at 5% level on standard length and total length.
- The seasonal effect of winter, summer and monsoon are significant at 5% level on body weight.

Section 11 *Anabas testudineus* (Young Male)

Part A Table of significant correlations among the different factors

Table-46	**Significant Correlations -*Anabas testudineus***		
Young Male			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P-Value**
Body weight (gm.)	Water Temperature 0° C	0.708	0.049
Body weight (gm.)	Total length (cm)	0.901	0.002
Body weight (gm.)	Standard length (cm)	0.777	0.023
Body weight (gm.)	Weight of stomach (gm.)	0.842	0.009
Body weight (gm.)	Gastrosomatic index (GaSI) (%)	0.796	0.018
Total length (cm)	Body weight (gm.)	0.901	0.002
Total length (cm)	Standard length (cm)	0.901	0.002
Standard length (cm)	Body weight (gm.)	0.777	0.023
Standard length (cm)	Total length (cm)	0.901	0.002
Standard length (cm)	Condition factor (K)	-0.85	0.007
Weight of stomach (gm.)	Body weight (gm.)	0.842	0.009
Weight of stomach (gm.)	Weight of liver (gm.)	0.893	0.003
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.989	0
Weight of liver (gm.)	Weight of stomach (gm.)	0.893	0.003
Weight of liver (gm.)	Gastrosomatic index (GaSI) (%)	0.902	0.002
Weight of testis (gm.)	Gonadosomatic index (GSI) (%)	0.987	0
Gastrosomatic index (GaSI) (%)	Body weight (gm.)	0.796	0.018
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.989	0
Gastrosomatic index (GaSI) (%)	Weight of liver (gm.)	0.902	0.002
Gonadosomatic index (GSI) (%)	Weight of testis (gm.)	0.987	0
Condition factor (K)	Standard length (cm)	-0.85	0.007

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

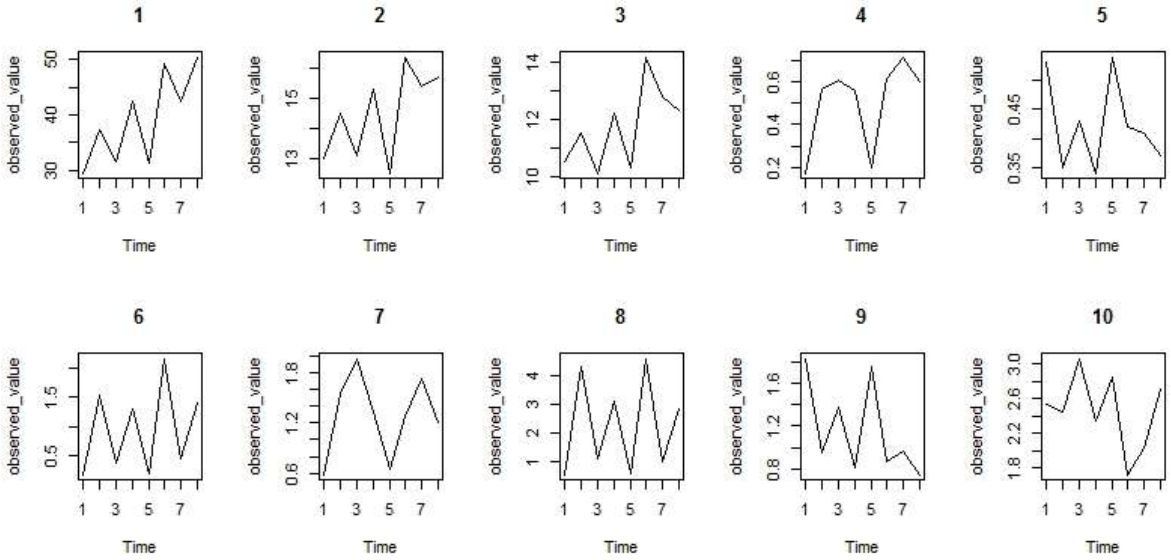
- All the four seasons' winter, summer, monsoon and post-monsoon are significant at 5% level on GaSI.
- The four seasons do not exhibit any significant effect on GSI.
- The seasonal effects of winter, summer and post-monsoon on HSI are significant at 5% level but monsoon do not significant effect.
- Winter and monsoon have significant effect on condition factor (K) at 5% level while the other two seasons do not have any effect on this factor.
- All seasons do not exhibit any significant effect.
- The effect of the winter, monsoon and post-monsoon are significant on both the weight of stomach and liver.
- Winter and post-monsoon are significant at 5% level.
- Winter has significant effect on standard length at 5% level whereas rest of the seasons do not exhibit any significant effect.
- Winter and summer are significant at 5% level on total length.
- Winter has significant effect at 5% level on body weight whereas rest of the seasons do not exhibit any significant effect.

Section 12 *Anabas testudineus* (Young Female)

Part A Table of significant correlations among the different factors

Table-47	**Significant Correlations - *Anabas testudineus***		
Young Female			
Var - 1	**Var - 2**	**Corr. Coeff. (r)**	**P - Value**
Body weight (gm.)	Water Temperature 0° C	0.728	0.041
Body weight (gm.)	Electrical conductivity (µ/cm)	0.73	0.04
Body weight (gm.)	Water level (ft)	-0.707	0.05
Body weight (gm.)	Total length (cm)	0.957	0
Body weight (gm.)	Standard length (cm)	0.894	0.003
Body weight (gm.)	Weight of ovary (gm.)	0.786	0.021
Body weight (gm.)	Hepatosomatic index (HSI) (%)	-0.886	0.003
Total length (cm)	Body weight (gm.)	0.957	0
Total length (cm)	Standard length (cm)	0.953	0
Total length (cm)	Weight of stomach (gm.)	0.741	0.035
Total length (cm)	Weight of liver (gm.)	-0.716	0.046
Total length (cm)	Weight of ovary (gm.)	0.812	0.014
Total length (cm)	Gonadosomatic index (GSI) (%)	0.727	0.041
Total length (cm)	Hepatosomatic index (HSI) (%)	-0.913	0.002
Total length (cm)	Condition factor (K)	-0.753	0.031
Standard length (cm)	Body weight (gm.)	0.894	0.003
Standard length (cm)	Total length (cm)	0.953	0
Standard length (cm)	Weight of ovary (gm.)	0.772	0.025
Standard length (cm)	Hepatosomatic index (HSI) (%)	-0.773	0.025
Standard length (cm)	Condition factor (K)	-0.887	0.003
Weight of stomach (gm.)	Total length (cm)	0.741	0.035
Weight of stomach (gm.)	Weight of liver (gm.)	-0.813	0.014
Weight of stomach (gm.)	Gastrosomatic index (GaSI) (%)	0.876	0.004
Weight of stomach (gm.)	Hepatosomatic index (HSI) (%)	-0.857	0.007
Weight of liver (gm.)	Total length (cm)	-0.716	0.046
Weight of liver (gm.)	Weight of stomach (gm.)	-0.813	0.014
Weight of liver (gm.)	Gonadosomatic index (GSI) (%)	-0.714	0.047
Weight of liver (gm.)	Hepatosomatic index (HSI) (%)	0.922	0.001
Weight of ovary (gm.)	Body weight (gm.)	0.786	0.021
Weight of ovary (gm.)	Total length (cm)	0.812	0.014
Weight of ovary (gm.)	Standard length (cm)	0.772	0.025
Weight of ovary (gm.)	Gonadosomatic index (GSI) (%)	0.977	0
Weight of ovary (gm.)	Hepatosomatic index (HSI) (%)	-0.79	0.02
Gastrosomatic index (GaSI) (%)	Weight of stomach (gm.)	0.876	0.004
Gonadosomatic index (GSI) (%)	Total length (cm)	0.727	0.041
Gonadosomatic index (GSI) (%)	Weight of liver (gm.)	-0.714	0.047
Gonadosomatic index (GSI) (%)	Weight of ovary (gm.)	0.977	0
Gonadosomatic index (GSI) (%)	Hepatosomatic index (HSI) (%)	-0.76	0.029
Hepatosomatic index (HSI) (%)	Body weight (gm.)	-0.886	0.003
Hepatosomatic index (HSI) (%)	Total length (cm)	-0.913	0.002
Hepatosomatic index (HSI) (%)	Standard length (cm)	-0.773	0.025
Hepatosomatic index (HSI) (%)	Weight of stomach (gm.)	-0.857	0.007
Hepatosomatic index (HSI) (%)	Weight of liver (gm.)	0.922	0.001
Hepatosomatic index (HSI) (%)	Weight of ovary (gm.)	-0.75	0.02
Hepatosomatic index (HSI) (%)	Gonadosomatic index (GSI) (%)	-0.76	0.029
Condition factor (K)	Total length (cm)	-0.753	0.031
Condition factor (K)	Standard length (cm)	-0.887	0.003

Part B. Time Series Plot of Fish data



Part C. Test for seasonal study

Findings:

- The seasonal effects of winter, summer and post-monsoon are significant at 5% level for GaSI.
- All seasons have significant effect on GSI at 5% level.
- Winter and summer at 5% level are significant on HSI.
- Only winter has significant effects at 5% level on condition factor (K) whereas rest of the seasons do not exhibit any significant effect.
- Winter, summer, monsoon and post-monsoon are significant factors for the weight of testis at 5%.
- The seasonal effects of winter, summer and post-monsoon on weight of liver are significant.
- Winter and summer have significant effects at 5% level on weight of stomach whereas monsoon and post-monsoon do not exhibit any significant effect.

- Only winter has significant effect on standard length at 5% level whereas the other three seasons do not exhibit any significant effect.
- Winter and summer have significant effect on total length at 5% level whereas rest three seasons do not any significant effect.
- The seasonal effect of winter is significant at 5% level on body weight of young female of *Anabas testudineus* whereas rest of the seasons do not exhibit any significant effect.

6.4 DISCUSSION

The three hundred twenty fishes of *Heteropneustes fossilis*, the mean values of gastrosomatic index increases in monsoon to post-monsoon and decreases in the winter to summer. The mean values of hepatosomatic index increases in the season of monsoon to winter whereas decreases of male in the season of monsoon and post-monsoon and female in the monsoon to post-monsoon and decreases in the winter and summer. The mean values of gonadosomatic index of male increases in the season of monsoon and that of female in summer decreases in post-monsoon to winter. Condition factor (K) increases in winter and decrease in monsoon and post-monsoon.

The mean values of gastrosomatic index on *Clarias batrachus* increases in post-monsoon and winter and decreases in monsoon. The mean values of hepatosomatic index increases in young male and female in summer whereas in adult male and female it is in post-monsoon whereas it decreases in monsoon. The mean values of gonadosomatic index increases in summer and monsoon as well as decreases in monsoon and post-monsoon. The highest values of HSI indicates heavier liver. In the present study, condition factor (K) increases as increasing in body weight. The lowest values during the post-spawning period (Htun-Han, 1978) where similar results are indicated (Table-30-33). The condition factor (K) increases in winter and decreases

in monsoon of both male and female. Similarly in *Anabas testudineus*, the mean values of gastrosoomatic index increases in monsoon and decreases in winter and summer. The hepatosomatic index increases in winter and decreases in post-monsoon. Hepatosomatic index level undergoes regular fluctuation throughout the breeding season. The mean values of gonadosomatic index increases in summer and post-monsoon. The highest value of HSI indicates in male and that of female in summer. The lowest value of condition factor (K) is found in winter in the case of both male and female whereas it increases in monsoon and gradually decreases from winter to summer. According to Chondar (1999) GSI of *Corydoras punctatus* normally varies from 1.1, 3.6. Jons et al., (2005) indicates that feeding activates of fish (matured) becomes high during February to April. In present study, the highest GSI values of female than the male indicate that the female attains early maturity than the male. Similarly HSI value of female establishes higher than male indicates that again signifies the growth and maturity in female is faster than male.

The GSI value of female is higher than male in summer and monsoon. Such results indicate that the spawning season of the fish commence little later (July to September). According to Coates (1990) that spawning season of *Liza tade* may start in May to June and continue till September. With regards to condition factor (K) value, the female again shows little higher fecundity than the male. The same opinion has been made by Ghosh (2000).

Generally the GSI values are low during spawning season of fish species (Kamanga et al., 2000). In this study, the GSI value is observed to be low in male than the female. Further the GSI value of both female and male are quite higher during pre-spawning season (Chacko, 1945). The present study also agrees with the above researchers. The GSI value of the female specimen which refers to a quite higher value than present observation. It indicates that the male specimen under observation is immature and female is about to mature. Beginning from

January, the condition factor (K) is higher in female and lower in male whereas condition factor (K) increases in February in female and decreases in male. The minimum condition factor (K) is exhibited by both the sexes during April may be due to spawning activity. The higher condition factor (K) is exhibited during July to October in female and July to August in male may be due to body maturity and matured condition of higher gonads. In the beginning of study in between the period of November, 2014 to October, 2016, progression of curve shows similar trend. Condition factor (K) is used on seasonal variation of the condition of fish in relation to its environment, relation nutritional and biological cycles of fish species (Chatterjee et al., 2007). Condition factor (K) always shows an inverse relationship with the gonadosomatic index and percentage of empty stomach.