INTERNATIONAL JOURNAL OF BIOASSAYS
ISSN: 2278-778X
CODEN: IJBNHY
ORIGINAL RESEARCH ARTICLE
OPEN ACCESS

STUDIES ON COMPARATIVE MORPHOLOGY AND ANATOMY OF CERTAIN BODY TISSUES OF THREE FRESHWATER TELEOSTS

Sanatan Singh*, PK Dixit and AK Patra
Post Graduate Department of Zoology, Berhampur University, Berhampur-760007, Ganjam, Odisha, India

Received for publication: February 12, 2015; **Accepted:** April 28, 2015

Abstract: The present study was carried out to determine the morphological and anatomical characters of three freshwater air-breathing fishes *Clarias Batrachus, Channa Punctatus*, *Anabas testudineus* and to characterize the length, weight of alimentary tract and reproductive aspects like condition factor (k), Gastrosomatic Index(GSI), Gonadosomatic Index (GnSI), Hepatosomatic Index (HSI), Relative length of Intestine and Somatogastric Index. The result obtained indicated adverse effects on the gonads as well as on liver weight. The remarkable factor of Gastrosomatic Index (GSI) of three different fishes were significantly decreased as compared to their increase in body weight. The average Gastrosomatic Index (GSI), Gonadosomatic Index (GnSI), Hepatosomatic Index (HSI) and condition factor (k) of *C. Batrachus, C. Punctatus* and *A. testudinas* were (4.42, 4.60, 4.62), (3.74, 3.59, 1.48), (4.10, 3.41, 3.46), (0.91, 1.63, 2,88) were reported respectively. The weight length relationship, Gastrosomatic Index, Gonadosomatic Index, Hepatosomatic Index and Condition factor were found to be differed in three freshwater fishes analyzed. The relative length of Intestine and somatogastric Index value were found to be inconsistent in all the fishes studied.

Key words: *Clarias Batrachus; Channa Punctatus; Anabas testudineus*; Gastrosomatic Index (GSI); Gonadosomatic Index (GnSI); Hepatosomatic Index (HSI); Condition factor (k) Relative length of Intestine and Somatogastric Index.

INTRODUCTION

The study of fish Biology is a subject of relevance to the wider audience for its considerable applied importance to mankind and to biologist for interesting research (Chondar, 1999). Teleosts (bony) fishes support subsistence, commercial fishes and aquaculture systems throughout the world Wootton, 2002). Needless to say, man has made considerable use of bony fishes, which indeed provide inconsiderable part of total human food. Teleosts fishes have representatives in virtually all aquatic ecosystems and an enormous variety is exhibited in their way of living. Three main air-breathing species are of commercially important and edible fresh water fishes. These fishes are a treasured resource in terms of biodiversity values, their utility as food and as materials for scientific study. It has been rightly stated that aquatic living resources is a vital tool for transforming India into a nutritionally secured nation (Gupta, 2008).

Fishes have some unique anatomical and physiological characteristics that are different from other animals; however that still possess the same organ systems that are present in other animals. Scientist concerned with any activity of fisheries should understand well about fish feeding activity, which is the dominant activity in any animal's entire life. Investigation in to the problems in respect of feeding, growth, reproduction and population studies in fishes call for appropriate methodologies. An understanding of the biological parameters of food, fishes are of immense importance, which will provide an effective opportunity to determine the developing requirements of fishes in culture system. The feeding intensity or the degree of feeding is related with season, maturity, spawning and availability of materials. Through observation in the field and examination of the contents of the digestive tracts, researchers have learnt much concerning feeding behavior and the kinds of organisms that are eaten as well as mechanisms that are developed for digestion.

Aims and objectives of the present study:

1. To display and note the difference in the structure of alimentary tract of some fresh water fishes.
2. To determine the size of internal organs (liver, stomach, intestine, gonad) of the fin fishes of different sizes.
3. To estimate the gastrosomatic and hepatosomatic indices of the fin fishes during the study period (December 2014-January 2015).
4. To estimate the condition factor and gonadosomatic indices of the fin fishes during the study period (December 2014-January 2015)

MATERIALS AND METHODS

Study site

The study was carried out at the Physiology and Biochemistry Unit, Department of Zoology, Berhampur University, Odisha, India during the period from September 2014–March 2015.

Procurement of fishes, Dissection and analysis

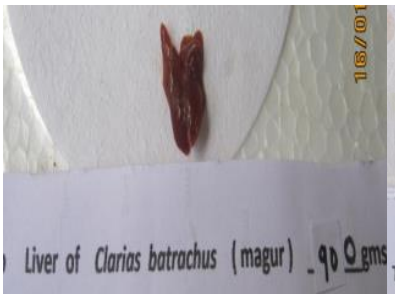
A total of three (03) different species of fresh water fishes (with more than one specimen of

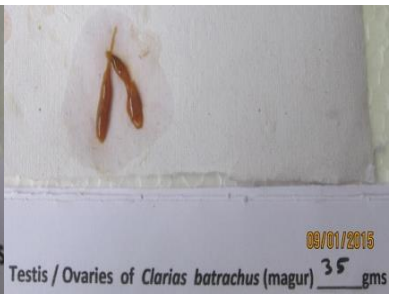
***Corresponding Author:**
Sanatan Singh,
Post Graduate Department of Zoology,
Berhampur University,
Berhampur-760007, Ganjam, Odisha, India.

dissimilar weight for twelve fishes) were studied to record the shape of alimentary tract, size of internal organs and the values of biological parameters. The fishes were procured in dead but fresh condition from nearby university campus fish market located in and around Berhampur University campus. While procuring, the vernacular (Odia) names of fishes were noted down by discussing with experienced fish sellers, their weight was recorded in electronic weighing machine (Model: Excon Instruments, Hyderabad) and brought to laboratory.

The fishes after being brought to laboratory were correctly identified up to the species level following the comprehensive account of taxonomic description and identification keys as described by, Talwar and Jhingran (1991), MPEDA guidebook (2002) and Ghosh (2006). Before commencing dissection, the total length, standard length, head length and eye diameter of all the fishes were recorded properly using one foot long scale, divider and thread.

Sterile biological stainless steel equipment like bone cutter, scissors, forceps were used for dissection. The internal organs like stomach, intestine, liver, ovary and testis were exposed, carefully detached from main body and their size was determined. The structures of stomach, liver, intestine, and gonads were carefully observed, existing similarities and differences of the same in difference fishes were noted down. The weight of stomach, liver and gonads was taken in laboratory electronic balance (Model: Aafcoset electronic balance, Bombay –Burma trading Co. Ltd).





The morphometric features viz. total length, standard length, head length and eye diameter of the fin fishes and the biological parameters were measured and determined following standardized protocols. Brief information on the fundamental aspect of these features and the general biological parameters studied are mentioned below:

Total length: It is the maximum elongation of the body from end to end. Thus from the most anterior projecting part of the head to the posterior most tip of caudal fin in included in total length (Biswas, 1987).

Standard length: This is the distance from the anterior most part of the head (snout) to the end of the vertebral column (caudal fin).

Head length: It is a straight measurement of the distance from the tip of the snout up to the posterior most edge of the opercular bone (Grant and Spain, 1975).

Eye diameter: It is the distance between the margins of the eyeball across the cornea. In another words, it is the distance between the anterior and posterior rims of the eye in the longitudinal axis (Grant and Spain, 1975).

Condition factor of fish is expressed by relating the standard length of the fish to its weight (Beckman, 1948). It is calculated by the formula= 100W/L3 where

'K' is the coefficient of condition
'W' is the weight of fish (in gram)
'L' is standard length of fish (in cm)

Gonadosomatic index: The development of gonad is estimated by determining its weight relative to the body weight of the fish (Hopkins, 1979). This can be expressed as: Weight of the gonad (testis or ovary) in gram x 100 / Weight of the fish in gram.

Gastrosomatic index: It is the weight of gut as percentage of total body weight of gut as percentage of total body weight of the fish (Desia, 1970). It is expressed as: Weight of the gut and contents in gram x 100 / Weight of the fish on gram

Hepatosomatic index: It is defined as the ratio of liver weight of body weight. It is expressed as: Weight of liver in gram x 100 / Weight of fish-weight of its gonad

Relative length of gut: It is defined as the ratio of the length of intestine of fish to standard body length (Biswas, 1987). It is calculated as: Intestine length / standard body length

Somatosogastric index may be defined as the ratio of the total body length to total intestine length. It is calculated as Total body length / Total intestine length during the month of Dec-Jan 2015, the values of the biological parameters were calculated for each of the fishes based on the previously recorded values of the size of different internal organs.

Table 1: Index value and condition factor of *C. batrachus*: Details of observation made on *C. batrachus* (Magur)

S. No	Descriptive	Specime. 1	Speci. 2	Speci. 3	Speci. 4
1	Body Weight (gm)	35	50	73	90
2	Total length (cm)	19.5	20	21.6	24.3
3	Standard length (cm)	17	17.6	18.3	22.1
4	Head length (cm)	2.5	3.5	3.8-	4.3
5	Eye diameter (cm)	0.5	0.5	0.5	0.5
6	Weight of Stomach (gm)	2.1	2.4	2.7	2.9
7	Length of intestine (cm)	12.8	13	13.1	13.5
8	Weight of liver (gm)	13	2.6	2.69	2.9
9	Weight of ovary(gm)	--	--	--	2.49
10	Weight of testis (gm)	1.89	2.01	2.05	--
11	Gastrosomatic index (GSI)	6	4.8	3.61	3.22
12	Condition Factor (K)	0.71	0.91	1.21	0.83
13	Gonadosomatic index (GnSI)	5.4	4.02	2.80	2.76
14	Hepatosomatic index (HSI)	3.92	5.41	3.79	3.31
15	Relative length of intestine	0.75:1	0.73:1	0.71:1	0.61:1
16	Somatogastric index	1.52:1	1.53:1	1.64:1	1.8:1

Table 2: Index value and condition factor of *C. punctatus*

S. No	Descriptive	Specime. 1	Speci. 2	Speci. 3	Speci. 4
1	Body Weight (gm)	35	45	80	150
2	Total length (cm)	16.8	16.7	19.5	24
3	Standard length (cm)	13.5	14.1	16.5	20.5
4	Head length (cm)	4.7	4.6	6	7.2
5	Eye diameter (cm)	0.7	0.7	0.8	0.9
6	Weight of Stomach (gm)	2	2.12	4	4.5
7	Length of intestine (cm)	5.2	10	10	11
8	Weight of liver (gm)	0.3	2.1	4	4
9	Weight of ovary(gm)	--	2.3	--	2
10	Weight of testis (gm)	1.63	--	2.64	--
11	Gastrosomatic index (GSI)	5.71	4.71	5	3
12	Condition Factor (K)	1.42	1.60	1.78	1.74
13	Gonadosomatic index (GnSI)	4.65	5.11	3.3	1.33
14	Hepatosomatic index (HSI)	0.89	4.91	5.17	2.70
15	Relative length of intestine	0. 38:1	0.70:1	0.60:1	0.53:1
16	Somatogastric index	3.23:1	1.67:1	1.95:1	2.18:1

Table 3: Index value and condition factor of *A. testudineus*

S. No	Descriptive	Specime. 1	Speci. 2	Speci. 3	Speci. 4
1	Body Weight (gm)	50	70	75	95
2	Total length (cm)	16	16	16.9	18.5
3	Standard length (cm)	12	13.5	13.4	15.2
4	Head length (cm)	4.2	4.4	4.1	5
5	Eye diameter (cm)	1	0.9	0.9	1.3
6	Weight of Stomach (gm)	2.81	3.21	3.16	3.88
7	Length of intestine (cm)	12.4	14.6	11.2	14.2
8	Weight of liver (gm)	2.09	2.25	2.28	3.07
9	Weight of ovary(gm)	--	0.81	0.82	---
10	Weight of testis (gm)	1.11	---	---	1.39
11	Gastrosomatic index (GSI)	5.62	4.58	4.21	4.08
12	Condition Factor (K)	2.89	2.84	3.11	2.70
13	Gonadosomatic index (GnSI)	2.22	1.15	1.09	1.46
14	Hepatosomatic index (HSI)	4.27	3.25	3.07	3.27
15	Relative length of intestine	1.03:1	1.08:1	0.83:1	0.93:1
16	Somatogastric index	1.29:1	1.09:1	1.50:1	1.30:1

Table 4: Average Index value and condition factor of *C. batrachus*, *C. punctatus* and *A. testudineus*

S.No	Characters	*C. batrachus*	*C. punctatus*	*A. testudineus*
1	Condition factor (K)	0.91	1.635	2.88
2	Hepatosomatic index(HSI)	4.10	3.41	3.46
3	Gonadosomatic index (GnSI)	3.74	3.59	1.48
4	Gastrosomatic index (GSI)	4.42	4.605	4.62

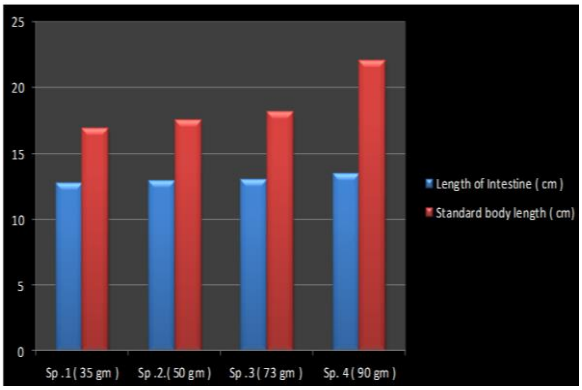


Figure 1a: Intestinal length and Standard body length (cm) of *Clarias batrachus* (Magur)

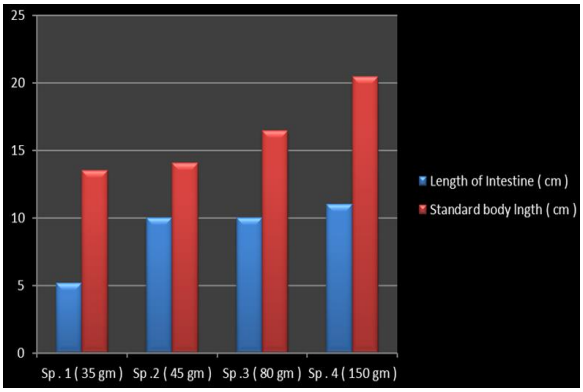


Figure 2a: Intestinal length and Standard body length (cm) of *Channa punctatus* (Gadisha)

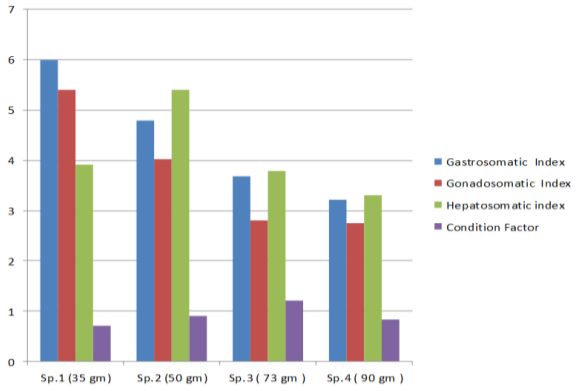


Figure 1 b: Gastrosomatic index, Gonadosomatic Index, Hepatosomatic Index and Condition Factor of Clarias *batrachus (Magur)*

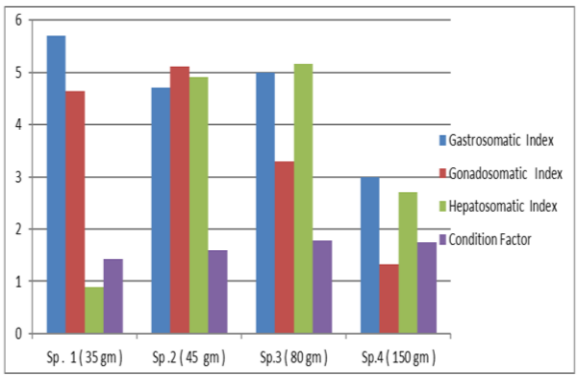


Figure 2b: Gastrosomatic index, Gonadosomatic Index, Hepatosomatic Index and Condition Factor of Channa *punctatus* (Gadisha)

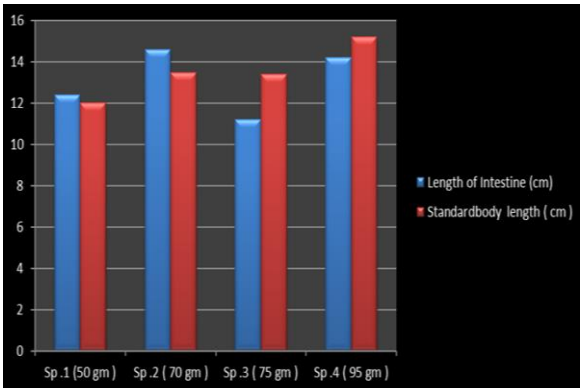


Figure 3a: Intestinal length and Standard body length (cm) *Anabas testudineus* (Kau).

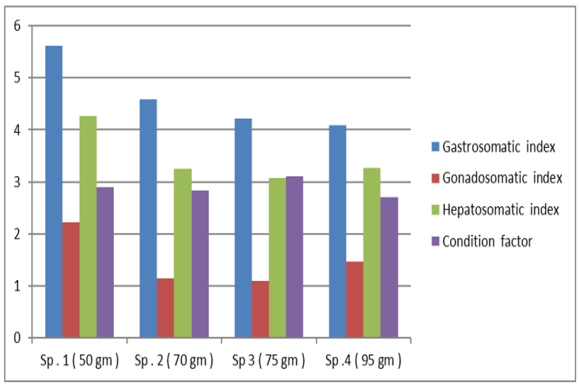


Figure 3b: Gastrosomatic index, Gonadosomatic Index, Hepatosomatic Index and Condition Factor of Anabas *testudineus (Kau)*

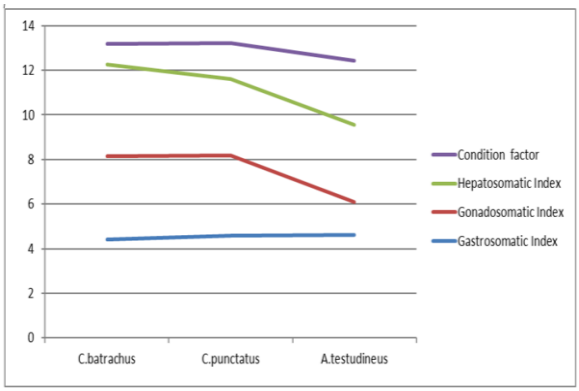


Figure 4: Shows that the average value of Gastro somatic Index (GSI), Gonad somatic Index (GnSI) Hepatosomatic Index (HSI) and Condition factor (K) of three different freshwater fishes

RESULTS

In between the fin fishes studied, it has been observed that there exists certain variations in the structure of alimentary tracts, standard body length and other internal organs; in the value of biological parameters gastrosomatic index (GSI), hepatosomatic index (HSI), relative length of gut, gonadosomatic index (GnSI), condition factor (K), somatogastric index.

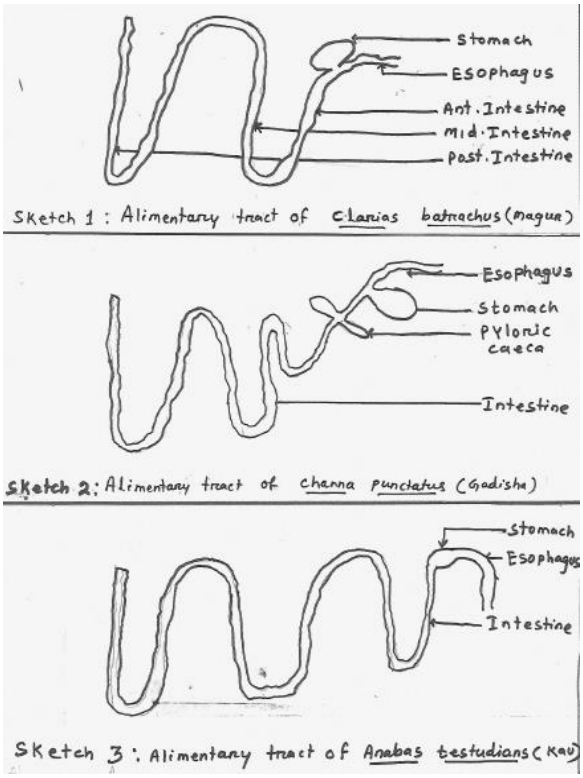


Figure 5: Sketch map of alimentary canal of *C. batrachus*, *C. punctatus*, *A. testudians*

***Clarias batrachus* (Magur)**

Four specimens of *Clarias batrachus* of body weight 35gm, 50gm, 73gm and 90gm have been dissected and studied. The alimentary tracts (Fig. I e, f with Sketch Figure 1) was having closely packed intestinal caeca (soft fingerlike projections), whereas the cardiac and pyloric stomach were not well differentiated. The intestine was of medium length, broad, thick-walled and muscular. Liver (fig I a, b) of this fish is brownish, well-built, triangular shaped. The ovary (Fig I c, d) of largest specimen was red in colour, cylindrical, ova not clearly visible to naked eye. The weight of stomach was between 2.1- 2.9 gm, liver 1.3-2.9 gm. Length of intestine range between 12.8-13.5 cm.

The value of Gastrosomatic index (GSI), Gonadosomatic Index (GnSI), Hepatosomatic Index (HSI), and the condition factor (K) of the species had been recorded as (3.22-6), (2.76-5.4), (3.31-5.41), (0.71-1.21) respectively were comparable related to weight of species. Relative length of intestine, Somatogastric Index was (0.75:1-0.61:1), (1.52:1 -1.8:1) respectively was variable and depends upon the weight of species. (Table 1)

***Channa punctatus* (Gadisha)**

Four specimens of *Channa punctatus* of different body weight are 35gm, 45 gm, 80 gm.; 150 gm had been dissected and studied the morphology and anatomical views. The Alimentary tracts (Fig III e, Iv f

with sketch map fig.2) was characterized by prominent stomach, pyloric caeca and intestine were visible. The intestinal wall was thin, short and muscular. The Liver was brownish red and short. The testis was ceramic, white, slightly thick. The length of intestine was 5.2-11 cm with average was 9 cm. The weight of alimentary canal 2-4.5gm was depending upon increasing of weight of fishes.

The Gastrosomatic index (GSI), Gonadosomatic index (GnSI), hepatosomatic index (HSI) and condition factor (K) were ranged from (3-5.71), (1.33-5.11), (0.89-5.17) (1.42-1.78) respectively, which were dependent upon length and weight of fishes studied. The relative length of intestine and somatogastric index value was found to be (0.38:1-0.70:1), (1.67:1-3.23:1) respectively. **(Table 2)**

***Anabas testudineus* (kau)**

Four specimens of *Anabas testudineus* (Kau) of body weights 50 gm, 70 gm, 75 gm, 95 gm had been dissected. The morphological study from lateral view, which is measuring about total body length, standard body length, head and eye diameter, was associated with it. The alimentary tract (fig. Ve, VI f and sketch map fig.3) was having closely with Esophagus, Stomach and Intestine. The Intestinal tract was thin, long muscular tube. The length of Intestine varies from 11.2-14.6 cm as compared to weight and length of fishes. Weight of stomach (2.81-3.88) was varied from species to species. Liver was found to be reddish dark brown in colour. Weight of liver was 2.09-3.07 gm. The testis was yellowish white in colour.

Gastrosomatic index (GSI), Gonadosomatic index (GnSI), Hepatosomatic index (HSI) and condition factor (K) were measured to be (4.08-5.62), (1.09-2.22), (3.07-4.27), (2.70 -3.11) respectively. Hepatosomatic index was decreased, as compared to the increase in body weight and length. Relative length of intestine and somatic index was found to be (0.83:1-1.08:1), (1.09:1-1.50:1) respectively. **(Table 3)**

DISCUSSION

There may be seasonal variation in gastrosomatic index (weight of gut expressed as percentage of total body weight of the fish) of several species of fishes. It is maximum during the post spawning period and minimum during breeding period (Yadav, 2006). Knowledge of the spawning period is one of the most important prerequisites in fishery management. The gastrosomatic index (GSI) indicates the spawning period in some telostean fishes. The rise fall of the gastrosomatic index (GSI) and condition factor (K) values always show an inverse relationship with the gonadosomatic index and percentage of empty stomach. In fully matured fishes, the condition factor values and gonadosomatic indices are high and the percentage occurrence of empty stomach is more which indicates the spawning season of the fishes (Bal and Rao, 1984). Carnivorous fishes usually have a large stomach and short intestine and this is applicable to many invertebrate feeders. In *C. batrachus, A. testudian,* the stomachs are often absent and the intestine is shorter than body length (Leveque, 2005). *Channa punctatus* has a pyloric stomach with a thick muscular and a keratinized inner lining forming masticatory gizzard (Russel and Yonge, 2002). In carnivorous fishes, stomach was with strong musculature clearly separable from intestine. Intestines are without coils, often straight with thick musculature. Intestine length / body length value is 1 or less than 1 (Kar, 2007).

The condition factor (k) is an index expression the interaction between biotic and abiotic factor in the physiological condition of fishes. It shows the population's welfare during the various stages of the life cycle (Angelescu, 1985). Condition factor (k) also gives information when comparing two populations living in certain feeding, density, climate and other conditions, when determining the period of gonadal maturation and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Bengal *et al.*, 1987). Olurin and Aderibigbe (2006) said that if the value of condition factor were higher than one, fish would be observed in good condition. It means that food availability, environment condition, stress and other conditions for this species are not suitable and need to be reviewed. In view of the importance of length weight relationships in understanding growth and stock dynamics of fish populations; it has been extensively studied in several species of fishes distributed in different parts of the world Kizhakrudan *et al.*, (2012).

Clarias batrachus

The highest value of HSI indicates heavier liver. The correlation of HSI and GSI in *N. notopterus* indicates inverse relationship such a rhythm of changes have been reported in some other fishes and suggested that hepatic tissue store large amount of nutrients during preparatory phase as HSI increase. The similar observation was also reported in the present study. The condition factor (K) increased from preparatory to pre-spawning phase indicating that the overall condition of the fish seems to get improved towards the approach of maturing and mature stage of gonad during pre-spawning (Kumar *et al.*, 2013). In the present study, condition factor (K) increase as increase in body weight. The condition factor (K) of adult usually reaches its lowest value during the immediate

post spawning period, and it take several weeks or months to recover from the energetic expenditure imposed by gamete production and spawning actives Jobling (1994), where similar results are indicates as my Table 1.

Channa punctatus

Information on condition factor (k) can be vital to culture system management because they provide the producer with information of the specific condition under which organisms are developing (Araneda *et al.,* 2008). The values of condition factor (K) recorded in the present study are 1.42-1.78 and the average value was 1.63 (Table 2). Similar results are also reported by Surjya Narayana *et al.,* 2013. Condition factor was 1.09 to 1.33 and average value is 1.19. The results are in conformity with study of Chandra and Jhan (2010) who were recorded the K value of *Channa punctatus* in the range of 1.05-1.89.

GSI of *C. punctatus* normally varies from 1.1-3.5. Parameswarm (1975) indicated that feeding activity of fish (maturated) become high during February-April. In present study, the higher GSI value in female than the male indicates that the female growth is faster than male during breeding period. The same opinion has been made by Dasgupta (2004) have mentioned that in ***Liza parsia*** (35gm). The gastrosomatic index (GnSI) value (1.48) was much higher than the gonadosomatic index (GnSI) value (0.45). The present study agrees with the above observation. Generally gastrosomatic index is low during the spawning season of fish species (Rehman, 2002). In ***Colisa fasciatus,*** Sarkar and Deepak (2009) observation a gradual increases in gonadosomatic index value during pre-spawning period and it peak was reached during spawning period. Similar observations were recorded by Tiwari K *et al.,* (2014).

Anabas testudineus

In present study, average condition factor (k) was recorded to be 2.88, the same trend was also noticed by (Le Cren 1951). The condition factor (K) of a fish reflects physical and biological circumstances and fluctuation by interaction among feeding condition, parasitic infections and physiological factors (Le Cren 1951). GSI level starts increasing during late preparatory phase (April), reaches the peak in July (Pre-spawning) before coming back to basal level during post-spawning (September). HSI level undergoes regular fluctuation throughout the breeding season, preparatory and pre-spawning phase respectively. It indicated similar result in Nagahama, Y. (1983). The average present study of Hepatosomatic (HSI) was 3.46 and Gonadosomatics (GnSI) index was 1.48 were reported by by Swdekarpawer, S. *et al.,* (2013). In present studies GnSI and HSI were varies depends upon length, weight and sex etc. In present study experiments were conducted on the months of December 2014-January 2015 and the similar results were also recorded by, Hossain, Z *et al.,* (2002). In addition, Hossain, Z *et al.,* (2002) said that HSI and GnSI index values were subjected to changes on impact of temperature, dissolve oxygen and pH value of species.

ACKNOWLEDGEMENT

We acknowledge our deep sense of gratitude to the Head of the Department of Zoology, Berhampur University for providing the necessary laboratories facilities.

REFERENCES

1. Angelescu VFS, Gneri and Nani A., (1985): Lamerluza del mar argentine (Biologia e taxnomia). Secr. Mar. Serv. Hidrog. Nav. Publico, H 1004:1-224 pp.

2. Araneda M, Perez EP and Gasca LE (2008): White shrimp Penaeus vannamei culture in freshwater at three densities: condition state based on length and weight. Aquacult, 283:18-13pp

3. Bagenal TB and Tesch AT, (1987): Conditions and growth patterns in freshwater Habitats. Blackwell Scientific Publications, Oxford, 75-89pp.

4. Bal DV and Rao KV (1984): Marine fisheries of India. Tata McGraw Hill publishing company limited, New Delhi. 4-20pp

5. Beckman CW (1948): The length weight relationships and coefficients of condition for seven Michigan fishes. Trans. Am. Fish. Soc., Vol.75, 237-256 pp

6. Biswas SP (1987): Studies on the intestine length in relation to feeding habits of five, commercially important fishes from Assam. J.As. Sci. Soc. Vol.28 (1), 10 -13pp

7. Chandra R, Jhan N (2010): The analysis of length-weight relationship of *Channa punctatus* with relative physico-chemical parameters. J Exp Science 1 (5):4-5pp

8. Chondar, SL (1999): Biology of finfish and shellfish. SCSC Publishers, Howarh, 390 -410pp.

9. Dasgupta M (2004): Relative length of Intestine of some freshwater fishes in relation to their food and feeding habits. Indian journal of fisheries.51 (3):381 -384 pp.

10. Desai VR (1970): Studies on fishery and biology of *Tor tor* from river Narmada. J. Inland. Fish. Soc. India, Vol.2, 101-112 pp.

11. Ghosh A (2006): Fishes of the Hooghly-Matla Estuary. CIFRY (ICAR) Publication 1-10 pp.

12. Grant P and Spain RA (1975): Reproduction, growth and size allometry of *Mugil cephalus* from North Queensland inshore waters. Aust. Jour.Zool., Vol. 23, 181-221 pp

13. Gupta MV (2008): Challenges to be addressed for aquaculture to meet the growing global demand. In. Souvenir Book of 'Brainstorming Meet on Aquaculture 2025: Challenges and Opportunities.' CIFA Publication, 1-13pp

14. Hopkins R (1979): Reproduction in Galaxias fasciatus.N.Z.J. Mar. Freshwater Vol. 13 (2), 225-230pp.

15. Hossain Z, Rahman MZ and Mollah MF (2002): Effect of Dimecron 100 SCW on *A. testudineus*, *C. Batrachus* and *B. gonionotus*. Indian J.fish. 49 (4):405-417pp.

16. Jobling M (1994): Environmental Biology of Fishes. Chapman and Hall Publication 175-210pp.

17. Kar D (2007): Fundamental of Limnology and Aquaculture Biotechnology, Daya Publishing House, 428-449pp

18. Kizhakudan SJ and P Sitaram Reddy, (2012): Length-weight relationship in three species of silver bellies from Chennai coast. Indian Journal of Fisheries, 59 (3):65-68 pp.

19. Kumar K, Lalrinsanga PL and Sahoo M (2013): Length-weight Relationship and Condition Factor of *Anabas testudineus* and *Channa* sp. under Different Culture Systems. World Journal of Fish and Marine. Sciences, 5(1):74-78.

20. Le Cren ED (1951): The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). J. Anim. Ecol. 20:201-219 pp

21. Leveque C (2005): Biodiversity dynamics and conservation, Cambridge University Press, 141-150 pp.

22. Nagahama Y (1983): The functional morphology of teleost gonads. In: Hoar *et al.,* (eds).Fish physiology, vol-9, Reproduction, Part A, (Academic press, Newyork) 223-276 pp

23. Olurin KB and Aderibigbe OA (2006): Length-Weight Relationship and Condition Factor of Pond Reared Juvenile *Oreochromis niloticus*. World Journal of Zoology, 1(2):82-85 pp.

24. Parameswaran S (1975): Investigations on the biology of some fishes of the genus Channa. Ph.D. thesis, Magadhu University, Bodh Gaya: 1-299 pp.

25. Rehman S, Islam ML Mondal S and Alam MJ (2002): Observation on the fecundity and gonadosomatic index of grey mullet *Liza parsia.* J. Biological Science, 2(10):690-693.

26. Russell FS and Yonnge M (2002): Advances in Marine Biology, Academic Press, London, 207-210 pp.

27. Sadekarpawar S and Parikh P (2013): Gonadosomatic and Hepatosomatic of Freshwater fish *Orechromis mossambicus* in Response to a Plant Nutrient. World journal of Zoology. 8 (1), 110--118pp.

28. Sarkar UK and Deepak PK (2009): The diet of clown knife fish *Notopterous cheetala* from different wild population. Electronic J. of Ichthyology, 11-20 pp.

29. Surjya ND, Kaur VI, Dhawan A and Jassal G (2013): Estimation of length –weight relationship and condition factor of spotted snakehead *Channa punctatus* (bloch) under different feeding regimes. SpringerPlus, 2: 436.

30. Talwar PK and Jhingran AG (1991): Inland Fishes of India and Adjacent Countries. Oxford and IBH Company Pvt. Ltd., New Delhi.

31. Tiwari K, Singh BK, Singh S and Tiwari A (2014): Study of Gonadosomatic index of fresh water fish *C. marulius*. I.J.S.R. Publication. Vol-4 (5),

32. Wootton RJ (2002): Ecology of Teleost Fishes. Kluwer Academic Press Publishers, 8-10 pp

33. Yadav BN (2006): Fish and Fisheries, Daya Publishing House, New Delhi, 23pp.

CITE THIS ARTICLE AS:
Sanatan Singh, PK Dixit and AK Patra, Studies on Comparative Morphology and Anatomy of Certain Body Tissues of Three Freshwater Teleosts, International Journal of Bioassays, 2015, 4 (06), 4013-4020.

Source of support: Nil
Conflict of interest: None Declared