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Morphological Study of the Digestive Organs (Oesophagus, Intestinal Bulb, Intestine, Rectum) in Post Flexion to Finger Ling Stages of the Himalayan Snowtrout *Schizothorax Plagiostomus* (Heckel)

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The morphology and relative length of gut (RLG) of the digestive tube among the larvae of *S. plagiostomus* is directly related to the age and size of the larvae. The digestive tube is almost straight when larvae are less than 1.5 cm in length, but as the size of larvae increases the gut increases in length and The RLG value also increase as 1.5 cm long larvae are having RLG value 1.0. While in 6.7 cm larvae RLG value was 3.34. When the larvae of *S. plagiostomus* become more than 6.0 cm long, they move towards the mainstream. Again, if the size of the fish is about 7.0 - 8.0 cm the relative length of gut (RLG) decreases (3.16). This is the size when most of the larvae move towards the mainstream (deep water) where the quality of food is different from the shallow water. Also the temperature is less than that is shallow water. The 1.0-8.0 cm *S. plagiostomus* larvae are having short oesophagus, which shows four walls viz. mucosa, submucosa, muscularis, and serosa layers. In 1.0 cm larvae the oesophagus lumen is very narrow and short and has a single layer of cuboidal epithelial cells.The lumen is also lined with a stratified squamous epithelium. The mucous cells are continuously arranged at the corners of the mucosal layer, helping in the food movement. When the size of fingerling stage larvae of *S. plagiostomus* is about 6.0 cm the submucosa reduces due to invasion of striated muscle fibres and projects into the folds forming the lamina propria. Also the same has been seen in the 7.0 cm larvae. Here the T.S. and L.S. are showing muscularis, which is having an inner longitudinal and outer circular muscle fibers. In quite healthy fingerling larvae which are having size about 8.0 cm , the fully developed oesophagus with all four layers and well organized mucosal folds, mucous cells and epithelial cells are present. In *S. plagiostomus* larvae, the walls of intestine consist of mucosa, submucosa, muscularis, and serosa in all the stages of the development viz.post-flexion to fingerling stage larvae. Only the difference was recorded in their thickness. This is related to the feeding quality (micro-phytoplankton to macro-phytoplankton). The intestine started to form coils as the age and size increases and it's divided into three regions (1^{st}, 2^{nd}, & 3^{rd}) based on coiling formation.The mucosal folds become shorter as the intestine diameter becomes narrow towards the rectum. They were uniform in shape in the 2^{nd} region, while in the 3^{rd} region they become shorter in post-flexion and fingerling stage. The number of goblet cells is more in the 2nd region, but it decreases towards the 3^{rd} region, which is showing more absorption of food in the 2nd region than the 3rd region. The last region of the intestine through which the gut opens to the outside is the rectum which is comparatively narrower than the intestine.

Introduction

In many fishes there are “critical periods” in development whereby they must reach certain functional threshold in order to procure and digest food [1-3].The onset of exogenous feeding represents a period of high mortality for fish larvae, particularly those in tropical and sub-tropical waters, where the transitional period between yolk absorption and first feeding is short (1,4-5). The same has also been reported in the larvae of snow trout *Schizothorax species* by Bahuguna (6-7). Fish larvae must be competent at procuring and assimilating food before the yolk sac and oil globules are depleted, or risk starvation (8-9). A second ‘Critical period’, at the end of the larval period during the transition to a benthic juvenile form, has been proposed for demersal fish species (2).For many species a complex metamorphosis occurs at this time involving rapid changes in morphology (10), Sensory systems (11-13), locomotory ability (9), respiration and digestive and hormonal physiology (14). Studies on the ontogeny of fish larvae have been often focused on only one area of development, either osteological (15-16) or changes in the digestive system (17). However, an integrated consideration of different structures during ontogeny is important to understand how structural changes may influence functional capability as the fish change its environments. The intestinal tract must grow and differentiate with changes in the feeding and metamorphosis. The transition from endogenous to exogenous nutrition is a major change requiring the development of organs that can digest food. During embryonic or larval development the swim bladder also develops from the anterior portion of the alimentary tract (18-19). Histology of the digestive system during post-hatching development of the *carp, Cyprinus carpio,* has been described (20-21).The morphology of the digestive system and the food habits of the *carp* are quite different from those of the many other fishes as described by Turner (22) & Thomas (23).

Knowledge of gastrointestinal tract (GIT) developmental changes associated with the process of food assimilation is essential for understanding the nutritional physiology in larval stages (6-7). In some fishes when larvae initiate feeding, they possess an anatomically complete digestive tract (24-25).and an enzyme complement which is similar to that of juveniles and adults (26). As a consequence, artificial larval diets have been used for the intensive commercial culture of several acipenserid species from the onset of exogenous feeding (27-30). However, the end of the lecithotrophic stage and transition to exogenous feeding still represents an important source of larval mortality (28,30-32) suggesting some nutritional problems associated with the digestion and assimilation of artificial diets, which are normally formulated for salmonids or marine fish species (29-30).

Detailed anatomical, histological, and physiological descriptions of the digestive tract of the coast rainbow trout have been performed (33-34). The ontogeny of the digestive system and the effect of growth conditions on this process have also been studied (35-36).

Phylogenetic predeterminations of the structure of the oesophageal epithelium and the characteristic features of the intestinal morphology have been suggested within the salmonidae (37). The oesophagus wall in fish is very muscular with interweaving skeletal muscle fibers, which may extend as far as the stomach (38). Therefore, a histological comparision of the tunica muscularis externa in the oesophagi of fish that consume different food was made (39). Considerable work has been done on the food and feeding habits of fresh water teleost fishes by some authors (7,40-45). However, very little information is available on the food and feeding habits of hillstream fishes (46-49). But there is no any information related to the early development of digestive organ among the Indian fresh water fishes including snowtrout *Schizothorax Species*.

Hence, an effort has been made to know how the development of digestive organs takes place in the larval stages of a Hill stream snow trout fish *Schizothorax plagiostomus*. This is an indigenous commercially as well as economically important food fish in the snow fed aquatic environment.

Methodology

Live brooders of *Schizothorax plagiostomus* (Heckel) were collected from the Glacierfed River Alaknanda located at an altitude of 540 m, longitude 78^0 47’ 26’’ and latitude of 30^0 13’16’’, 38.8 Km near the Chauras-Jhulapul, near Shrikot, Srinagar (Garhwal) during September-October 2006 by using “cast gill net”. The mature brooders were stripped for taking out the egg and melt by applying slightest pressure on the abdomen. The eggs and milt were mixed with the help of birds feathers in a cleaned enameled tray for 5-10 minutes (6-7). After fertilization, the eggs were plac in the hatching trays and kept in the laboratory with proper airation and controlled airation. The post flexion stage is the formation of the caudal fin (hypural elements vertical) to attainment of full external meristic complement (fin rays and scales) and loss of temporary specializations for pelagic life. In *Schizothorax plagiostomus* this stage begins after 12-15th days of hatching. At 12-15th days of hatching when caudal fin was fully flexed and forked most of the internal organs were developed morphological as well as functionally. At the end of this stage larva swim actively and move towards the main streams from the shallow water (this is seen among the natural site larvae). The fingerling stage is an active feeding stage when a quick growth in the body takes place. In this stage larvae were seen very active in their movement and later they become adult, means the development of gonads was seen. For the Morphological study of various organs, the different developmental stages have been fixed in Alcoholic Bouin’s, Aqueous Bouin’s, as well as in the 4% Formalin solution from post flexion to fingerling stages with 4-8 hrs intervals 5-10 as given by the authors (50-53) with some modifications were applied according to the local condition. After completion of fixation (18-24 hrs), the larvae were washed 2-3 times in distilled water than alcohol, till the excess of fixative comes out from the tissue. The photomicrographs were taken with the help of PM-6 and PM -10 Olympus- photomicroscope systems for detailed study.

Observation

Intestinal tract is the most important organ of the coelomic cavity of the larvae. It consists of four important parts viz. Oesophagus, Intestinal bulb, Intestine and Rectum.

The alimentary canal of an adult *S. plagiostomus* fish is longer than the total body length, while among the hatched larvae gut length increases as the age and size of the larvae increases. In larvae the pharyngeal bone and teeth are absent while the pharynx is a narrow passage. Overall the gut in hatched larvae is a short straight tubular structure. The lumen wall of the oesophagus is lined with mucous folds which are thrown into many thick longitudinal folds.These folds increase in number as the size of the larvae increases i.e.from 1.0-8.0 cm The number of mucosal folds also increases from 2.0-4.0 cm larvae reaching up to the fingerling stage. True stomach is absent in these fish larvae which were having length 2.0-8.0 cm The oesophagus leads directly into straight and short intestine. The anterior part of the intestine is slightly swollen in the later stages of the larvae (6.0-8.0 cm larvae) which may be called intestinal bulb. The mucosal folding has also been noticed inside the lumen of intestinal bulb/ swollen intestine in the form of zig zag linings. The rest of the intestinal tube increases in length as fish larvae increases in size. The coiling or the folds in the intestinal tube also increase from 2.0-8.0 cm fish larvae from 2-4 folds respectively. The thin zig-zag mucosal folds are in the lumen of intestine in the form of irregular lining. Rectum is comparatively very short and with a tubular structure. The number of mucosal folds in the lumen is shorter and less in comparison to the other parts of the gut. Overall, the morphology and relative length of gut (RLG) of the digestive tube among the larvae of *S. plagiostomus* is directly related to the age and size of the larvae. Table 1 showing the different parameters of the digestive tube and their size, etc. The morphological changes during the development of the gut is directly related to the age of the larvae. The digestive tube is almost straight when the larvae are less than 1.5 cm in length, but as the size of larvae increases the gut increases in length. The

RLG value also increases as shown in Table 1 as 1.5 cm long larvae are having RLG value 1.0, while in 6.7 cm larvae the RLG value was 3.34 when the larvae of *S. plagiostomus* becomes more than 6.0 cm long, they move towards the mainstream. Again, if the size of the fish is about 7.0 - 8.0 cm the relative length of gut (RLG) decreases (3.16). This is the size when most of the larvae move towards the mainstream (deep water) where the quality of food is different from the shallow water. Also the temperature is less than that in shallow water.

Table 1 Showing the length of the different parts of the digestive tract in postflexion to fingerling stage of *S. plagiostomus* larvae.

S. No.	No. of Observed Larvae	Age of the larvae in days	Larvae length (Mean value) (cm.)	Mean length of the digestive tract (cm.)				RLG
				Oesophagus (cm.)	Intestinal bulb (cm.)	Intestine (cm.)	Rectum (cm.)	
1	25	15	1.5	0.1	0.2	1.0	0.2	1.0
2	20	20-22	2.7	0.2	0.5	2.5	0.2	1.25
3	15	35-37	3.0	0.2	1.0	7.0	0.2	2.8
4	12	45-47	3.8	0.2	1.4	10.2	0.3	3.18
5	10	60-62	4.7	0.3	2.0	12.7	0.3	3.25
6	10	75-77	5.5	0.3	3.1	14.5	0.3	3.30
7	10	76-87	6.7	0.3	4.0	17.8	0.3	3.34
8	8	95-98	7.8	0.3	4.2	19.8	0.4	3.16

Discussion

The digestive tract can be divided into three periods the embryonic, larval and juvenile period (Balon, 1975; Loewe and Eckmam, 1998; Unal, 2001). The digestive tract of snow trout just after hatching was poorly developed (19,49). Gradually, when the fish grow in size and weight, the digestive system and digestive organs are developed systematically. The same gradual development or organogenesis in the digestive tract has been reported in other fishes (54-55). In the *Schizothorax plagiostomus* larvae, three developmental phases have been reported for the development of the digestive system (7,19). The first stage occurs when the first feeding started i.e. at the age of 4-6 days after hatching (preflexion stage). This was the time when the digestive tract enables to ingest as well as digest the exogenous nutrients in the hatching, nutrition is provided only by yolk sac (7). The second stage (flexion stage) was around the age 7-8th days after hatching when the functional intestinal bulb, mid gut and rectum were distinguished but functionally these organs were not active (19). The 3rd stage was post flexion stage when the fish larvae were 9-12th days old. In this stage, the gastric gland was developed and in the long intestine coiling started. Therefore, the relative length of the gut (RLG) increases (19,56). This morphological change in the gut with its RLG depends on different fish species and also with their body growth in respect to their different developmental stages, as well as quality of food and their availability in nature (57). Same finding is supported in the snow trout fish, *Schizothorax plagiostomus*, which is having different development stages and a variety of food in the different stages of development. After post flexion to fingerling stage, the digestive tract was having different morphological changes. This was the stage when larvae were having 1.0 cm long or 12 days old after hatching. In this stage, the exogenous feeding was started. Tanaka, Kaji, (54-55,58) etc. reported the presence of mucosal goblet type cells at postflexion stage when initial feeding was reported in some freshwater fish species where pharyngeal teeth also started to develop. In snow trout, *S. plagiostomus* mucosal goblet type cells were also found in the intestinal bulb just after exogenous feeding, supporting the finding in other fresh water fishes. Dabrowski (59) also reported the same finding in other teleost fishes as were seen in gut histology of snowtrout larvae just after exogenous feeding. In *Clarias lazera* larvae the third segment of gut (rectum) does not seem to play an important role in the absorption of nutrients. In the postflexion larval stage of *S. plagiostomus* small numbers of microvilli with low height are present and support the observation as proposed by Stroband and Karoon (60) in some other fishes.In Snow-trout larvae which was having 1.0-8.0 cm length the rectum was also having a small number of microvilli with low height with usual other region viz. mucosa, submucosa, muscularis and serosa layers, etc with cellular arrangement. Only the difference is in the number of mucosal cells, which were less compared to intestinal region. A long and looped intestine in 5.0-8.0 cm larvae of *S. plagiostomus* has been also described in a number of fishes studied by several authors (61-67). Histologically, it is well established fact that the teleostean intestine is provided with simple columnar absorbing cells covered by thin brush borders, although other constituents such as goblet cells, lymphocytes and various granulocytes do occur in between them (68). The histology of the larval intestine of *S. plagiostomus* having 1.0-8.0 cm length consists of the layers of serosa, muscularis, submucosa and mucosa with a large number of mucous cells, columnar cells and mucous secreting cells as were reported in other freshwater fishes by several authors (69,63,40,70-73). The last region of the intestine through which the gut open to the outside is the rectum which is comparatively narrower than the intestine. The same was observed in *S. plagiostomus* larvae from postflexion to fingerling stages. There is no distinct demarcation between the intestine and the rectum, which is a simple developmental or organogenesis process as in other fresh water teleost fishes as reported by Tandon and Goswami (74). In the *S. plagiostomus* 5.0-8.0 cm long larvae the rectal folds are shorter and broader than the intestinal folds. The mucous secreting cells are in abundance and are distributed along the entire epithelium. In 5.0-8.0 cm larval rectum the muscularis is thicker than the intestine and is traversed with numerous blood vessels as also reported by Al-Hussaini (62); Islam (69); Chaudhary and Khandelwal (71); Dixit and Bisht (65). According to Bullock (75) the anterior rectum is the principle site for the digestion in stomachless teleosts, *Gambusia affinis*, while Western (76) states that the function of the rectum is concerned with the final explosion of the faeces. The same has been seen in *S. plagiostomus*. In this finding, it retains the food for final absorption in the long intestine with their thick muscular structure as well as low height of lamina propria.

Notes and References

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1. Houde, E.D. (1974): Effects of temperature and delayed feeding on growth and survival of larvae of three species of subtropical marine fishes. Mar. Biol. 26: 271-285.
2. Blaxter, J.H.S. (1988): Pattern and variety in the development. Pp. 1-58. In: W.S. Hoar & D.J. Randall (ed.) Fish Physiology, Vol.11 A, *Academic Press,* New York.
3. Smallwood, W.B., and Smallwood, M.I. (1931): The development of the carp, Cyprinus carpio. I. The life of the carp, with special reference the development of the intestinal canal. *J. Morphophysiol*. 52: 217-231.
4. Thorisson, K. (1994): Is metamorphosis a critical interval in the early life of marine fishes. *Env. Biol. Fish.* 40: 23-36.
5. Bagarino, T. (1986): Yolk resorption, onset of feeding and survival potential of larvae of three tropical marine fish species reared in the hatchery. *Mar. Biol.* 91: 449-459.
6. Houde, E.D. and Zastrow, C.E. (1993): Ecosystem and taxonspecific dynamic and energetics properties of larval fish assemblages. *Bull. Mar. Sci.* 53: 290-335.
7. Bahuguna, S.N. (2002): Role of hormone, histochemical and bimolecular comparison of certain tissues with respect to migration of Himalayan mahseer *Tor putitora* in the Ganga river system in Uttarakhand. Final Technical Report. Submitted and adopted by ICAR, Krishi Anusandhan Bhawan, New Delhi.
8. Avila, E.M. and Juario, J.V. (1987): Yolk and oil globule utilization and developmental morphology of the digestive tract epithelium in larval *rabbitfish, Siganus guttatus* (Bloch). Aquaculture 65: 319-331.
9. Fukuhara, O. (1988): Morphological and functional development of larval and juvenile *Limanda yokohamae* (Pisces: *Pleuronectidae*) reared in the laboratory. *Mar. Biol*. 99: 271-307.
10. Markel, D.F., Harris, P.M. and Toole, C.L. (1992): Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus. U.S. Fish. Bull*. 90: 285-301.
11. McCormick, M.I. (1993): Development and changes at settlement in the barbel structure of the reef fish, Upeneus tragula (Mullidae). *Env. Biol. Fish.* 37:269-282.
12. Shand, J. (1994): Changes in retinal structure during development and settlement of the goatfish Upeneus tragula. Brain, Behav. Evol. 43: 51-60.
13. Job, S.D. and Bellwood. (1996): Visual acuity and feeding in larval *Premnas biaculeatus*. *J. Fish Biol*. 48: 952-963.
14. Walford, J. and Lam, T.J. (1993): Development of the digestive tract and proteolytic enzyme activity in seabass (*Lates calcarifer*) larvae and juveniles. *Aquaculture* 109:187-205.
15. Potthoff, T., Kelly, S., Saksena, V., Moe, M. and Young, F. (1987): Description of larval and juvenile yellow tail *damslfish*, *Microspathodon chrysurus,* Pomacentridae, and their osteological development. *Bull. Mar. Sci.* 40: 330-375.
16. Potthoff, T. and Tellock, J.A. (1993): Osteological development of the snook, *Centropomus undecimalis* (Teleostei, Centroponidae). *Bull. Mar. Sci.* 52: 669-716.
17. Kurokawa, T., Kagawa, H., Ohta, H., Tanaka, H., Okuzawa, K. and Hirose, K. (1995): Development of digestive organs and feeding ability in larvae of Japanesa eel (*Anguilla japonica*). *Can. J. Fish. A quat. Sci.* 52:1030-1036.
18. Jones, F.R.H., and Marshall, N.B.(1953): The structure and function of the teleostean swim bladder. *Biol. Rev. Cambridge Phil. Soc*. 28.
19. Bahuguna, S.N., and Rayal, R.(2006): Histo-Morphological study of the optic tissue in the larvae of Himalayan Snow Trout *Schizothorax plagiostomus* (Heckel). *Aquacult,* 7(2): 153-158.
21. Smallwood, W.B., and Derrikson, M.B. (1933): The development of the carp, *Cyprinus carpio.* The development of the liver-pancreas, the langerhans and the spleen. *J. Morphol* 15-28.
22. Turner, C. L. (1921): Food of the common Ohioenters. *Ohio J. Sci*.22: 41-62.
23. Thomas, D.L. (1970): An ecological study of four enters of the genus *Percina* (Percidae) in the Raskaskia River, IIInois. *IIInois Nat. Hist. Surv.* 1-18.
24. Buddington, R.K. and Doroshov, S.I. (1986 c): Structural and functional relations of the white sturgeon alimentary canal *Acipenser transmontanus*. *J. Morph.* 190: 201-213.
25. Gawlicka, A., S.J., Hung, S.S.O., Hinton, D.E. and de la Noue, J. (1995): Histological and histochemical changes in the digestive tract of white sturgeon larvae during ontogeny. Fish Physiology and Biochemistry 14: 357-371.
26. Buddington, R.K. and Doroshov, S.I. (1986 a): Development of digestive secretions in white sturgeon juveniles *Acipenser transmontanus*.Comp. Biochem. Physiol. 83 A: 233-238.
27. Charlon, C .and Bergot, P. (1991): Alimentation artificielle des larves de l'esturgeon siberien (*Acipenser baeri*, Brandt). In Acipenser. Actes du Colloque (Williot, P.ed.).Pp.405-415. Bordeaux: Cemagref.
28. Giovannini, G., Colombo, L., Bronzi, P. and Arlati, G. (1991): Growth of hatchery produced juveniles of Italian sturgeon. *Acipenser nacarii* Bonaparte reared intensively in fresh water. In Acipenser. Actes du Colloque (Williot, P., ed.), pp.401-404. Bordeaux: Cemagref.
29. Hung, S.S.O. (1991): Nutrition and feeding of hatchery-produced juvenile white sturgeon (*Acipenser transmontanue*): an overview. In Acipenser. Pp.65-77. Edited by P. Williot. CEMAGREF, Bordeaux.
30. Gisbert, E., and Williot, P. (1997): Larval behavior and effect of the timing of initial feeding on growth and survival of Siberian sturgeon larvae under small scale hatchery production. Aquaculture 156: 63-76.
31. Buddington, R.K. and Christofferson, J.P. (1985): Digestive and feeding characteristics of the chondrosteans. *Environmental Biology of Fishes* 14: 31-41.
32. Bardi, R.W., Chapman, F.A. and Barrows, F.T. (1998): Feeding trials with hatchery produced Gulf of Mexico sturgeon larvae. *Progressive Fish Culturist* 60: 25-31.
33. Bakke-McKellep, A.M.M., Nordrum, S., Krogdhl, A. and Buddington, R.K. (2000): Absorption of glucose, amino acid, and dipeptides by the intestines of Atlantic salmon (*Salmo salar* L.). *Fish Physiol. Biochem.* 22(1): 33-44.
34. Grosell, M., O'Donnell, M.J. and Wood, M. (2000): Hepatic versus gallbladder bile composition: In vivo transport physiology of the gallbladder in rainbow trout. *Am. J. physiol*. 278 (6part 2): R 1674-R1684.
35. Dement'eva, M.A. (1976): The anatomical and histological characteristics of the digestive tract of the rainbow trout *(Salmo irideus Gibb.)* during early ontogeny. Nauchno-Issled. Inst. Ozern. Khoz. 122: 78-86.

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36. Sarieyyupoglu, M., Girgin, A. and Koprucu, S. (2000): Histological study in the digestive tract on larval development of rainbow trout (*Oncorhynchus mykiss*, Walbaum, 1972). *Turk J. Zool* 24(2):199-205.
37. Dzhumaliev, M.K. (1981): Structure of esophageal epithelium in fishes belonging to various taxonomic groups. Vopr. lkhtiol. 37 (5): 676-688.
38. Brown, L (1993): Aquaculture for veterinarians Fish Husbandry and Medicine. Pergmon Press (1st ed.), New York.
39. Gentile, R., Abbate, F., Di Summa, A., Germana, G.P., Vita, G., Germane, G. and Passantino, G.f. (1993): Micro-anatomical compared observations on the oesophagus of different diet fish. Boll. Soc. Ital. Biol, Speriment. 69 (3): 137-144.
40. Kapoor, B.G. (1953): The anatomy and histology of the alimentary canal in relation to its feeding habits of a siluroid fish *Wallago attu* (III & schn.). *J. Zool. Soc. India* 5:191-200.
41. Pillay, T.V.R. (1953): Studies on the food, feeding habits alimentary tract of the gray Mullet (*Mugil tade*). *Pro. Nat. Inst. Sci. Calcutta* (India) 19:777-827.
42. Das, S.M., and Moitra, S.K. (1955): Studies on the food of some common fishes of Uttar pradesh, India (Part I). *Proc. Nat. Acad. Sci. India.*25: 1-6.
43. Agarwal, V.P., and Tyagi, A.P. (1969): Food, feeding habits of the alimentary canal of fresh water fishes of Muzaffarnagar. *Agra Uni. J. Res.* 18: 15-22.
44. Bhatnagar, G.K., and Karamchandani, S.J. (1970): Food and feeding habits of *Labeo fimbriatus* (Block) in river Narbada near Hoshangabad (M.P.). *j. Inland. Fish Soc. India* 2: 30-50.
45. Desai, V.R. (1970): Studies on the fishery and biology of Tor tor (Ham.) from river Narbada. Food and feeding habits.*J. Inland fish Soc. India* 2: 101-112.
46. Somvanshi, V.S., and Bapat, S.S. (1979): Food and feeding habits of a hill stream fish *Garra mullya* (Sykes). J. Inland Fish Soc. India Vol.II No. 1: (87-93).
47. Bahuguna, S. N. and Singh, H.R., (1984): Food and feeding habits with gross morphology of the alimentary tract of a hillstream fish *Barilius vagra* (Ham.). *J.Anim. Morph. Physiol*. 31(1&2):183-187.
48. Singh, N., Bahuguna, S.N., and Bhatt, K.C. (1993): The profile of riverine ecosystem food and feeding habitat of hill stream fishes and consequences of recent environmental degradation in Garhwal Himalaya. *Acta Icthologica* 23 (1): 1-30.
49. Bahuguna, S.N., and Maithani, S. (2005): Comparative morphological studies of the digestive tract in relation to growth of snow trout *Schizothorax plagiostomus* (Heckel). *Proc. Nat. Seminar, Chandigarh. Feb.* 16-18, 2005: 69-77.
50. Taylor, W.R. (1967): An enzyme method of clearing and staining small vertebrates. *Proc.United State National Museum*, 122:1-17.
51. Dingerkus, G, and Uhler, L.D. (1977): Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of carlage, stain technology.
52. Kaji, T., Tanaka, M., Takahashi, Y., Oka, M. and Ishibashi, N. (1996): Preliminary observation on development of pacific bluefin tuna *Tunnus thynnus* (Scombridae) larvae record in the laboratory, with special reference to the digestive system. *Mar. Freshwater Res.* 47: 261-69.
53. Tanaka, M. (1973): Studies on the development of the structure and function of the digestive system of teleost larvae.D.Phill.Thesis, Kyoto University. Kyoto. Japan.
54. Kaji, J. (2000): Studies on the early development of bluefin and yellowfin Tuna. Ph.D. Thesis. Kyoto University. Kyoto. Japan.
55. Bahuguna, S.N. (2001): Experimental determination of spawning and culture of Hill-stream snowtrout *Schizothorax richardsonii* of the River Alaknanda in Garhwal Himalaya. Final Technical Report. Submitted and adopted by ICAR, Krishi Anusandhan Bhawan, New Delhi.
56. Kapoor, B.G., Smith, H. and Verighina, I.A. (1975): The alimentary canal and digestion in teleost. In: *Advance in marine Biology,* VOL. (Russel, F.S. and Yonge, M.Eds.)13 Academic Press, London. 109-203.
57. Tanaka, M. (1971): Studies on the structure and function of the digestive system in teleost larvae V.Epithelial changes in the posterior –gut and protien ingestion. *Jap. J.Ichthyol*. 18:164-174. (In Japanese).
58. Dabrowski, K., (1979): Feeding requirements of fish with particular attention to common carp. *Pol. Arch. Hydrobiol*., 26:135-158.
59. Stroband, H.W.J.and Kroon, A.G. (1981): The development of the stomach in *Clarias lazera* and the intestinal absoption of protin macromolecules. Cell Tissue. Res., 251:397-451.
60. Sarabahi, D.S. (1939): The alimentary canal of *Labeo rohita* (Ham). Journal of the Royal Asiatic Society of Bengal, Science. 5:87-116.
61. Al-Hussaini, A.H. (1949): On the functional morphology of the alimentary tract of some fishes in relation to the differences in their feeding habits: Anatomy and Histology. *Quart. J. Micr. Sci.,* 90:109-139.
62. Girgis, S., (1952 b): On the anatomy and histology of the alimentary tract of a herbivorous bottom-feeding cyprinoid fish *Labeo horie* (Cuv.).*J. Morphol.,* 90:317-362.
63. Lal, M.B., (1968): Studies on the anatomy and histology of the alimentary canal of a carp, *Tor putitora* (Ham.).*Proc. Nat.*
64. Dixit, R.K. and Bisht, J.S., (1972): Histo-morphology of the alimentary canal of hillstream teleosts, *Schizothorax richardsoni* (Gray and Hard). *Zool. Beitr.,* 18 (3): 321-338.
65. Osman, A.H.K. and Caceci, T. (1991): Histology of the stomach of *Tilapia nilotica* (Linnaeus, 1758) from the river Nile. *Journal of Fish Biology* 38:211-223.
66. Murray, H.M., Wright, G.M. and Goff, G.P. (1994 a): A study of the posterior esophagus in the winter flounder, americanus and the yeololowtail flounder, *Pleuronectes ferruginea*. Morphological evidence for pregastric digestion? *Canadian Journal of Zoology* .72:1191-1198.
67. Sinha, G.M. (1994): Ultrastructure of the columnar absorptive cell of the intestinal mucosa in Indian freshwater major *carp*, *Labeo rohita* (Hamilton). In "Advances in fish Biology and fisheries" (ed., H.R.Singh) Hindustan Publishing Corporation Delhi. 1: 25-32.
68. Islam, A-UI (1951): The comparative histology of the alimentary canal of certain fresh water teleost fishes. *Prceedings of the Indian Academy of Science* .38 B: 297-321.
69. Bahuguna, S.N. (2006): Morpho-functional developmental study of Garhwal Himalayan snow trout *Schizothorax plagiostomus* (Heckel) Larvae from post hatching to yolk absorption stages. *Final technical report submitted* and adopted *ICAR, Krishi Bhawan New Delhi.*
70. Kapoor, B.G. (1957 b): The digestive tube of an omnivorous cyprinoid fish, *Barbus stigma* (Cuv. & Val.). *Japanese Journal of Ichthyology*. 6:48-53.
71. Chaudhary, H.S.and Khandelwal, O.P. (1961): The anatomy and histology of the alimentary tract of *Oreinus plagiostomus* (Heckel).*Annotationes Zoologicae, Japoneses.* 34:139-152.
72. Ezeasor, D.N. and Stokoe, W.M. (1981): Light and electron microscopic studies on the obsorbtive cells of the intestine, caeca and rectum of the adult rainbow trout *Salmo gairdneri* (Richardson). *Journal of Fish Biology*. 18:527-544.
73. Kuperman, B.I., Verighina, I.A., and Kuzmina, V.V (1986): The ultrastructure of the intestinal epithelium in *burbot Lota lota* (L) (Gadidae) Voprosy *Ichtiologii* 25:275-282.
74. Tandon , K.K. and Goswami,, S.C. (1968): A comparative study of the digestive system of *Channa species*. Research Bulletin (N.S.) of the Panjab University. 19 (l -2):13-31.
75. Bullock, W.L. (1967): The intestinal histology of the mosquito fish *Gambusia affinis* (Baird and Girad). *Acta Zoologica Stocholme* 48:1-17.
76. Western, J.R.H. (1969): Studies on the diet feeding mechanism and alimentary tract in two closely related teleosts the fresh water *Cottus gobio* L.and the marine *Parenophrys bubalis* Euphrasen. *Acta Zoologica, Stockholm*. 50:185-205.