Indian J. Fish., 37 (3) : 189 -198 (1990)

STUDIES ON CERTAIN ASPECTS OF THE MORPHO-HISTOLOGY OF INDIAN SHAD HILSA, *TENUALOSA ILISHA* (HAMILTON) IN RELATION TO FOOD AND FEEDING HABITS

D. K. DE AND N. C. DATTA*

Central Inland Capture Fisheries Research Institute, Barrackpore, 743 101, India

ABSTRACT

Morphology and histology of the alimentary canal of hilsa, *Tenwlosa ilisha* (Hamilton) in relation to feeding habit have been studied. The study reveals that the absence of teeth and masticatory organs in the mouth, presence of very fine, numerous elongated closely set gill rakers, pharyngeal pouch, short narrow cylindrical oesophagus, highly developed muscular gizzard like pyloric stomach and moderately long intestine (RLG varies between 0.86 and 1.87) in hilsa show that the species is predominantly microphagous in feeding habit. The results of stomach content analysis of fry, juvenile and adult also give support to the above contention. It is also evident that young hilsa mainly subsist on zooplankton and adult are microphagous planktivore.

INTRODUCTION

Very little work has so far been done on the morpho-histology of the alimentary canal of commercially important Indian shad hilsa, *Tenualosa ilisha* (Hamilton) excepting the account of Swarup (1959). Other fragmentary information on pyloric caeca, pharyngeal organ, gill rakers, morphological structure of alimentary canal and buccopharynx of the species are available from the accounts of Rahimullah (1945), Kapoor (1954), Dutta Munshi (1960) and Khanna (1961,1962) respectively. The knowledge on food and feeding habits of the species is still confined to the reports of Hora (1938), Nair (1939), Hora and Nair (1940), Pillay (1958), Swarup (1959) and Haider (1970), and no detailed information is available so far from the Hooghly estuary. The present paper reports the findings of detailed investigations conducted on certain important aspects of morpho-histology of the alimentary canal in relation to food and feeding habits of this fish in Hooghly estuary.

MATERIALS AND METHODS

Live adult specimens of hilsa were obtained from the freshwater stretch of Hooghly estuary and were dissected carefully for morphological studies of the alimentary canal. The alimentary canal was cut open longitudinally for studying the arrangement of the mucosal folds. For histological studies, small pieces of the different regions of the alimentary canal were selected, washed in saline water and fixed in Bouin's fluid. Transverse paraffin sections at 6 to 7 n were made and stained with haematoxylin and eosin. As regard to studies on gill rakers, total counting of gill rakers of upper and lower parts of the first gill arch was made. Free hand drawings for the mucosal folds at different selected regions of alimentary canal and structure of gill rakers were made with the help of either hand lens or binocular microscope. Selected histological sections of different regions of alimentary canal were photomicrographed. Stomach contents of the fish were studied based on 362 specimens belonging to length

* Present address: * Department of Zoology, University of Calcutta, Calcutta - 700 019, India.

range of 16-525 mm collected during October, 1981 to September, 1984, while fry and juveniles were procured during the period from October to June since their occurrence was seen in the freshwater zone of the estuary for that period only. The gut contents were analysed both qualitatively and quantitatively. The various food items were identified, as far as possible, upto generic level. The feeding intensity was recorded by observing the degree of distension of stomachs (Job, 1940 and Pillay, 1952) and was also measured by calculating the gastrosomatic index (GSI). The quantitative analysis of stomach contents was done by "point method" and the prevalence of each food item was also calculated by "occurrence method" (Hynes, 1950). The relative importance of various items in the stomach contents of the fish was calculated using "Index of Preponderance" (Natarajan and Jhingran, 1961).

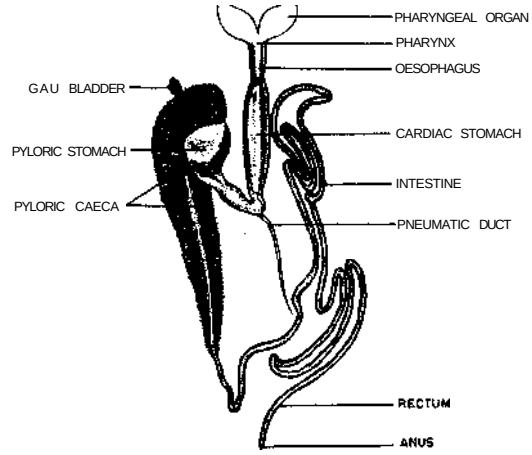


FIG. 1. Alimentary canal of T.itisha.

RESULTS

A. The alimentary canal (Fig. 1)

a) The buccopharynx (Fig. 2).

The almost terminal and slightly upturned mouth of hilsa is small bound by thin upper and lower lips. The month is edentulous and opens into laterally compressed buccopharyngeal cavity. There are four pairs of well developed gill arches. Each arch bears gill filaments and rakers on its outer and inner surface respectively. The number of rows of gill rakers is variable. In adult hilsa, the gill rakers are numerous plate like, fine processes and each raker is differentiated into four zones (Fig. 3) where the inner marginal layer possess conical papillae. All these distinct four zones as well as papillae are not fully developed or absent in the gill rakers of fishes below 50 mm in total length. Characteristics of gill rakers in various size groups are shown in Tablel. The pharyngeal organ looks like a pair of bilaterally symmetrical

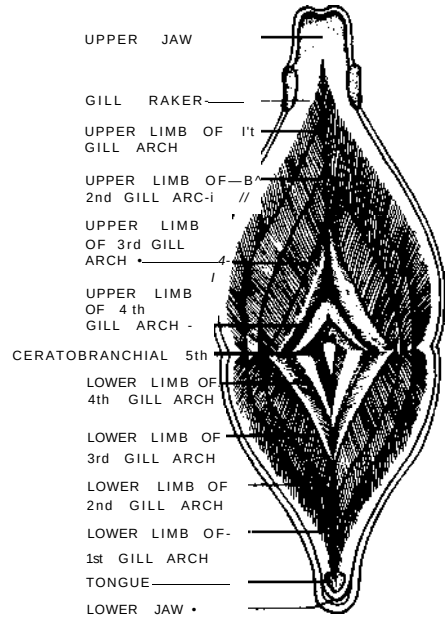


FIG. 2. A diagrammatic representation of buccal cavity and pharynx of *T. ilisha* showing the gill arches.

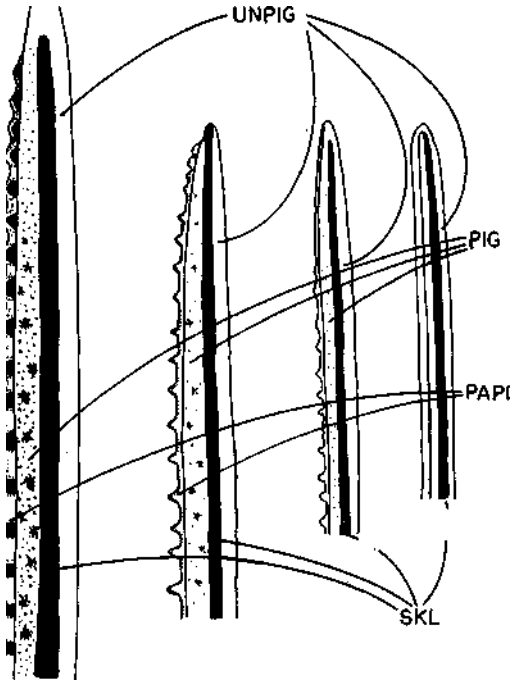


Fig. 3. Diagrammatic sketch (from left to right) of gill rakers of 362,127,86 and 44 mm long specimens respectively along with different zones. (UNPIG, outer unpigmented; SKL, skeletal; PIG, pigmented and PQPI, inner margin with concical papillae).

pouches and each such pouch consists of two parts : (i) the canal passage and (ii) the sac. The internal wall of the canal passage is provided with two rows of small sized rakers as well as two rows of gill lamellae like structure (Figs. 4 & 5). The sac ends blindly.

b) The gut

Pharynx leads into the oesophagus. The oesophagus is very short in length, narrow and moderately thick walled tube. The innermost layer (mucosa) of the oesophagus is provided with rows of longitudinally and densely arranged papillae of different shapes (Fig. 6). The stomach is a typically "V" shaped muscular tube which is divisible into

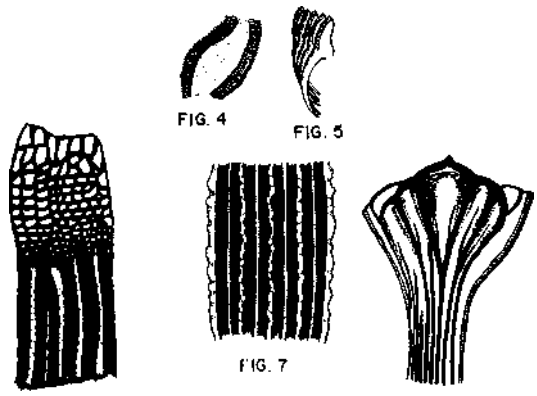


FIG.9

Fig. 4. Demonstrative diagram of the canal passage of pharyngeal organ (ventral side) showing rakers and lamellae like structure.

Fig. 5. Enlarged view of few rakers and lamellae.

Fig. 6. Folds of the oesophageal region.

Fig. 7. Folds of the cardiac stomach.

Fig. 8. Folds of the pyloric stomach.

Fig. 9. Folds of the intestine.

two parts: (i) an anterior cardiac stomach and (ii) the posterior, pyloric stomach. The distal end of the pyloric stomach is highly muscular, spherical and looks like the gizzard of bird. The inner wall of the stomach is provided with thick well marked longitudinal folds (Figs. 7 & 8). The space of the pyloric stomach is much reduced. Immediately behind the pyloric stomach. The anterior most intestine is provided with numerous small caecae in the form of clusters which open into the intestine. The pyloric caecae are variable in number (several hundreds) and the number varies depending on the size of the fish. The remaining part of the gut and hind gut form a coiled tube of moderate length. The rectum is not well differentiated from the intestine. The wall of the intestine

TABLE 1. *Characteristics of gill rakers* o/T. ilisha

Fish size (mm)	No. of fish examined	Maximum length of gill raker (mm)	Width of gill rakers (flattened side) (mm)	Density (number) of gill rakers per (mm)	No. of gill rakers 1st branchial arch (left side only)
44-54	6	1.40-1.50	0.05-0.07	12.80-15.20	150-158
86-88	5	2.25-3.00	0.10-0.12	10.40-11.20	176-183
127	1	4.12	0.15	8.80	222
362-392	5	12.50-13.25	0.55-0.60	4.00-4.50	361-384
448-465	5	14.75-15.62	0.75	2.90-3.40	371-391

is thin and inner side of the wall possesses vary faint transverse foldings (Fig. 9). Among the digestive glands, the liver is the largest covering the entire stomach and major portion of anterior intestine. The liver is not differentiated into lobes. Diffused pancreas is scattered in between the pyloric caeca and around intestine. A gradual increase in RLG (Relative Length of Gut) value is also noticed among the fish of different length groups from fry (59 mm) to adult hilsa (525 mm) which varies from 0.86 to 1.87 (Table 2).

TABLE 2. *RLG values* o/T. ilisha

Length range (mm)	No. of fish examined	Max. /minimal value	Average values
59-99	9	0.86-1.14	1.05
115-161	2	1.08-1.17	1.13
230-285	10	1.26-1.55	1.37
309-392	21	1.35-1.70	1.47
401-475	12	1.43-1.77	1.50
510-525	4	1.80-1,87	1.82

B Histology

The histological structure of the buccal cavity is the same as that of pharynx. The only striking difference is the presence of numerous mucous cells in the pharynx and pharyngeal pouch (Figs. 10 & 11). Taste buds are completely absent from buccal cavity, pharynx, pharyngeal pouch and oesophagus. The most striking feature of the pharyngeal pouch is the presence of vascular gill lamellae like structure and gill rakers (Fig. 12). The oesophagus consists of mucosa, the submucosa, the muscularis and the serosa. All these four layers are common in the rest of the alimentary canal, but the only difference is the characteristic structure of mucosa which differs in different parts of the gut. The mucosa of the oesophagus is greatly folded and forms large, extensive and branched villi (Fig. 13). Oesophagus ultimately leads into oesogaster where the mucosa is composed of columnar epithelial cells and a layer of numerous densely arranged gastric glands. Mucous cells are completely absent from this region (Fig. 14). In the cardiac stomach, the glandular epithelium of the mucosa consists of numerous tubular glands which are the gas-

pharyngeal **puch** X33.

Fig. 11. T.S. tin

'**ood** and feeding habits

The **quantitative analysis of the** items **bod** found in **the** stomach is expressed both in volumetric and **occurrence percent-**

Hg.15.

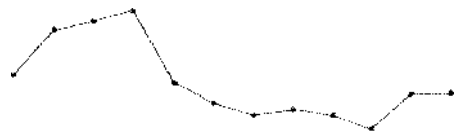
Pig. 16. T.S. through the pyloric stomach X66.

gh the pancreas.

DISCUSSION

20. T.S. **through** the **!iv<>r.**

ADULT



« A M J J A S 0 N 0

MONTHS

ariation in theGastrosomatic index of

til

tial. It is well known **from the** review **article**

fig. of

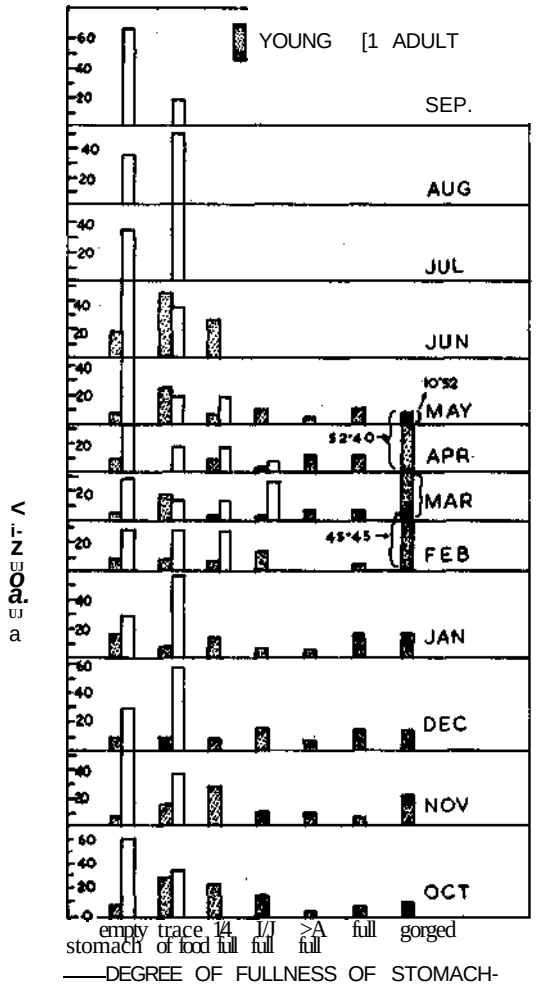


Fig. 23. Seasonal variation in the feeding intensity of young and adult Hilsa.

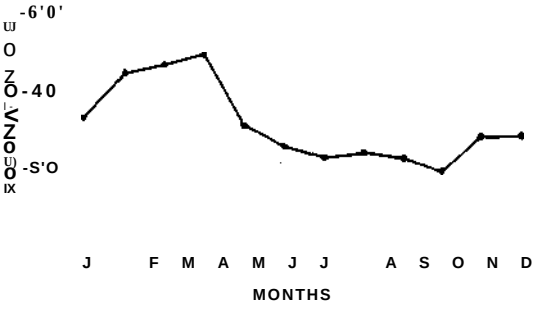


Fig. 24. Seasonal variation in the Gastrosomatic Index of T. ilisha.

1958 & Khanna, 1962). Although, minute and weakly developed teeth are known to occur in few planktivorous fish namely *Atherina forskali* (Al-Hussaini, 1947, *Ilisha filigera* and *Pampus argenteus* (Khanna & Mehrotra, 1970). The absence of teeth and masticatory organs in the mouth of hilsa obviously indicates that the fish feeds on micro-organisms where mastication or crushing of food is not essential. It is well known from the review article of Kapoor *et al,* (1975) that all plankton feeder may not possess fine, numerous and closely set gill rakers (eg. *Boleopthalmus)* but fish with long, fine, closely set gill rakers are mostly plankton feeders (e. g., *A. forskali, Gudusia chapra, Alosa pseudoharengus, Ilisha filigera* and *Rhinomugil corsula).* In adult hilsa, the fully developed gill rakers with minute papillae form an efficient filtering mechanism for seiving minute food organisms, while imperfectly developed gill rakers without papillae in fish (below 50 mm) fail to develop such efficient filtering device. The results of stomach content analysis also give support to the above contention. The presence of both minute gill rakers and gill lamellae in pharyngeal pouch is indicative of their associations with both digestive and respiratory system. The oesophagus is short, narrow and cylindrical which indicates its planktivorous habit. Carnivorous and predatory fish possess longer and dialated oesophagus (Mehrotra and Khanna, 1969). In hilsa, the absence of teeth and masticatory apparatus in the mouth and pharynx respectively are well compensated by the presence of a highly developed muscular gizzard like pyloric stomach for crush-

ing the food materials apart from normal function of digestion. While working on clupeoid fish Nelson (1967) found that development of a gizzard may be considered as one of the series of gut specialisations, such as, loss of teeth, development of pharyngeal organ, well developed gill rakers and moderately long intestine indicating microphagous habits of the group. The intestine of hilsa is thin walled and of considerable length. The intestine is thrown, into 10 bends and 5 loops. The increase in RLG value from fry to large adult hilsa is due to the changes in food and feeding habits in the same environment. Khanna (1961) has reported the RLG value for adult hilsa as 1.72 which is very close to the present observation.

The absence of taste buds from the mucosa of buccal cavity, pharynx, pharyngeal pouch, oesophagus and oesogaster provides reasonable evidence to indicate that the fish searches for food chiefly by means of its sight and not by taste, which lends support to the contention that a plankton feeder does not require an acute sense of taste. The presence of large number of mucous cells in the pharynx, pharyngeal pouch and anterior part of oesophagus significantly indicates that the constant secretion of mucous takes place in these regions and serves as an efficient lubrication of the food. Whereas, the presence of gill lamellae in the pharyngeal pouch is still amazing to signify its function which warrants further detailed investigation to justify its existence. Oesogaster is the transitional region where mucous cells are gradually disappearing and gastric glands start appearing. Thus, it is mixed in character by secreting both mucous and gastric juices. In most of the fish, gastric glands are absent in pyloric stomach. The cuticular layer of the pyloric stomach protects mucosa from the mechanical injury during the operation of grinding of coarse food like diatom, crustacean larvae etc. Thus, pyloric stomach of hilsa is a secretary as well as masticatory organ. The gastric glands secrete digestive juices that hydrolyse the diet of the fish. The presence of columnar epithelial cells in the mucosal villi of intestine significantly suggests its absorptive function. The relatively bigger sized villi in the anterior region of intestine indicate that maximum absorption takes place in the anterior intestine. Pyloric caecae have the same histological structure and probably they have the same function as that of the intestine (Rahimullah, 1945). Although there is no external demarcation between anterior and posterior intestine histological studies reveal that increased number of mucous cells are present in the posterior intestine.

Stomach content analysis of fry, juvenile and adult hilsa reveals that copepods are the most important food items consumed by the fish of all sizes at all times of the year. The only basic difference is that the fry and juvenile hilsa mainly feed on copepods while the stomach content analysis of adult hilsa show that a considerable amount of organic matter along with the copepods is present. The other notable difference in the food items is the uniform presence of minute organisms like diatoms, rotifers, green algae and protozoans in the stomach of adult. But these minute organisms are either totally absent in the stomachs of fry or are poorly present in the stomachs of juveniles. In the present study, the percentage of feeding individual is found much higher in case of young hilsa (fry and juveniles). As regard to adult hilsa, stomachs are mostly found empty showing a very low percentage of feeding. Moreover, the cessation of feeding activity during spawning seasons (September-October) is also no-

ticed in the present study. The nature of food items indicates that young hilsa feed mainly from surface and column niche of waterbody whereas, the presence of decayed organic matter diatoms, sand and mud along with copepods strongly suggests the bottom and column feeding habits of adult hilsa during upstream migration. It is evident from the above discourse that young hilsa mainly subsist on zooplankton while adult hilsa are microphagous planktivores. Similar observations have been made by Hora (1938), Nair (1939), Hora and Nair (1940) and Swarup (1959).

ACKNOWLEDGEMENTS

The first author expresses his gratefulness to late A. V. Natarajan, former Director and Dr Aran, G. Jhingran, Director, Central Inland Capture Fisheries Research Institute, Barrackpore for kindly providing all facilities and encouragement for this work.

REFERENCES

AL-HUSSAINI, A. H. 1947. The anatomy and histology of the plankton feeder *Atherina forshili* (Rupp.). /. *Morph.,* 80: 25-286.

Dun A MUSHI, J. S. 1960. The structure of the gills of certain freshwater teleosts. *Ind.]. Zootomy,* 1:1-40.

HALDER, D. D. 1970. Observation on the food of young *HUsa Uisha* (Ham.) of the Hooghly estuarine system. /. Bombay *nat. Hist. Soc.,* 67 (3): 578-583.

HORA, S. L. 1938. A preliminary note on the spawning grounds and bionomics of the so called Indian shad, *Hilsa Uisha* (Ham.) in the river Ganges. *Rec, Indian Mus.,* 40 (2) : 147-148.

HORA, S. L. AND K. K. NAIR 1940. Further observations on the bionomics and fishery of the Indian shad, *Hilsa Uisha* (Ham.) in Bengal waters. *Rec. Indian Mus.,* 42 (1): 35-50.

HYNES, H. B. N. 1950. The food of the freshwater stickle backs *(Casterosteus aculeatus* and *Pygosteus pungitius)* with a review of methods used in studies of the food of fishes. /. *Anim. Ecol.,* 19 (1) : 36-58.

JOB, T. J. 1940. Nutrition of Madras perches. *Rec. Indian Mus.,* 42 : 286-364.

KAPOOR, B. G. 1954. The anatomy and histology of the pharyngeal organ in *HUsa Uisha* (Hamilton). /. *Zool. Soc. India, 6 :* 167-172.

KAPOOR, B. G. 1958. The morphology **and** histology of the alimentary tract of a plankton-feeder, *Gadusia chapra* (Hamilton). *Annali del Museo Civico di stork Natarale di Cenova,* 70 : 8-32.

KAPOOR, B. G., H. SMrra AND I. A.VERIGHINA 1975. The alimentary canal and digestion in teleosts. *Adm. Mar. Biol.,* 13 : 109-239.

KHANNA, S. S. 1961. Alimentary canal in some teleostean fishes. /. *Zool. Soc. India,* 13 (2) : 206-219.

KHANNA, S. S. 1962. A study of buccopharyngeal region in some fishes. *Indian]. Zool,* 3 (2) : 1-48.

KHANNA, S. S. AND B. K. MEHROTRA. 1970. Histomorphology of the buccopharynx in relation to feeding habits in teleosts. *Proc. nat. Acad. Sci. India,* B 40 (I) : 61 - 80.

MEHROTRA, B. K. AND S. S. KHANNA 1969. Histomorphology of the oesophagus and the stomach in some Indian teleosts with inference on their adaptational features. *Zoologische, Beitrage,* 15:375-391.

NATARAJAN, A. V. AND A. G. JHINGRAN. 1961. 'Index of Prepondarence', a method of grading the food elements in the stomach analysis of fishes. *Indian]. Fish.,* 8 (1) : 54-59.

NAIR, K. K. 1939. On some early stages in the development of the so-called Indian shad, *HUsa Uisha* (Ham.). *Rec. Indian Mus.,* 41 (4): 409-418.

NELSON, G. J. 1967. Gill arches of teleostean fishes of the family Qupeidae. *Copeia,* No. 2 : 389-399.

PIIXAY, T. V. R. 1952. A critique of the methods of study of food of fishes. /. *Zool Soc. India,* 4 (1): 17-36.

PILLAY, T. V. R. 1958. Biology of the hilsa, *Hilsa Uisha* (Hamilton) of the river Hooghly. *Indian* J. *Fish.,* 5 (2) : 201-257.

RAHIMULLAH, M. 1945. A comparative study of the morphology, histology and probable functions of the pyloric caeca in Indian fishes, together with discussion on their homology. *Proc. Ind. Acad. Sci.,* 21 (1) : 1-37.

SWARUP, K 1959. The morphology and histology of the alimentary tract of *HUsa Uisha* (Hamilton). *Proc. nat. Acad. Sci. India,* B 29 (3) : 109-126.