CHAPTER III
JAWS AND TEETH
INTRODUCTION

The mouth cavity is an important component of the alimentary canal. It may be involved in the seizure, selection of food, rejection of undesirable items ingested by fish and pre-digestion preparation of food. Among species, the mouth cavity shows great plasticity and structural adaptability for the exploitation of different food items (Kapoor et al., 1975; Kapoor and Khanna, 1994; Horn, 1998). Literature on the surface ultra-structure of the mouth cavity in fish is scanty. Surface organisation of the mouth cavity, using scanning electron microscope, was studied for the carnivorous fishes by Bishop and Odense, (1966) in Gadus morhua Linnaeus, 1758; Cataldi et al., (1987) in Sparus aurata Linnaeus, 1758 and the surface plankton feeder by Sinha and Chakrabarti (1985) in Catla catla Hamilton, 1822.

Meyer-Rochow (1981) described the distribution and surface morphology of taste buds on the tongue of a variety of fishes having different food habits and inhabiting a variety of habitats. In fishes, taste buds occur not only within the oral and pharyngeal cavities, but also on external structures such as the barbels and skin (reviewed by Caprio, 1988; Jakubowski and Whitear, 1990). Excitation of taste buds in the oropharyngeal cavity of two species of catfish, Ictalurus natalis and Ictalurus punctatus, is known to induce swallowing of food, whereas taste buds on the barbels and skin are involved in the location and pickup of food Atema, (1971). Ezeasor (1982) described taste buds in the oropharyngeal cavity of
an active predator *Salmo gairdneri*. Richardson, (1836), Hansen et al., (2002) reported the development of taste buds at different locations including the oropharyngeal cavity of *Danio rerio*.

More recently, Fishelson and Delarea (2004) and Fishelson et al., (2004) described the form and distribution of taste buds and dentition in the oropharyngeal cavity of several blenniid, gobiid and cardinal fish species. The mouth cavity has been described by Islam, (1951); Khanna, (1962) using light microscopy in catfish *Rita rita* (Hamilton, 1822). Khanna (1962) studied mouth cavity using light microscopy in *Mystus sperata aor* (Hamilton, 1822) and *Silonia silondia* (Hamilton 1822). Pasha (1964) described the mouth cavity of *Mystus gulio* (Hamilton, 1822), and similar studies were carried out by Sastry (1973); Sinha and Moitra (1976) in *Clarias batrachus* (Linnaeus, 1758). Sinha and Chakrabarti (1986) and Chakrabarti and Sinha (1987), using scanning electron microscopy, described the surface architecture of the mouth cavity of *Mystus sperata aor* (Hamilton, 1822) and *Mystus vittatus* (Bloch, 1794) respectively.

Atema (1971) described the structure, function and distribution of taste buds in the mouth cavity of the channel catfish *Ictalurus natalis* (Lesueur, 1819). More recently, Golubtsov et al., (2004) studied the dentition in African catfish *Andersonia leptura* (Boulenger, 1900) and *Siluranodon auritus* (Geoffroy Saint-Hilaire, 1809).

Teleost fishes generally possess a combination of two traits, teeth on numerous bones of the oral jaws, palate and tongue, and pharyngo-branchial
skeleton; and polyphyodonty (many tooth generations) (Huysseune and Sire 1998).

These traits provide opportunities for variability in locations and numbers of teeth (Nelson 1969) and through successive replacement cycles, sizes and shapes of teeth may vary ontogenetically (Stoner and Livingston 1984, Gottfried (1986), Nakajima and Yue 1995, Mullaney and Gale 1996, French 1997) or in response to environmental conditions, (Greenwood 1964, Kas’yanov et al., 1982, Meyer 1990, Wimberger 1991).

Meyer (1990) and Greenwood (1964) described polymorphism found in the pharyngeal bones and teeth of a number of cichlid fishes (Teleostei: Cichlidae) and characterized by two morphotypes. One morph exhibits a gracile dentition with a large number of fine, conical teeth “papilliform”, while the other morph exhibits a robust dentition with a small number of large, broad and flat teeth “molariform”. These differences may result from genetic and/or environmental factors, and in some species molarization may be triggered when individuals consume foods of increased hardness (e.g., crushing snails versus eating soft detrital material).

Teeth are present in the oropharyngeal cavities of many fishes. Teeth in the pharynx are frequently associated with pharyngeal jaws, which are situated immediately anterior to the oesophagus (Casciotta and Arratia, 1993; Vandewalle et al., 1994, 1995). Pharyngeal jaws and teeth in some species involved in the processing of food, whereby it is masticated and crushed before being transported
to the oesophagus for swallowing (Sibbing, 1982; Claes and De Vree, 1991; Vandewalle et al., 1994, 1995).

Brush- and gouge-like devices are ideal for scraping food off substrates, and are most often found in aquatic organisms particularly, aquatic insect larvae (Arens, 1994), amphibian larvae (Orton, 1953; Wassersug and Yamahita, 2001), and fishes. In all these cases the diet primarily consists of adherent algae.

In teleosts the rake-like denticles of the Osmeriform ayu, (Howes and Sanford, 1987, Uehara and Miyoshi, 1993), the tooth-like keratinous hooks of Gyrinocheilidae, (Ono 1980, Benjamin 1986) spatulate teeth of certain Cichlidae (Vandervennet et al., 2006) and Mochokidae, the scraping teeth of species of the Loricariidae or suckermouth catfishes. The latter family exhibits the most exquisite and diverse teeth forms (Muller and Weber, 1992; Schaefer and Stewart, 1993; Delariva and Agostinho, 2001), the S- or Z-shaped recurved teeth are generally asymmetrically bicuspid, but in some taxa, have one cusp only. Teeth of the related loricarioid, scoloplacid, and astroblepid families are usually symmetrically, bifid (Schaefer, 1990), although shape variation exists (Cardona and Guerao, 1994). Teeth are absent in adults of the more basal callichthyids, while simple conical teeth have been found in small juveniles (Huysseune and Sire, 1997a), while many genera of the basal loricarioid trichomycterids have rather conical teeth; Henonemus has unicuspid recurved teeth, reminiscent of loricariid teeth (DoNascimiento and Provenzano, 2006).
Cichlid teeth are key components of the trophic machinery on both oral and pharyngeal jaws. Morphologies range from widely spaced, sharply pointed unicuspsids in piscivorous, planktivorous and insectivorous species (e.g., *Cynotilapia afra*; *Rhamphochromis esox*,) to closely packed tricuspsids in algal scrapers (e.g., *Labeotropheus fuelleborni*). The majority of African cichlids have unicuspid or bicuspid dentitions of the oral jaw; many species like *Metriaclima zebra* possess an outer row of bicuspid teeth with tricuspsids in posterior rows. Very few species have exclusively, or primarily, tricuspid teeth. The addition of a third cusp on teeth of the outer row is an evolutionary novelty among cichlids, shared by a single species in Central America.

The shape of cichlid teeth may respond rapidly to natural selection; tooth shape characterizes diverging morphs (Tichy and Seegers, 1999; Hulsey *et al*., 2005), and evolves replicatively (Ruber *et al*., 1999). A great deal is known about the development of cichlid teeth (Huysseune, 1990; Huysseune and Sire, 1992a, b; Streelman *et al*., 2003a; Vandervennet and Huysseune, 2005). Adult cichlids and many teleost fishes have multiple rows of teeth on two sets of jaws (oral and pharyngeal), similarly shaped teeth within a row (homodonty), and tooth replacement throughout life via de novo formation of tooth germs, (polyphyodonty) (Huysseune and Thesleff, 2004).

A strong correlation between the character of food, feeding habit and the structure of teeth exist. Most of herbivorous fishes posses pharyngeal teeth, which may be simple comb like, pointed or curved type or have occlusal molariform
surface as in Cyprinidae. Such teeth are used in grasping, tearing or grinding the objects of food.

The teeth of most of fresh water carnivores, like bagarid cat fishes and air breathing cat fish are sharply pointed (villiform) and are adapted for grasping, puncturing and holding the prey. Conical or sub conical teeth adapted for piercing and holding the prey are found in snake heads *Channa* sp. In *Hemiramphus* they are mostly pointed and a few are tricuspid. In *Xenentodon* they are sharp and large and are widely placed.

Modifications in the position, shape and the size of the mouth in various species of fishes are correlated with the character of food and the manner in which it is obtained. Highly protractile mouth of *Nandus nadus* and of various species of *Channa* and the slightly protractile mouth of *Anabas* are the adaptations for increasing the gape of mouth. The mouth is usually guarded by the lips. These are, fleshy in suctorial fishes like sturgeon, *Labeo, Cirrhinus* and *Puntius*, etc.
MATERIALS AND METHODS

For the study of jaws and teeth of Channa punctatus, Cyprinus carpio and Oreochromis mossambicus. The fishes were collected from local fish market, washed and preserved in 10% formaline solution. The preserved fishes were cut and opened at each angles of the mouth. The roof and floor of the buccopharynx were properly washed and preserved in 70% alcohol and glycerine for stretching. The jaws, teeth, gills and gill rakers were examined properly for detailed studies.

RESULTS AND DISCUSSION

Channa punctatus
**Food and feeding Habits**

The food analysis of *Channa punctatus* revealed that it consisted of crustaceans, insects, molluscs, fishes, plant materials and sand and mud particles (Chapter 2). Thus *Channa punctatus* shows carnivorous type of feeding habit.

**Mouth**

During the present study it was observed that the mouth of *Channa punctatus* is horizontal and terminal in position and the gap of the mouth is wide, surrounded by strong papillated jaws, the upper jaw and lower jaw. The upper jaw is shorter than the lower jaw and is not protrusible. The lower jaw is protruding, large and is not protractile (Plate 4a).

Similar observations were reported by Talwar and Jhingran, (1992); Jayaram, (1999), Courtenay and Williams, (2004); Das and Moitra (1956); Das and Nath (1965), Paul *et al.*, (2009) while describing the morphological characters of *Channa* species.

**Buccal cavity**

During the course of study it was observed that the buccal cavity of *Channa punctatus* is wide and spacious. Its roof is formed by the base of the cranium and side walls, and the floor of the buccal cavity is formed by the branchial arches. It is observed that the smooth mucous membrane with a large number of mucous secreting cells line the walls of buccal cavity (Plate 4b).

Pharynx

Pharynx of *Channa punctatus* is observed to be wide and spacious. It is observed that, a pair of ovoid upper pharyngeal pads are present on the roof of the pharynx (Plate 4b).

Paul *et al.*, (2009), Chao-Kai Kang (2010) reported that in Siamese fighting fish a carnivorous fish has similar pharyngeal organ located on the dorsal pharynx where the four pairs of gills converge. Miller, 1964; Sanderson *et al.*, 1991; Bauchot *et al.*, 1993 observed that the structure of the pharyngeal organ of *Channa punctatus* is similar to that of other teleosts.

Tongue

Tongue of *Channa punctatus* is observed to be well developed and mobile which is affixed along the mid dorsal line of the floor of the buccal cavity (Plate 4d).

Similar observations are made by Gautam Ranjan (2008) in carnivorous fish *Mystus seenghala* where the tongue is well developed and mobile and help in pushing the prey into the buccal cavity.

Teeth

During the study it was observed that numerous teeth are present in groups in the bucco pharyngeal region.

On the roof of the buccal cavity maxillary, palatine, vomerine and pharyngeal teeth are present. The maxillary teeth on the upper jaw are observed to be small and sharp. They are borne on the pre maxillaries. The anterior maxillary
teeth are observed to be larger than the posterior. Just behind and parallel to the upper jaw, the vomerine teeth are present in a small patch (Plate 4c and 5a).

It was observed that the palatine teeth are located just behind the maxillary teeth on the palate. The anterior maxillary teeth extend in a patch and are present just behind the palatines. The palatine teeth are similar in size and shape to the posterior maxillary teeth. The pharyngeal teeth are the largest and strongest on the roof of the buccal cavity (Plate 4c and 5a).

The lower jaw of *Channa punctatus* has a single row of villiform teeth which widens to form 5 to 6 rows at the jaw symphysis. The horny pad teeth are present on the inner side of the villiform teeth (Plate 4d). Mandibular teeth are present on the lower jaw with 3 to 6 canines behind single row of villiform teeth (Plate 5c).

It was observed that the anterior mandibular teeth and the posterior mandibular teeth on the lower jaw are arranged in rows. The anterior mandibular teeth are smaller than the posterior mandibular teeth. The anterior mandibular teeth are similar in size and shape to the anterior maxillary teeth.

It was observed that the horny pad teeth are present on the lower jaw. There are two pairs of horny pads, the anterior horny pad teeth and the posterior horny pad teeth. The anterior horny pad teeth and the posterior horny pad teeth are similar in size and shape to the vomerine teeth. The anterior horny pad teeth are observed to be lodged in a patch on the horny pads. The lower pharyngeal teeth are absent in the posterior pharyngeal region.
A pair of ovoid upper pharyngeal pads are observed on the roof of the pharynx. The teeth are distinctly arranged in two groups on the pharyngeal pads. The larger teeth are present in the anterior half and the smaller teeth are present in the posterior half of the pharyngeal pads. All the teeth appear recurved, especially the larger ones, each with a strong base and high conical cusp. The lower pharyngeal bones together form a triangular structure and are situated on the floor of the pharynx present just opposite the upper pharyngeal tooth pads. Each lower pharyngeal bone shows several rows of straight teeth on its surface. Some teeth are large with stumpy base and some are smaller. The arrangement and direction of teeth on the pharyngeal pads suggest that they aid in preventing the escape of prey.

Nijaguna et al., (1990) on studying *Channa gachua* reported that the upper and lower jaws of *Channa gachua* bear teeth of varied shape and size arranged in several rows. The villiform and pointed teeth on the premaxilla are not only large but also directed inwards. The size of the teeth on the premaxilla decreases towards posterior end of the maxilla. He reported that the entire dentary has small villiform teeth on its surface. In addition, the anterior region and along the outer margin, large inwardly directed teeth are present. This type of arrangement of teeth suggests their function in seizure and prevention of escape of prey.

Similar observations were reported by Talwar and Jhingran, (1992); Jayaram, (1999), Courtenay and Williams, (2004) while describing the morphological characters of *Channa* species.

**Gill rakers**
The gill rakers are situated on each side of the gill arch in a single row. The gill rakers of the *Channa punctatus* are observed to be modified into flat circular plates (Plate 4b).

Nijaguna *et al.*, (1990) reported that these discs are provided with a series of small pointed teeth.
Cyprinus carpio

Food and Feeding habits

The food analysis of Cyprinus carpio revealed that it consisted of diatoms, unicellular algae, aquatic plants, detritus, multicellular algae and sand and mud particles (Chapter 2). Thus Cyprinus carpio shows herbivorous type of feeding habit.

Mouth

During the present study it was observed that the snout of the Cyprinus carpio is blunt, mouth is large and crescentic. Cyprinus carpio has two barbels, one on each side of the mouth. Mouth is terminal and is not protractile, surrounded by strong upper and lower jaws. (Plate 6a, 6c and 6d).

Gautam Ranjan (2008) reported that the variation in the structure of mouth is related to the feeding habit while studying the buccopharynx in Cirrhina mrigala, Schizothorax plagiostomus and Mystus seenghala.

Buccal cavity

The buccal cavity of Cyprinus carpio is not very large. It is observed that the teeth are absent on upper and lower jaws. The roof of buccal cavity of Cyprinus carpio is formed by the base of the cranium. The side walls and the floor of the buccal cavity are formed by the branchial arches (Plate 6b).

Similar observations were reported by Sibbling (1984) while studying the architecture of the head and its function in food processing in Cyprinus carpio.

Pharynx
It is observed that the pharynx of *Cyprinus carpio* is dorso-ventrally compressed. It is found that the fifth branchial arch is reduced to a single strong bone on each side called as pharyngeal dental apparatus which is usually referred in cyprinids as the 'pharyngeal jaw'. It is observed that *Cyprinus carpio* has three rows of teeth converging towards each other forming a stud-like 'molariform' prominence. A horny pad is observed in the dorsal wall of the pharynx beneath the occipital region of the skull opposite to the pharyngeal teeth (Plate 6b).

Similar observations have been reported by Goodrich (1930), Sibbling (1984) as the 'esopharyngeus inferior' the pharyngeal dental apparatus is usually referred in cyprinids as the 'pharyngeal jaw'. Similar observations were reported by Chu (1935) where pharyngeal pad, along with the pharyngeal molariform teeth, enabled to shear the food, forms an exceedingly efficient masticating apparatus. Overall size of the pharyngeal jaws as well as of the muscles which actuate them is found to be well developed in *Cyprinus carpio*.

Similar findings were also reported by Al-Hussaini (1949) that a pharyngeal pad is present in the dorsal wall of the *Cyprinus carpio*.

**Tongue**

The tongue of *Cyprinus carpio* is small, immobile and affixed along the mid dorsal line of the floor of the buccal cavity (Plate 6c).

Similar observations were reported by Gautam Ranjan (2008) while studying the buccopharynx in *Cirrhina mrigala, Schizothorax plagiostomus* and *Mystus seenghala*. 
**Gill rakers**

It was observed that in *Cyprinus carpio* the branchial arches bear long, slender, numerous, and thin gill-rakers arranged in two rows on each side. The gill rakers are arranged just like leaves on the branchial arches (Plate 6b).

Similar observations were reported by Sibbling (1984) while studying the architecture of the head and its function in food processing in *Cyprinus carpio L.* Kyle (1926) reported that long gill-rakers characterize the majority of bottom-feeders which stir up the mud, a habit which the carp is known to have.
**Oreochromis mossambicus**

**Food and feeding Habits:**

The food analysis of *Oreochromis mossambicus* revealed that it consisted of algae, diatoms, rotifers, crustaceans, insect larvae and sand and mud particles (Chapter 2). Thus *Oreochromis mossambicus* shows omnivorous type of feeding habit.

**Mouth**

During the study it was observed that the mouth of *Oreochromis mossambicus* is large, surrounded by upper and lower lips which are thick. The lower jaw extends the upper jaw (Plate 7a).

Similar observations were reported by Gautam Ranjan (2008) while studying the buccopharynx in *Cirrhina mrigala, Schizothorax plagiostomus* and *Mystus seenghala*.

**Buccal cavity**

It was observed that the buccal cavity of *Oreochromis mossambicus* is not very large. *Oreochromis mossambicus* possesses teeth on upper and lower jaws. The roof of buccal cavity is formed by the base of the cranium. The side walls and the floor of the buccal cavity are formed by the branchial arches (Plate 7b).

Similar observations were reported by Khanna (1970) in some Teleosts. Similar observations were reported by Gautam Ranjan (2008) while studying the buccopharynx in *Cirrhina mrigala, Schizothorax plagiostomus* and *Mystus seenghala.*
Pharynx

The pharynx of *Oreochromis mossambicus* was observed to be dorso-ventrally compressed. It was observed that the pharyngeal teeth of *Oreochromis mossambicus* are fine, thin, unicuspid and hooked on the pharyngeal bones (Plate 7b, 9a, 9b and 9c).

Similar observation were reported by Lanzlng and Higginbotham, (1976); Sasagawa, (1997) in *Tilapia species*. Similar observations were reported by Gautam Ranjan (2008) while studying the buccopharynx in *Cirrhina mrigala, Schizothorax plagiostomus* and *Mystus seenghala*.

Tongue

The tongue is small and not fleshy, which is affixed along the mid dorsal line of the floor of the buccal cavity (Plate 7d).

Gautam Ranjan (2008) reported that the variation in the structure of mouth is related to the feeding habit while studying the buccopharynx in *Cirrhina mrigala, Schizothorax plagiostomus* and *Mystus seenghala*.

Teeth

It was observed that there are several rows of teeth on the upper and lower jaw of *Oreochromis mossambicus*. During the study it was observed that the teeth of *Oreochromis mossambicus* are uniformly small, distally flattened, unicuspid, bicuspid and tricuspid enameloid structures. The outer rows of teeth are observed to be capped with a brown material.
Teeth on the pharyngeal bones of the *Oreochromis mossambicus* were observed to be fine, thin and lodged on the pharyngeal bones. (Plate 7c, 7d, 8a, 8b, 8c and 8d).

Similar observation was made by Lanzing and Higginbotham, (1976); Sasagawa, (1997) where they reported that Tilapias possess jaw teeth between one and five rows. The structure of the teeth is typical of generalist feeders, being uniformly small, distally flattened, unicuspid, bicuspid or tricuspid enameloid structures. Fryer and Iles, 1972a; Lanzing and Higginbotham, (1976) reported that the jaw teeth of *Tilapia* are small, tricuspid, bicuspid or tricuspid structures, arranged in one to five rows and flattened distally to form blades that can he used as scrapers.

Northcott and Beveridge, (1988) reported that the outer row of teeth in *Oreochromis niloticus* is capped with a brown material that may be iron oxide and may afford some protection during grazing or browsing.

Fryer and Iles, (1972); Caulton, (1976); Bowen, (1982) reported that the jaw teeth are employed by *Tilapia* species to bite and tear plant material. Caulton, (1976) reported that the pharyngeal teeth of the phytoplanktivorous tilapia, such as Saratherodon, are fine, thin and hooked on the pharyngeal bones, whereas those of macrophyte feeders, such as rendalli, are coarse and robust. Fryer and Iles, (1972a) reported that *Tilapia* have pharyngeal teeth which are varied in configuration from one tilapia species to another, to suit the different diet
preferences. Lanzing and Higginbotham, (1976) also reported similar observations.

Dempster et al., (1993); Zimudzi, (1995) reported that *Oreochromis* species have been observed being used to tug at and detach periphyton from substrates. Periods of periphyton grazing are interspersed with periods of buccopharyngeal processing, swallowing and foraging.

**Gill rakers**

The gill-rakers in *Oreochromis mossambicus* are observed to be short, thicker, numerous and more widely spaced, arranged in two rows on the branchial arches on each side (Plate 7b).

Goutam Ranjan et al., (2008) reported that when gill arches are closer to each other the gill rakers help in forming sieve to retain the food in buccopharynx.
a) Lateral view of mouth of *Channa punctatus*.

b) Buccal cavity of *Channa punctatus*.

c) Upper jaw or roof of the mouth of *Channa punctatus* showing teeth, (PM) premaxillary, (M) maxillary, (V) vomerine, and (P) palatine.

d) Lower jaw or floor of the mouth of *Channa punctatus* showing, (MT) mandibular teeth, (T) tongue.
Plate 5

a) Magnified view of upper jaw of *Channa punctatus* showing (M) maxillary teeth.

b) Magnified view of lower jaw of *Channa punctatus* showing,

   (C) canine teeth (caniniform).

c) (MT) Mandibular teeth on the lower jaw of *Channa punctatus*. 
Plate 6

a) Lateral view of mouth of *Cyprinus carpio*.

b) Buccal cavity of *Cyprinus carpio* showing, (Mo) molariform teeth (PDA) pharyngeal dental apparatus and (GR) gill rakers.

c) Upper jaw or roof of the mouth of *Cyprinus carpio*.

d) Lower jaw or floor of the mouth of *Cyprinus carpio* showing, (T) tongue.
Plate 7

a) Lateral view of mouth of *Oreochromis mossambicus.*

b) Buccal cavity of *Oreochromis mossambicus* showing, (PhT) pharyngeal teeth on the pharyngeal bones, (G) gullet and (GR) gill rakers arranged in four rows on the branchial arches.

c) Lower jaw or floor of the mouth of *Oreochromis mossambicus* showing, (MT) mandibular teeth, (T) tongue.

d) Upper jaw or roof of the mouth of *Oreochromis mossambicus* showing, (M) maxillary.
Plate 8

a) Front magnified view of mouth of *Oreochromis mossambicus* showing, teeth on (UJ) upper jaw and (LJ) lower jaw.

b) Magnified view of lower jaw (LJ) of *Oreochromis mossambicus* showing (BC) bicuspid teeth capped with a brown material.

c) Magnified view of lower jaw (LJ) of *Oreochromis mossambicus* showing the outer row of teeth capped with a brown material and is (BC) bicuspid whereas the inner line of teeth is (TC) tricuspid.

d) Magnified view of upper jaw (UJ) of *Oreochromis mossambicus* showing (BC) bicuspid teeth.
Plate 9

a) Plate showing (PHT) pharyngeal teeth of *Oreochromis mossambicus*.

b) Magnified view of pharyngeal bone of *Oreochromis mossambicus* showing (PHT) pharyngeal teeth.

c) Magnified view of pharyngeal bone of *Oreochromis mossambicus* showing (UC) unicuspid teeth hooked on the pharyngeal bone.
PLATE - 9

[Images a, b, and c with labeled parts: PHT and UC]