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LIGHT AND SCANNING ELECTRON MICROSCOPIC STUDIES ON THE GILL RAKERS AND TASTE BUDS OF TWO INDIAN HILL-STREAM FISHES

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Abstract: Light and scanning electron microscopic studies of the gill-arch and gill-rakers in two Indian hill-stream fishes, *Garra lamta* (Hamilton) and *Noemacheilus rupicola* (McClelland) show many striking features. In the former fish, due to its herbivorous nature and for leading an active life even in the midst of high current of water with the help of its adhesive apparatus, gill-rakers are reduced without showing taste-buds, whereas in the later one, due to is carnivorous nature and a burrowing and a sluggish life at the bottom in sand/mud, the system is elaborate, with stumpy gill-rakers, provided with girdle like lamellae at the surface, many taste-buds with transverse like openings, provided with thick rim. Origin of the gill rakers has been suggested from the gill-arch tissues, by invagination.

Key words: Gill rakers, taste buds, hill-stream fish.

INTRODUCTION

Although in recent years considerable advancement has been made in the study of animal adaptation to different types of environment, little attention seems to have been paid to the wonderful modifications exhibited by the fauna of mountain torrents (Hora, 1992). Hill-stream fishes constitute an interesting group of small sized fishes, belonging to different genera like *Lepidocephalichthys, Noemacheilus, Botia, Garra, Glyptothorax, Glyptosternum* etc., which due to their peculiar habitat have undergone a variety of modifications specially in their external features, scales, paired fins, girdles, caudal fins, mouth and associated structures, eyes, skin, gill-openings etc. The chief factors which mainly influence for modifications are the strength of the current, food, shallow rocky water bed, water with constant motion and plenty of oxygen.

Light and electron microscopic studies on the gill-rakers and taste buds of Indian teleosts have attracted the attention of different workers very recently (Rooj, 1984; Munshi *et al.,* 1984; Ray *et al.,* 1987; Ghosh *et al.,* 1988; and Munshi *et al.,* 1989). The importance of gill-rakers of various types of morphology in connection with different types of feeding habits in fishes are well known. These structures are well represented in large number of teleosts in their buccopharyngeal cavity attached with the gill-arches, either in one or two rows on each arch. They serve mainly to prevent the food from escaping out along with the respiratory water current (Khanna, 1970). However, the taste buds or taste receptors have been seen to be generally situated on the tip of gill-rakers (Ghosh *et al.*, 1989) and buccopharynx of a number of species (Ray *et al.*, 1987). The presence of the taste buds at the base of the gill-rakers and on the gill-arch epithelium have also been observed earlier (Rooj, 1984; Ojha and Singh, 1986 and Ojha, 1987).

In the present study the presence of taste buds at the base of the gill-rakers and beneath the gill-arch epithelium of two Indian hill-stream fishes *Noemacheilus rupicola* (McClelland) and *Garra lamta* (Hamilton) have been shown with the help of light and scanning electron microscopes.

MATERIALS AND METHODS

Live specimens were collected from Jonha Fall (Gautamdhara) near Ranchi (India) during the month of March when the rush of water in the stream remains low.

Light microscopy

Live specimens were anaesthetized by MS-222, 40mg/liter, opercula were removed, gills were taken out carefully, washed in Ringer's solution and small pieces were fixed in Bouin's fixative. After washing, the gill-pieces were decalcified, re-washed and dehydrated in graded ethanol, embedded in paraffin and horizontal sections (6-7μm) were obtained by a Weewox (India) microtome, the slides were stained in haematoxylin, counter stained with eosin and microphotographs were taken.

Scanning electron microscopy

Gills were carefully taken out from freshly anaesthetized (MS-222, 40mg/liter) specimens, and small pieces were fixed in 5% glutaraldehyde solution for about two hours inside a thermos flask filled with ice to maintain a cold temperature possible at the site. The required dilution of glutaraldehyde was obtained by cacodylate buffer (pH 7.4). The materials were transferred to 12% cacodylate buffered glutaraldehyde and stored inside ice-filled thermos flask for about 48 hours. After washing with buffer to remove fixative, the materials were dehydrated through a graded ethanol series and kept in acetone, before critical point drying. Gill pieces were glued on stubs with silver paint and coated with a thin layer of gold and observed under a Philips scanning electron microscope (PSEM/500), at regional Sophisticated Instrumentation Centre, Bose Institute, Calcutta and photographs were taken.

RESULTS

Light microscopy

In horizontal sections the gill-arch in *N. rupicola* shows short and stumpy projections of gill-rakers with shallow, concave tips (Fig. 10), whereas in *G. lamta* these are without any concavity (Fig. 11) and are lined with large cuboidal epithelium.

Both the figures indicate their origin as evaginations of gill-arch tissues. The gill arch of *N. rupicola* shows distinct epithelium. Thick layer of striped musculature is also distinct in the gill-arch above which many mucous gland cells, supporting cuboidal epithelium cells and groups of large taste buds are visible (Figs. 7-9). Each taste buds is more or less circular in shape, provided with many spindle shaped gustatory cells.

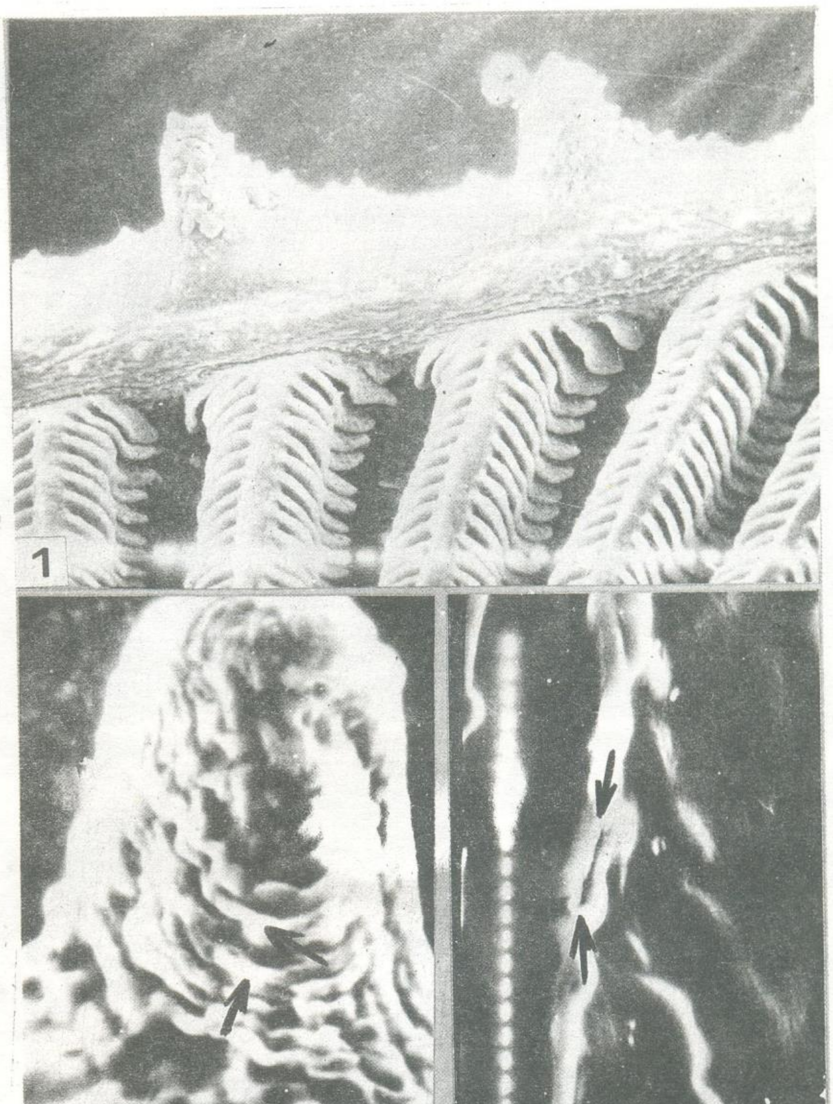

Fig. 1. Low power SEM of the part of the gill of *N. rupicola*, showing gill-arch, gill-rakers, primary and secondary gill lamellae (x157).

Fig. 2. High power SEM of a single gill-raker of *N. rupicola*, showing girdle like parts (x700 arrows)

Fig. 3. High power SEM of the base of a gill-raker of *N. rupicola* showing opening of a taste bud (arrow, x1600)

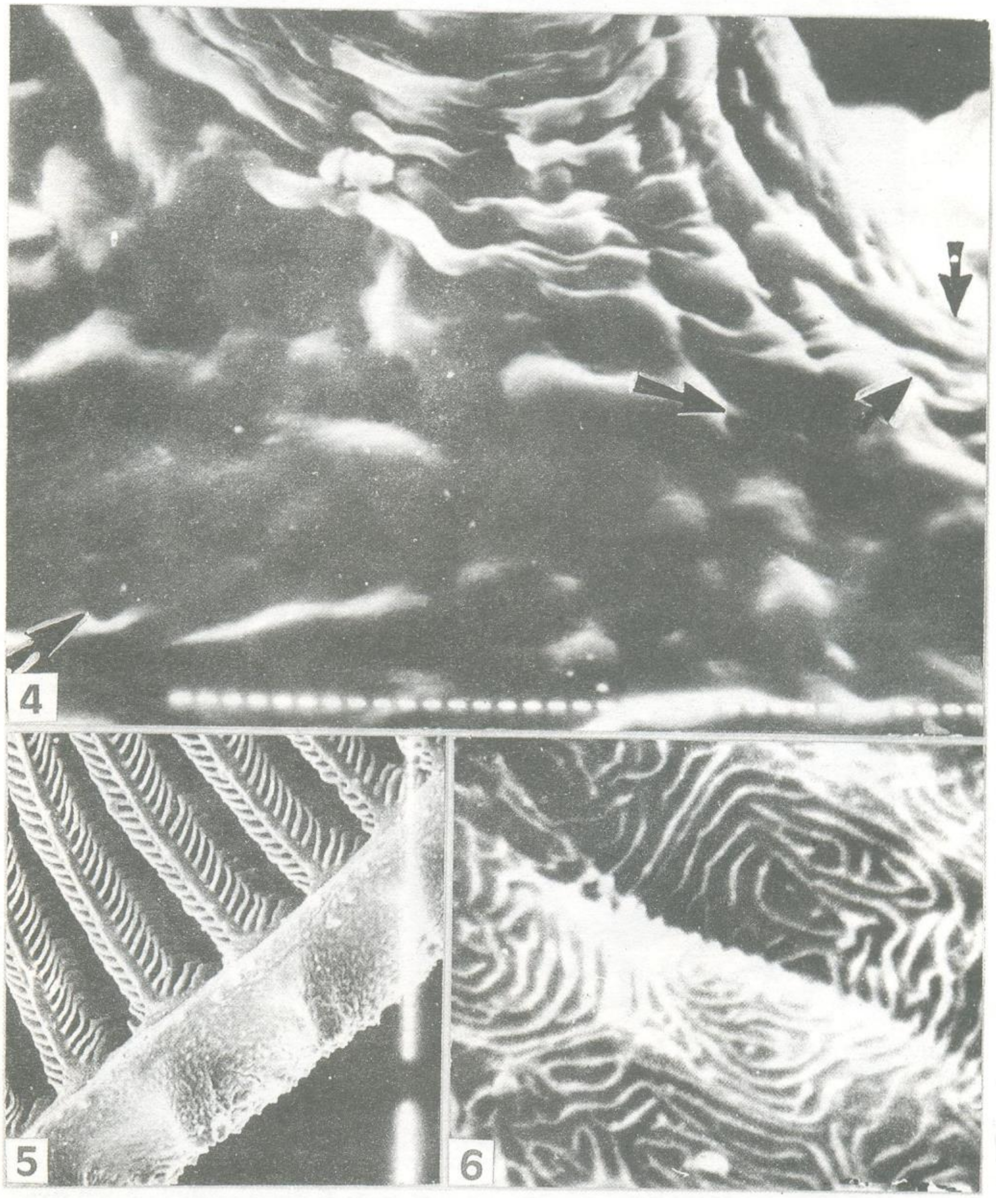

Fig. 4. High power SEM of the base of a gill-raker of *N. rupicola*, showing girdle like parts and openings of taste buds (arrow x5750).
Fig. 5. Low power SEM of a part of the gill of *G. lamta* (x80).
Fig. 6. High power SEM of the surface structure of the gill-rakers of *G. lamta* (x5750).

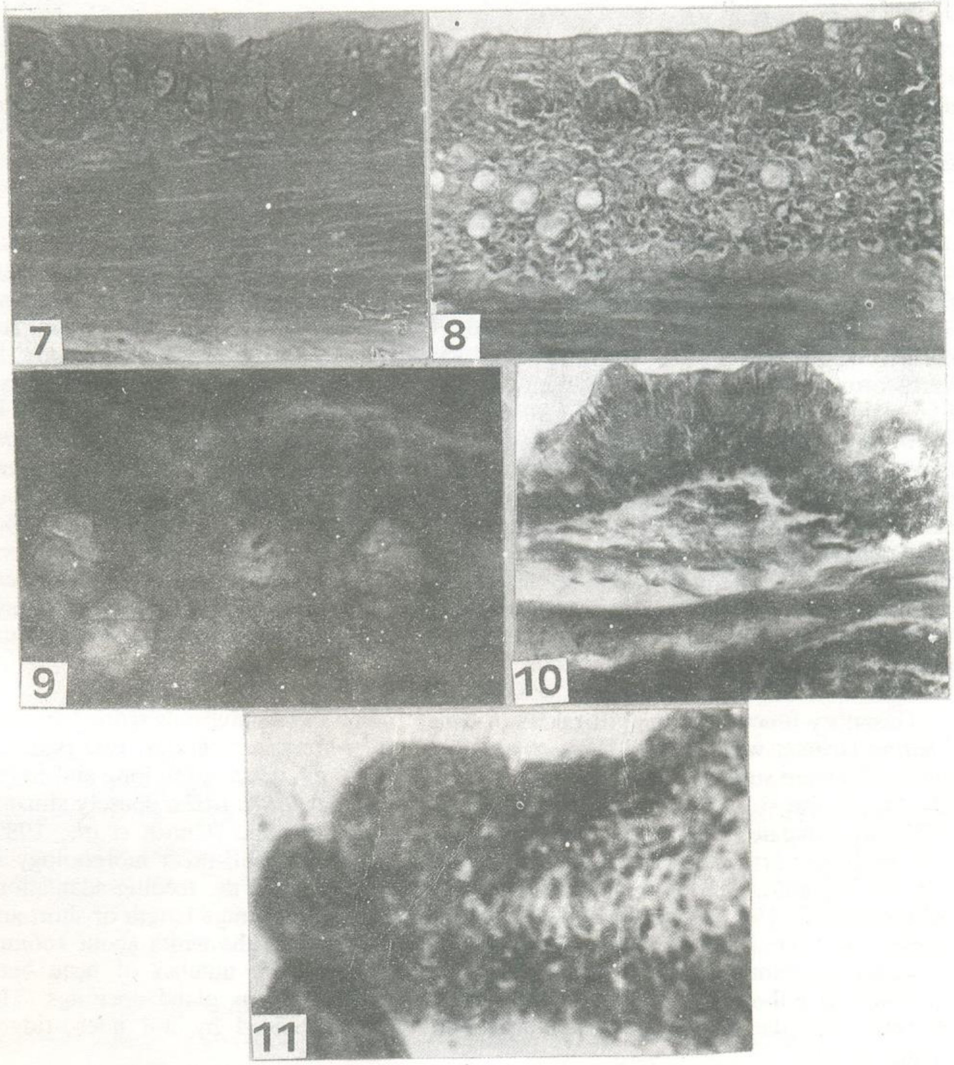

Fig. 7. H.S. paraffin section of the gill-arch of *N. rupicola* showing taste buds, mucous glands, and muscles (x100).

Fig. 8. Fig. 7 magnified, showing the structure of the gill-arch more distinctly (x400).

Fig. 9. Fig. 8 magnified, showing the mucous glands (x100).

Fig. 10. H.S. paraffin section of the gill-arch of *N. rupicola*, showing the origin of a gill-raker (x400)

Fig. 11. H.S. paraffin section of the gill-arch of *G. lamta*, showing the histology of a gill-raker (x400).

Electron microscopy

Each gill-raker in *G. lamta* and *N. rupicola* is short and stumpy structure (Figs. 1 and 5). Surface of the gill-rakers in *N. rupicola* is not smooth but provided with many transverse girdle like structures, openings of taste buds, and of mucous glands (Figs. 2 and 4). Each taste bud opening forms an elongated transverse slit like structure encircled by wide rim like portion (Fig. 3). Surface of the gill-raker in *G. lamta* is differently organized and shows micro-ridged sculpturing (Fig. 6).

DISCUSSION

Tooth like gill-rakers have also been reported in large number of carnivorous and predatory Indian teleosts, like *Wallago attu*, *Mystus seenghala*, *M. aor*, *Channa marulius*, *C. punctatus*, *C. gachua* and *Notopterus chitala*. In the generalized omnivorous species like *Tor tor, Puctius sarana, P. ticto*, they are short and stumpy. In herbivorous forms like *Labeo rohita, Cirrhina mrigala*, gill-rakers form broad sieve like structures across the gill-slits for filtering the water in order to retain the food in the bucco-pharynx. This function is best developed in plankton feeders like *Hilsa ilisha* and *Gadusia chapra*, in which the gill-rakers are long and thin, and form a perfect sieve so as to retain zooplankton and phytoplankton in the buccal cavity. Numerous taste buds have been observed on the lips and buccopharynx of a number species, but their number is smaller in some forms and absent in others. Taste buds have also been found in the epithelium covering the gill-arch (Khanna, 1970). Taste buds were reported also in the barbels, tongue and gill rakers of Clarias batrachus (Linn) (Ray, 1987), and the gustatory pores of the taste buds were found to be provided with minute projections of the neuro-epithelial cells.

Gustatory function of the gill-rakers in *Labeo rohita* and carnivorous striped murrel, *Channa striatus* was doubted (Ray *et al.*, 1987). In *Notopterus chitala*, two types of gill-rakers were studied (Ghosh *et al.*, 1988) on its gill-arch which were long and finger like on the oral side, while knob like on the aboral side. In *Hilsa ilisha* densely situated (120/cm) elongated gill-rakers with flattened tips were studied (Ghosh *et al.*, 1989) with biserially arranged taste receptors (about 380-400/cm). Gill-raker morphology in *Cirrhina mrigala*, *Danio dangilla* and *Channa striatus* showed the feeding adaptations (Munshi *et al.*, 1989). Ojha and Singh (1986) measured the average length of short and stumpy gill-rakers of *Danio dangilla*, to be about 222μm and the width about 166μm. The two adjacent gill-rakers were about 185μm apart. The number of taste buds openings in gill-arch were found to be more than the mucous gland openings. The elevated rim like opening of each taste bud was surrounded by 3-4 micro-ridged epithelial cells.

Gill-rakers and taste buds are concerned mainly with feeding. Many carnivorous and predacious fishes, like *Harpodan nehereus* and *Murasnesox telabon* feed by sight and taste buds are rare or absent. Some species like *Tor tor*, *Catla catla Cirrhina mrigala* depend more on the gustatory faculty for feeding and possesses a large number of taste buds. The loach *Noemacheilus rupicola* as most of the times remains buried in the sand and mud and leads to a rather sluggish and sedimentary life (Rooj, 1984), presence of gill-rakers and taste buds in good number in gills is a part and parcel of its adaptation for survival, while *G. lamta* as is an active fish and lives even in the midst of high current of water, with its adhesive disc (Bose *et al.*, 1971; Ojha *et al.*, 1982 and Ojha and Singh, 1992) is a herbivore, hence the system is not well developed in the gill-arch rather is simple.

SUMMARY

Fish gills are provided with gill-lamellae towards the outside, and in many cases, gill-rakers internally. Gill-rakers are pointed structures, projecting into the pharyngeal cavity and are arranged either in one or two rows on each arch. They serve to prevent the food from escaping out through the respiratory current of water. Taste buds are also present in fishes in the epithelium covering the gill-arch and gill-rakers, in addition to bucco-pharynx, lips, barbels and even on the surface of the body. Species which do not feed by sight (as many catfishes and loaches, who keep themselves embedded in mud and under the stones) have a large number of taste buds on the lips and barbels. Each taste bud is oval or circular in shape. Fishes with their taste buds can sense salty, sweet, bitter and acid stimuli, and many fishes are seen to reject the unsuitable food after taking it in the buccal cavity.

Presence of large number of taste buds in Noemacheilus rupicola a cobitid of hill-streams is a special adaptation for survival which help the species to detect the chemical nature of water and also of food material, which are of immense importance to the fish. Gill-rakers are evaginations of gill-arch epithelium, a fact which is corroborated also by histological studies. Taste buds are smaller in gill-arch epithelium.

Scanning electron microscopy reveals the morphological details of gill-rakers, their mucous glands and taste bud openings etc, in *N. rupicola*. In *G. lamta* it is simple.

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