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Comparative study of paired fin epidermis of hill-stream fishes: A scanning electron micrioscopic investigation

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Abstract

The adhesive nature of pectoral and pelvic fins of hill-stream fishes *G. gotyla, G. pectinopterus and P. sulcatus* as examined by scanning electron microscopic investigation is an attempt to understand the structural and functional modifications in epithelial cells in relation to life in torrential streams. The outer rays of these fins are modifies into structures that bear prominent transverse ridges and grooves in *G. pectinopterus* and *P. sulcatus*, where as the rough epidermis covered the ventral surface of entire length of first anterior ray of both the fins and also the proximal part of third and fourth rays of pectoral fin only in *G. gotyla*, the rough epidermis provided with horny projections. The outer epidermal cells of ridges are thrown into elongated spines. Mucous pore (opening to mucous glands) are frequently present in the epidermis of ridges. These spines are absent in the cells that line by the groove regions. Presence of these grooves and ridges could be interpreted as the means of adhesion, affected by suction pressure generated by the musculature attached to the grooves and ridges and mucus and spines aid in this process.

Keywords: *Fin epidermis, Kumaun himalaya, hill-stream fish, SEM*

Introduction

The aim of present the investigation is to study surface morphology of adhesive structures located in paired fins of mountain stream fishes, *G. gotyla, G. pectinopterus* and *P. sulcatus.* The paired fins of the hill stream fishes *G. gotyla*, *G. pectinopterus* and *P. sulcatus*, in the alternate to understand the structure and the functional modifications in epithelia, in relation to life in torrential streams. The glacier-fed mountain-streams of the Himalayas are perennial shallow-water bodies, characterized by low temperature, high turbulent currentand sandy-rocky substratum (Nag & Bhattacharjee 2002). To thrive successfully against the action of strong water currents, many Himalayan fishes demonstrateseveral unique adaptive modifications. One notable feature is the possession of a ventral adhesivedisc, surrounding the mouth in the cyprinids and at the thoracic region in the mountain-stream catfishes of the family Sisoridae (Hora 1922, 1930; Saxena 1966; Sinha et al. 1990; Singh & Agarwal 1991, 1993). In the latter, a rather unusual form of the adhesive.

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organs is present in the pectoral and pelvic fins. In these fishes, the skin of the pectoral and pelvic fins, instead of being plain, is thrown into a series of alternate grooves and ridges, especially at the outer rays (Hora 1922, 1930). Observations on the adhesive nature of the pectoral and pelvic fins of the mountain-stream catfishes are limited to gross morphology only (Hora 1922, 1930). The aim of the present investigation is to study the detailed general organization of the epidermis of pectoral fin and pelvic fin of *G. gotyla, G. pectinopterus* and *P. sulcatus*, adapted to life in torrential streams.

Material and Methods

Live adult specimens of *G. gotyla* (7-9 cm long) were collected from Kosi River at Kakrighat, Distt Nainital, *G. pectinopterus* (5-7 cm long) from west Ramganga River at Chaukhutiya, Distt. Almora, and *P. sulcatus* (6-7 cm long) from east Ramganga River at Thal, Distt. Pithoragarh respectively water current was very fast having velocity 0.5 to 2.0 m/sec. in Kosi, 1.5 to 2.5 m/sec. in west Ramganga and 2.0 to 3.0 m/sec. in east Ramganga (Bhatt & Pathak, 1991). Specimens were maintained in laboratory at 25 ± 2^0C. The fish were cold anesthetized, following Mittal & Whitear (1978), for SEM preparation of

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paired fins. Tissue were excised and rinsed in 70 % ethanol and one change saline solution to remove debris and fixed on 3% Glutaraldehyde in 0.1M phosphate buffer, at p^H 7.4 for one night at 4^oc at Refrigerator. The tissue were washed in 2-3 changes in phosphate buffer and dehydrated in the graded series of ice cold Acetone (30%, 50%, 70%, 90%, and 100% approximate 20-30 min.) and critical point dried, using Critical Point Dryer (BIO-RAD England) with liquid carbon dioxide as the transitional fluid. Tissues were glued to stubs, using Conductive Silver Preparation (Eltecks, Corporation, India) Coated with gold using a sputter Coater (AGAR, B 1340, England) and examined in a Scanning Electron Microscope (Leo, 435, VP, England). The results were recorded using Kodak T-MAX 100 professional film (Kodak Ltd., England).

Results and Discussion

The paired fins of *G. gotyla, G. pectinopterus and P. sulcatus* are large, expanded and fan-shaped in appearance they are pushes outward and placed horizontally on the side of the body. The epidermis covering of paired fin of all three fishes is rough and keratinized (Fig. 1, 2, 3,).

In *G. gotyla, G. pectinopterus and P. sulcatus,* the epidermis of ventral surface is much thick at ray than that of the interrays region in between the first four anterior rays of pectoral and two rays of pelvic fins of all the three fishes.

In *G. gotyla,* the epidermis on ventral surface covering the entire length of first two anterior rays of pectoral and pelvic fins shows remarkable modification from the epidermis of rest of the parts of fins. The above epidermis is non-glandular and provided with a large number of horny projections (unculi) (Fig.4) at the surface and so is designated as uncular epidermis where as epidermis of rest of the parts of fins is devoid of such projections, hence is designated as smooth epidermis which is further differentiated into glandular and non-glandular epidermis on the bases of presence and absence of gland cells.

In *G. pectinopterus*, the epidermis on ventral surface covering the entire length of first anterior ray of both the fins shows significant modification from the epidermis of rest of the parts of fins, epidermis is here non-glandular and provided with unculi at surface (Fig. 5). It is, however, glandular in remaining parts of the fins both at rays and interrays region, except that at interrays region between the first and second rays at parts of rays having poorly developed elevations where, it is non-glandular (Fig. 5).

In *P. sulcatus,* also the epidermis is differentiated into rough and smooth. The epidermis on ventral surface along the entire length of first ray of pectoral fin and pelvic fin and proximal part (approximate $^1/_{10}{}^{th}$ part) of second ray of pectoral fin only, is rough and is provided with a large number of irregularly arranged transverse ridges separated by superficial grooves. The epidermis of rest of the parts of fins is smooth at surface and is devoid of unculi (Fig. 6, 7).

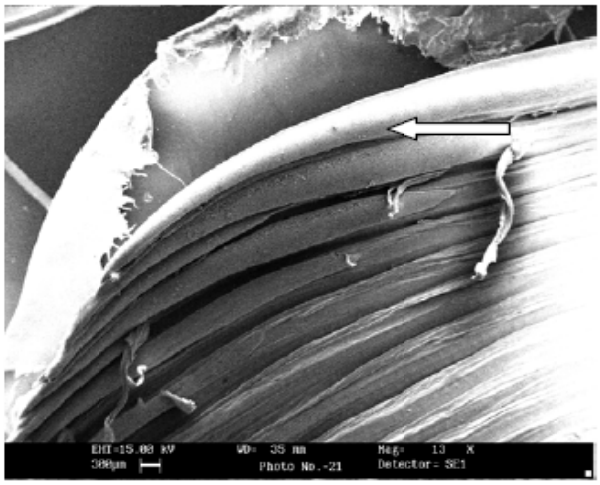
In *G. gotyla,* in the smooth epidermis, epithelial cells are characterized by microridges. The microridges are compactly arranged, branched as like microridges of general body epidermis (Fig. 8). In *G. pectinopterus,* and *p. sulcatus,* microridges are compactly arranged, numerous and filamentous (Fig. 9 and 10). Interspersed between the epithelial cells mucous cells apparatus are distinguished. The mucus cells appear with developed mucous cell opening in all of three fishes in glandular epidermis. In *G. pectinopterus,* the unculi are tall and conical with broad base projection. Each unculi are separated by groove (Fig. 10, 11). In *P. sulcatus*, these unculi are blunt with separated by groove (Fig. 12). These unculi are of uniform size shape and remain projected at the free surface. Each unculus represents a modified surface relief of compactly layer of epithelial cells all three fishes (Fig.13, 14 and 15). Some developed taste buds are described in the smooth epidermis of *P. sulcatus* (Fig. 16).

The epithelial cells are keratinized in the both pectoral and pelivic fins in *G. gotyla, G. pectinopterus* and *P. sulcatus* as revealed by a SEM techniques.

The adhesive nature of the pectoral and pelvic fins is examined by scanning electron microscope. The outer rays of these fins are ventrally and dorsally modified into structures that bear prominent ridges and grooves in *G. pectinopterus* and *P. sulcatus*. Such structures regressively developed on dorsal side of paired fin.

In *G. pectinopterus and P. sulcatus,* a rather usually form of the adhesive apparatus is present in the pectoral and pelvic fin. In these fishes, the skin of the pectoral and pelvic fins, instead of being plain, is thrown into a series of alternate groove and ridges, especially at the outer rays (Hora 1922, 1930).

In the flying fish, *Exocoetus volitans,* the modified pectoral fins are used for gliding for a considerable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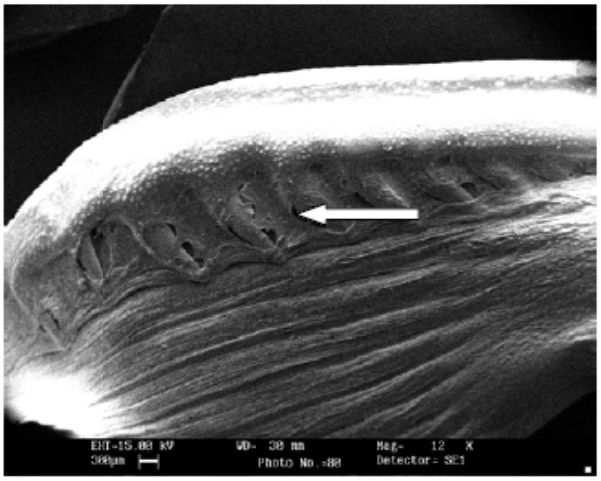
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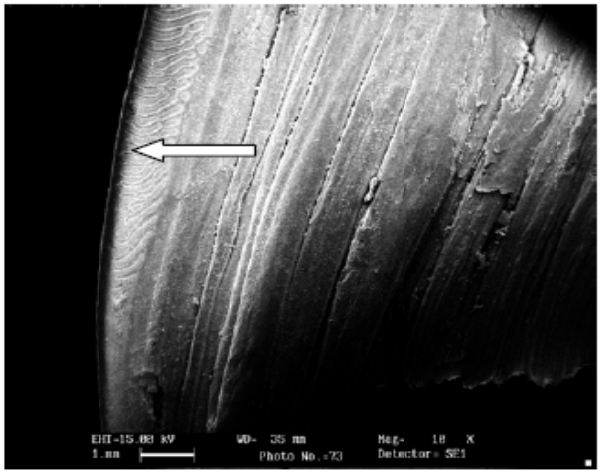
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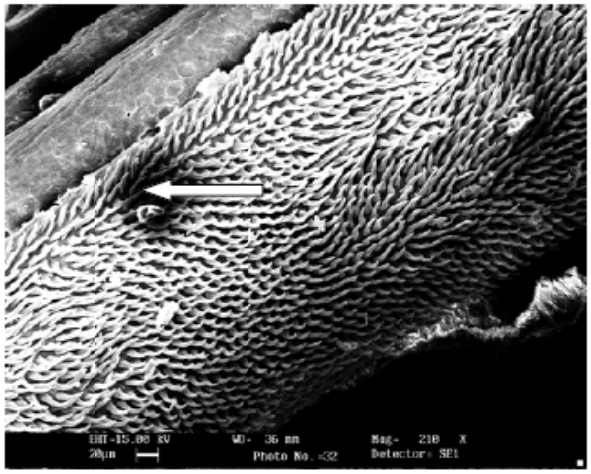
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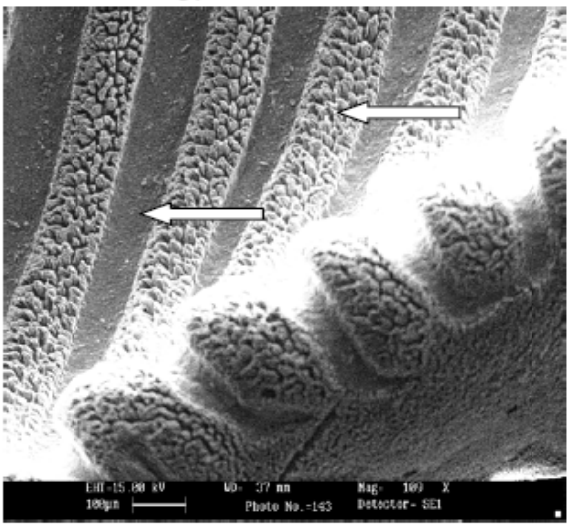
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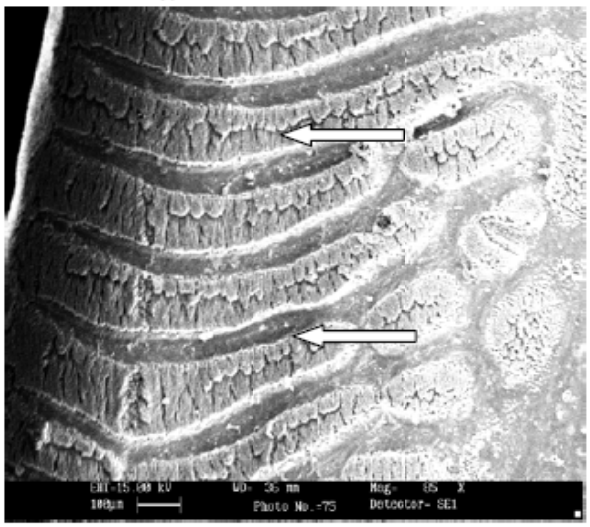
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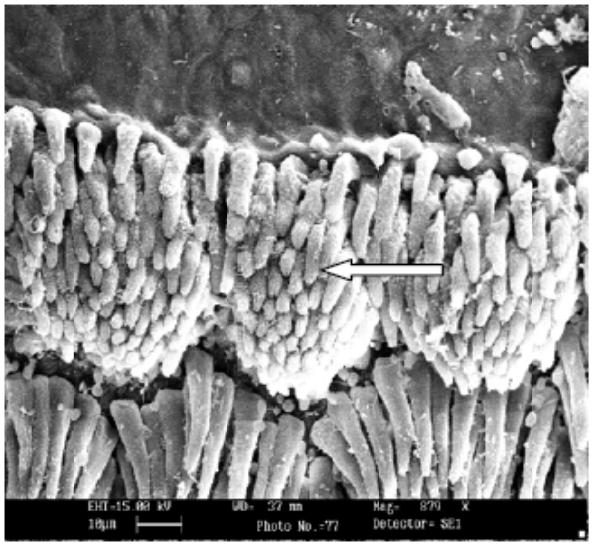
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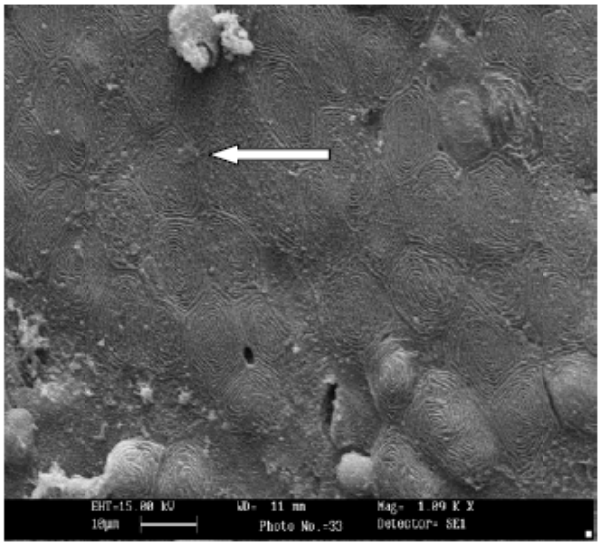
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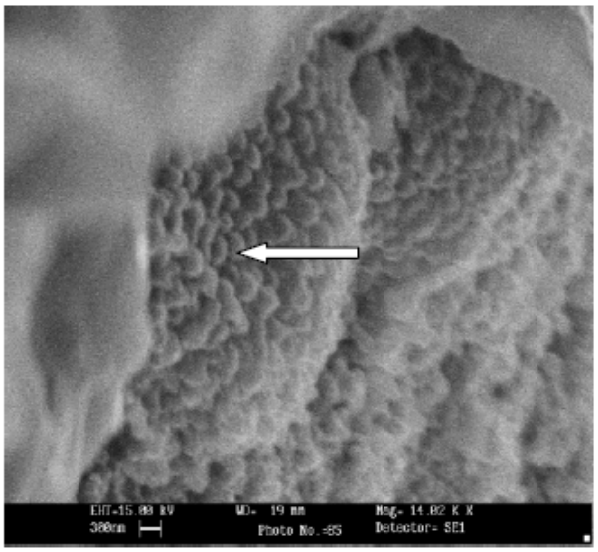
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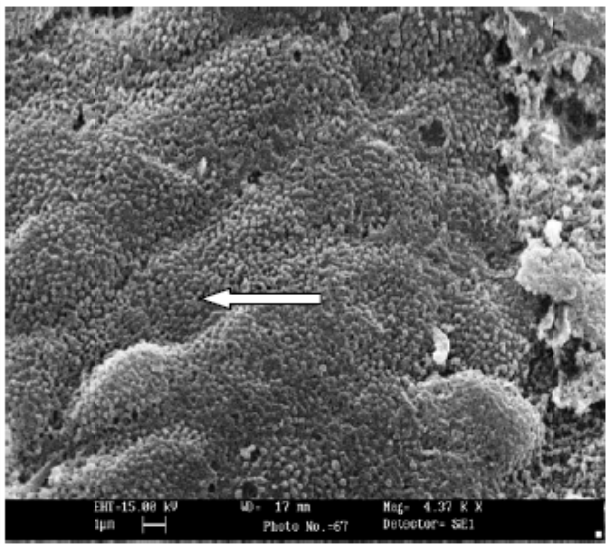
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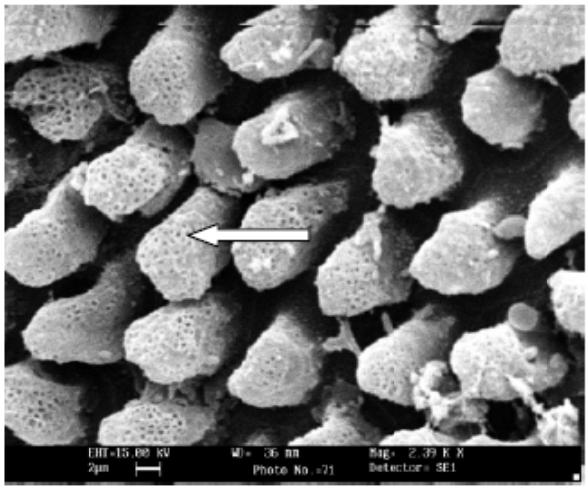
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12

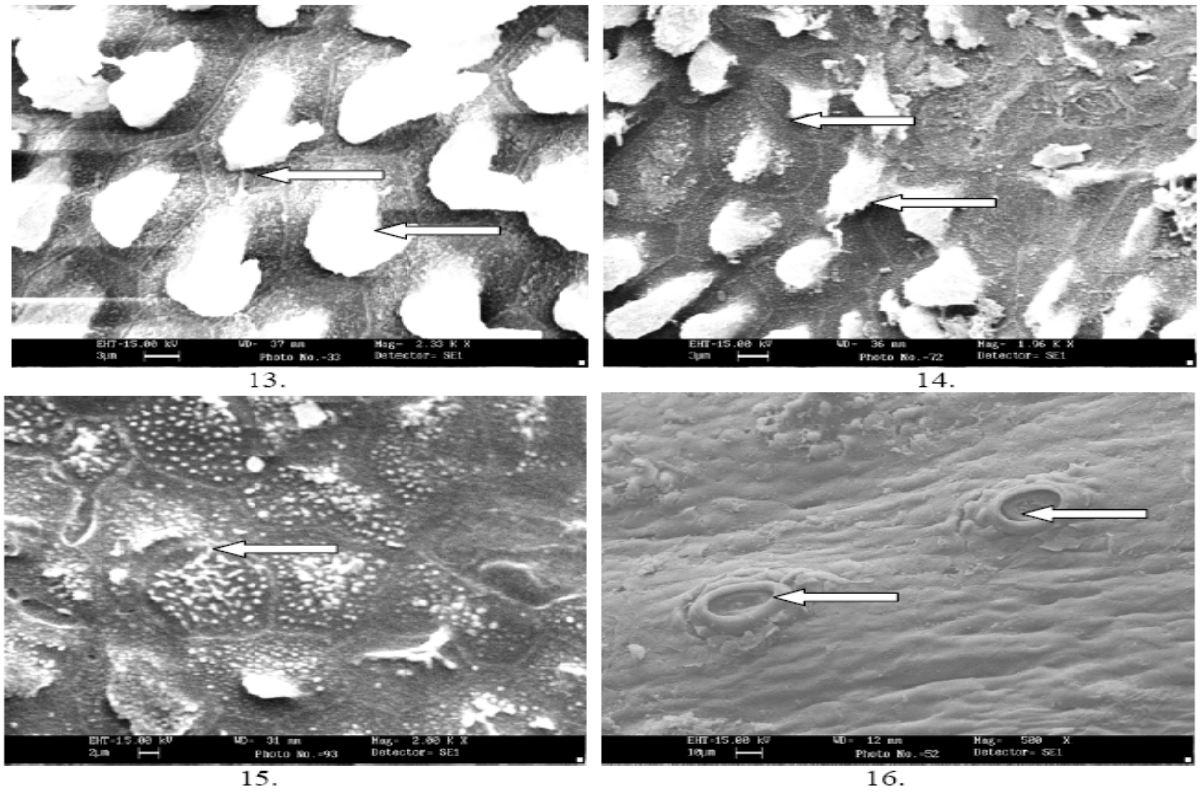

Fig 1: Surface electron microphotograph (SEMPH) of the paired fin (Pectoral and pelivic) epidermis of *G. gotyla* showing well developed fin rays (marked by arrow) (Scale bar - 300 µm and 1 µm).

Fig 2: Surface electron microphotograph (SEMPH) of the paired fin (Pectoral and pelivic) epidermis of *G. pectinopterus* showing well developed fin rays (marked by arrow) (Scale bar - 300 µm and 1 µm).

Fig 3: Surface electron microphotograph (SEMPH) of the paired fin (pectoral and pelvic) epidermis of *P. sulcatus* showing well developed fin rays (marked by arrow) (Scale bar - 1 µm and 200 µm).

Fig 4: SEMPH of paired fin (pectoral and pelvic) epidermis of *G. gotyla* showing the unculi (Marked by arrows) at the surface of epithelia of first fin ray (Scale bar- 20 µm and 20 µm and 2 µm).

Fig. 5: SEMPH of the paired fin (pectoral and pelvic) epidermis of *G. pectinopterus* showing well developed longitudinally ridges separated by groove (marked by arrow) (Scale bar 1 µm and 10µm).

Fig. 6 & 7: SEMPH of the paired fin epidermis of *P. sulcatus* showing well developed longitudinally ridges separated by groove (marked by arrow) (Scale bar 100 µm).

Fig. 8: SEMPH of the paired fin epidermis of *G. gotyla* showing microridges (marked by arrows). (Scale bar- 10 µm and 1 µm).

Fig. 9: SEMPH of the paired fin epidermis of *G. pectinopterus* showing the filamentous microridges (marked by arrows) at the surface of epithelia of groove region. (Scale bar- 300 µm).

Fig. 10: SEMPH of the paired fin epidermis of *P. sulcatus* showing the numerous filamentous microridges (marked by arrows) at the surface of epithelia of groove region. (Scale bar- 300 µm).

Fig 11: Surface electron microphotograph (SEMPH) of the paired fin epidermis of *G. pectinopterus* showing well developed cluster of unculi (marked by arrow) (Scale bar – 10 µm).

Fig 12: SEMPH of the paired fin epidermis of *P. sulcatus* showing blunt type of unculi on the surface of ridges (marked by arrows) (Scale bar –2 µm).

Fig 13: SEMPH of f the paired fin epidermis of *G. gotyla* showing hexagonal epithelial cells (marked by arrows) at the base of each unculi (marked by arrows head) (Scale bar – 3 µm).

Fig 14: SEMPH of the paired fin epidermis of *G. pectinopterus* showing hexagonal epithelial cells (marked by arrows) at the base of each unculi (marked by arrows head) (Scale bar – 2 µm).

Fig 15: SEMPH of the paired fin (pectoral and pelvic) epidermis of *P. sulcatus* showing hexagonal epithelial cells (marked by arrows) at the base of each unculi (marked by arrows head) (Scale bar – 3 µm).

Fig 16: SEMPH of the paired fin (pectoral and pelvic) epidermis of *P. sulcatus* showing well developed taste bud (Scale bar – 30 µm and 10 µm).

distance above the water surface, and in the sucking fish *Remora remora,* the first dorsal fin is utilized for adhesion (Migdalski & Fichter 1983). In several genera of the mountain-stream fishes (eg. *Pseudecheneis sp.*, *Glyptothorax sp.*, *Balitora sp.*), the expanded pectoral and pelvic fins are used for swimming against the strong water current. At rest, however, these fins are involves in adhesion (Hora 1930). The outer rays of these paired fins are generally employed for this purpose. This change seems to have been brought about for two reasons. First, it allows the ventral surface of the body to be firmly applied to rocks and second, to enable the fins to act as organs of attachment. The epidermis covering of the outer rays of these fins is an extension of the abdominal skin, and in order to achieve the function of adhesion, the epidermis has undergone remarkable modifications. The epidermis covering the ridges of the outer rays is characterized by the presence of spines, whereas the part that lines the grooves between the ridges is devoid of spines. These ultrastructural features allow us to speculate about the possible mechanism operative in the process of adhesion by the pectoral and pelvic fins in these teleost. It is likely that the outer rays of these fins work on the principle of suction for adhesion. When the fins are pressed against the substratum, a reduced pressure is created by the musculature attached to the ridges and grooves. The spiny projections might then assist in organic growth on the submerges rocks. The mucus secretion from the mucous glands causes a weak adhesion and prepares the sub-stratum for subsequent action of the spines. In addition, the mucus seems to afford protection to the spines from abrasion during adhesion. The apparent lack of spines in some of the epidermal cells (located near the base of the ridges) indicate that these structures are often damaged and then possibly lost, to generate new spines. The factors causing damage to the spines could be the constant mechanical abrasion or reduced mucus secretion from the surrounding mucous glands in altered physiological states.Hora (1930) considered that the non unculiferus groove as sulci on the thoracic adhesive apparatus and paried fins of sisoridae served as channels for the exit of water from beneath the surface, so that the unculiferus laminae can be brought into more intimate contact with the substrate and ‘seizing’ can take place. Hora (1930) also suggested a seizing function of papillated structures including the lips of hill-stream fishes, although he was unaware that such papillae frequently are unculiferous.The well-developed unculiferous pads on the ventral surface of paired fins, in addition to providing adhesion, may help achieve the seal for the suction device; possibly the seal enhanced by suction or seizing due to exit of water from the interradial grooves, between unculiferous pads.

The presence of unculi and differences in these structures of different fishes could be considered as adaptive modifications that reflect varied functional demands.A complementary relationship between development of multicellular tubercles on the dorsal surface of paried fins and unculiferus unculi on the ventral surface in many species of *Paraerossocheilus, Homolaptera* and *Gastromyzon*, multicellular tubercles are well as in adults and are equally well developed in sexually mature individuals as both sexes. Roberts (1982) described some multicultural tubercles are well developed on the dorsal surface of the paired fin in sexually mature males and poorly developed or absents in female, the unculiferous pads appear to be equally well developed in both sexes.In *G. gotyla*, *G. pectinopterus* and *P. sulcatus* the currents investigation shows the presence of characteristic microridges on the surface of epithelial cells on the interpapillary region.A dense network of microridges could be interpreted as a means to retain more and more mucus at the surface of epithelial cells possessing few mucus cell in this region as suggested by Hughes and Wrignt (1970); Ojha & Hughes (1988); Fishelsones (1984).

The mucus secretion from the mucous cells caused a weak adhesion and prepares the substratum for subsequent action of the spine. In addition the mucus seems to afford protection to the spines from abrasions during adhesion.

The apparent lack of spines in some of the epidermal cells indicates that these structures are after damages and then possibly lost to generate new spines. The factors causing damage to the spines could be the constant mechanical abrasion to reduced mucus secretion from the surrounding mucus glands in altered physiological states (Das & nag 2004 and 2006).Mucous cells occupy much higher area in epidermis of *G. gotyla* and secrete profuse amount of mucus on surface than those in epidermis of *G. pectinopterus* and *P. sulcatus*, that has to withstand a high strength of current of water, and may protect the fish from frictional stress by lubricating the surface.

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