



# The Adaptive Modifications of Snout epidermis of a hill-stream Fish *Schizothorax richardsonii* of Kumaun Himalaya: A SEM Investigation

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## Abstract

Surface architecture of snout epidermis of hill-stream fish, *Schizothorax richardsonii* (Gray) was examined by scanning electron microscopy, in an attempt to understand the structural and functional modifications in epithelia, in relation to life in torrential streams. Mucous pores (opening of mucous cells) and epithelial cells were visualized to have developed a dense network of irregularly interwoven microridges which could be interpreted as a means to retain maximum possible mucus at the surface of the epithelial cells in *S. richardsonii* in order to protect against physical abrasions. Snout epidermis is subjected to more frictional stress if compared with the epidermis covering the general body surface as it is first to come in contact with water current, especially when fish swims upstream and hence correlation has been made in relation to friction.

**Keywords:** SEM, snout epidermis, hill-stream, surface.

## Introduction

The snow trout *Schizothorax richardsonii* is the principal indigenous fish of the Himalayas available in various upland resources. Snow trout *S. richardsonii* is the most important food fish of Kumaun Himalaya inhabits in snow fed Rivers and also plays an important role in commercial fish production. Many teleost fishes are reported to inhabit the Subhimalayan streams and rivers of India. These mountain streams are perennial shallow water bodies characterized by low temperature, high turbulent current and sandy rocky substratum<sup>1</sup>. To thrive successfully against the action of strong water currents, many hill stream fishes demonstrate several unique adaptive modifications. The epidermis is the outermost defense organ against the surrounding aquatic environment comes into direct contact with mechanical hazard. The hill-stream environs in the Kumaun Himalaya are unique in their characteristics inclusive of recent geomorphological transformations resulting from many multipurpose rivers, which are likely to adversely affect the overall health of hill-stream habitats. Such changing scenario will certainly have profound impact on the preferential distribution of the fish species and the nature of the external stimuli. Breeding tubercles are keratin-based epidermal nodules, which are found in at least 15 families of fishes in four orders. Breeding tubercles might offer a workable tool for examination of sexual selection among cyprinids.

## Material and Methods

Live adult specimen of *S. richardsonii* (approximate length 9-14 cm.) was collected from Kosi River at Hawalbagh district Almora. Water current was very fast having velocity 0.5 to 2.0 m/sec.<sup>2</sup>. Specimen was maintained in laboratory at 25±2<sup>o</sup>C. The fishes were transferred from the site of collection to laboratory

in well ventilated plastic containers and were kept for a period of about 5-6 days in glass aquaria having an artificially made rocky bed and aquatic vegetation grown therein. The aquaria were cleaned and supplied with fresh spring water on alternate days. The fishes were fed on aqua feed (tropical fish food). The fishes were cold anesthetized following<sup>3</sup> for SEM preparation of snout.

Tissues was excised and rinsed in 70% ethanol and one change saline solution to remove debris and fixed in 3% Glutaraldehyde in 0.1M phosphate buffer at pH 7.4 over night at 4<sup>o</sup>C at refrigerator. The tissues were washed 2-3 changes in phosphate buffer and dehydrated in ascending 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 (JFC 1600) and examined in a scanning electron microscope (JEOL, JSM- 6610 LV) and the images were observed on the screen.

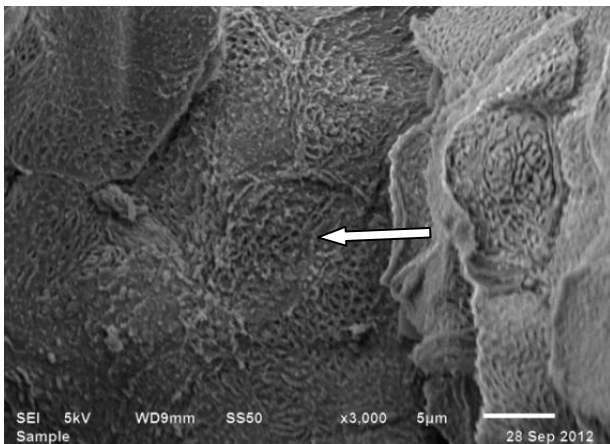
## Results and Discussion

The skin of snout is scale less in *Schizothorax richardsonii* (figure 1) and the epidermis is both types rough or keratinized and smooth or mucogenic. The smooth epidermis of snout possesses epithelial cells and mucous cells apertures intersperse between the epithelial cells in this fish. The surface architecture of the epithelial cells is characterized by the presence of a series of microridges separated by prominent irregular spaces. The microridges are compactly arranged, branched with abrupt ends of irregularly interwoven to form intricate mesh like pattern and interconnected with microbridges (figure 2). The mucous cells,

though distributed throughout the epidermis are in general, concentrated mainly in the outer layer of the epidermis often releasing their secretory contents profusely at the surface by a small pore. Interspersed between the epithelial cells, mucous cells are distinguished. Mucous cell openings, seen as wide, rounded apertures or crypts, often containing blobs of mucus are interspersed between the epithelial cells. Generally, such apertures occur where the boundaries of three or more epithelial cells meet (figure 3). In *S. richardsonii* the epidermis of snout possesses epidermal tubercles (approximate length 128.888  $\mu\text{m}$ ). The base of each tubercle is rounded (approximate width 282.065  $\mu\text{m}$ ) (figure 4, 5).

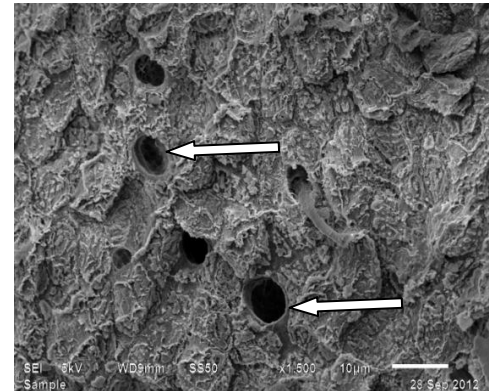


**Figure-1**  
 General view of *S. richardsonii*

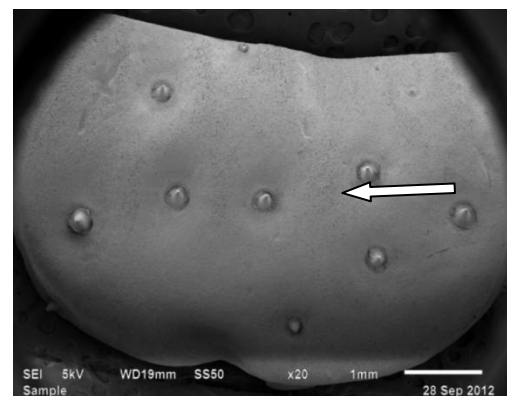


**Figure-2**  
 SEMPH of the snout epidermis of *S. richardsonii* showing microridges interconnected with microbridges (Marked by arrows) (Scale bar- 5  $\mu\text{m}$ )

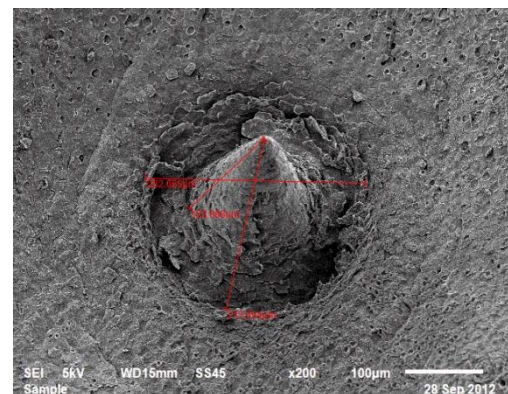
The skin of snout is scale less. Epidermis is smooth and possesses epithelial cells and mucous cell apertures between the epithelial cells. The epidermal cells at the surface of the snout investigated are composed of vertically compressed epithelial cells. It forms a continuous covering of the surface. It is interspersed with mucous cells opening to the surface. The primary function of the epidermis is protection against environmental hazards.



**Figure-3**  
 SEMPH of the snout epidermis of *S. richardsonii* showing mucous opening (Marked by arrows) (Scale bar- 10  $\mu\text{m}$ )



**Figure-4**  
 SEMPH of the snout epidermis of *S. richardsonii* showing epidermal tubercles (Marked by arrows) (Scale bar- 1 mm)



**Figure-5**  
 SEMPH of the snout epidermis of *S. richardsonii* showing single epidermal tubercles (Scale bar- 100  $\mu\text{m}$ )

In fish, this function is generally attributed mainly to the gland cells secreting their contents on the surface. The large number of mucous cells in *S. richardsonii* suggests that the overall production of mucus in this fish is very high. This may be an adaptation to their peculiar bottom-scooping habit disturbing bottom mud more frequently in search of food, requiring

increased efficiency in the fish keeping its surface clean, mucus has remarkable power to precipitate mud held in suspension<sup>4</sup>. Thus the mucus secreted by the skin in the air breathing fishes may also serve to keep the skin clear for respiration. The abundance or dearth of the mucous cells in the epidermis may also be correlated with their mode of life<sup>5</sup>. Mucus is secreted in receiving the necessary the stimuli from the surrounding environment, providing a sort of platform in the feeble adhesion, such neuromuscular organs have also been reported in *G. garhwali*<sup>6</sup>. Kotschal K. et al<sup>7</sup> and Mittal A.K. et al<sup>8</sup>. suggested anti-viral, bactericidal and fungicidal effects of the secretion and found some role in defense and wound healing. The free surface of epithelial cells is bearing a series of microridges. The microridges are compactly arranged, branched with abrupt ends of irregularly interwoven to form intricate mesh like pattern and interconnected with microbridges. Interspersed between the epithelial cells, mucous cell apparatus distinguished on the snout epidermis. Sperry D.G. et al.<sup>9</sup> found no change of pattern after stretching fish oesophageal epithelium and suggested that spread of mucus from goblet (mucous) cells might be guided by the direction of ridges. Fishelson L.<sup>10</sup> correlated the variations in microridge patterns to locomotory activity and suggested that in faster swimming fishes, the most developed ridges served to trap mucus on the epithelial surface. Modifications in the pattern of microridges can also be caused by various intrinsic, e.g. hormonal<sup>11,12</sup>, or extrinsic factors e.g. temperature<sup>13</sup>, salinity<sup>14</sup>, mercury salts<sup>15</sup>, organic pollutants<sup>16</sup>, handling and ectoparasites<sup>17</sup>. Microridges have been reported to vary considerably in configuration and deposition, constituting varied patterns at different locations in different fish species and have been implicated to play variable roles. These include retaining mucus secretion to the cells surface, to increase the surface area for excretion and absorption through the skin, to facilitate the spread of mucus away from mucous cells, to aid in producing laminar flow, to provide reserve surface area for stretching and to have their relation with the process of secretion at the cell apex. Kumari U.<sup>18</sup> suggested the microridges on the surface of the epithelial cells, like in the gills of other fish species, are after compactly arranged and organized into elaborate whorls forming intricate patterns. These structures providing mechanical flexibility and protection<sup>19,20,21</sup>. Whitear M.<sup>17</sup> suggested the mucogenic epidermis that form of the microridges is related to the process of secretion of slime. This could be considered as an adaptation to withstand mechanical stress and protect the surface of the fish, which has the characteristic habit of bottom dwelling furthermore, these microridges may gain a firm base and support from a dense network of fine filaments.

The tubercles are found most often on males. The role and function of breeding tubercles are still uncertain. Breeding tubercles may be used for conspecific recognition<sup>22</sup> or for protection against mechanical injuries<sup>23</sup>. Müller G. et al<sup>24</sup> suggested that breeding tubercles may be used as weapons in intense pre-spawning male behaviour (defence of nests and territories). However, <sup>25</sup>proposed those tubercles originally

evolved to allow breeding individuals to maintain close contact during spawning as a means to ensure fertilization of the eggs. Breeding tubercles may also act as hydrodynamic or tactile stimulators of females during courtship. In roach, breeding tubercles are presumed to give females detailed information about a male's parasite load<sup>26,27</sup> and parasite resistance<sup>28,27</sup> and to act as a sexual ornament indicating his quality.

## Conclusion

The present investigation has been designed to have a study of functional organization of the epidermis of snout of *S.richardsonii*. Snout epidermis is first come in contact with water current, especially when fish swims upstream and hence correlation has been made in relation to frictional. Habitat observations substantiate that there is a considerable relation between habitat characters (morphology and structure) of fishes.

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