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Anatomy

THE SEM SURFACE STRUCTURE OF THE ADHESIVE ORGAN OF *PSEUDOECHENEIS SULCATUS* McCLELLAND (*TELEOSTEI: SISORIDAE*), FROM GARHWAL HIMALAYAN HILLSTREAMS

STRUKTURA W ELEKTRYCZNYM MIKROSKOPIE ELEKTRONOWYM (SEM) POWIERZCHNI ORGANU CZEPNEGO *PSEUDOECHENEIS SULCATUS* McCLELLAND (*TELEOSTEI: SISORIDAE*), Z GARHWAL, KRAINY HIMALAJSKICH POTOKÓW

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In the hillstream fish, *Pseudoecheneis sulcatus*, the adhesive organ is located on the ventral surface of thorax behind mouth, between opercular region and bases of pectoral fins. It is broader anteriorly and slightly narrower posteriorly, comprising a distinct arrangement of transverse ridge and grooves alternating with each other. Morphological ridges further display the wavy surface pattern with subridges and subgrooves. The subridges and subgrooves. The subridges bear a number of long, hooked or curved or blunt headed, epidermal spines. By attaching to the organic growth on the rocky substrata of river bed in a collective fashion, spines are responsible for the effective adhesion on substrata, thus, avoid the washing away of fish by violently fast flowing water current. Glandular secreation minimises the mechanical abrasion of spines.

INTRODUCTION

The parennial and glacier-fed streams of Garhwal Himalaya are mainly characterised by extremely low water temperature, violently swift water flow, steep gradient, river bad comprising stones, rocks, boulders, sand or gravals etc. Fast water current is the single most important limiting factor deciding the occurrance and survival of fauna and flora unless equipped with special adaptive features to withstand the vicissitudes of nature. In hillstream fishes, the presence of adaptive modifications, in their body organization, is of prime importance for their progress against the fast water flow. Such adaptions are primarily manifested in the form of adhesive organ, integumentary specialisation, usually situated on the ventral surface of body between mouth and pectoral fins and also on ventral fins.

Such adhesive structure have been studied only in a few species. While describing systematics of hillstreamfishes of Garhwal Hymalayan rivers, Day, 1958 briefly mentioned the adhesive features in some species. Hora, 1922, 1923, 1930 made an extensive survay of fishes with adhesive organs from North Eastern India torrents, depicted adhesive devices from evolutionary point of view and correlated these as a response to life conditions in unique hillstrean habitats. He especially studied adhesive apparatus of *Garra annandalei, Bhavania annandalei, Glyptothorax madraspatnum* Adhesive organs have also been described in *Discognathus lamta* (Rauther, 1928) *Glyptothorax telchitta* (Bhatia, 1950). *G. pectinopterus*(Lal et al., 1966 and Sinha et al., 1990). In this significant contribution on adhesive organs of hillstream teleosts, Saxana, 1959, 1961 and Saxena and Chandy, 1966, explained adhesive mechanism in *Garra mullya* and *Pseudoecheneis sulcatus.* As far as Garhwal hillstream fishes are concerned, the information is inconsistent except that of Lal, et. al., 1966 and Singh and Agarwal, 1990.

Therefore, it is evident from the work on adhesive apparatus and mechanism involved is either confined to gross morphology or light microscopic studies. Because morphological and physiological arrangements of adhesive surface to the mechanical and functional aspects of adhesion process are obviously concerned with adhesive organ as a subsequent outcome of problems experienced in the unique habitat during the course of evolutionary process, the present investigations deal with the description of morphoilogical surface pattern of adhesive organ of *Pseudoecheneis sulcatus,* extremaly specialised fish from Garhwal Himalayan hillstreams with the help of scanning electron microscopy.

MATERIAL AND METHOD

Life specimens of *P. sulcatus,* 15–25 cm long, were collected by angling method, from the river Alaknanda at Srinagar Garhwal (560 m, 30°13′N, 78°48 E). The adhesive organ was cleansed with 70% ethanol to remove debris, detached surgically from ventral side, placed on blotting paper to avoid wrinkles and fixed in 3% gluteraldehyde in 0.1 M phosphate buffer (pH 7.5) at 4° C for 24 hours. The tissue was cut into small pieces of 2×2 mm size, washed in 2–3 changes (30 min each) in phosphate buffer and dehydrated in the graded series of ics-cold acetone. Dehydration was done omitting the critical point drying procedure because the tissus and surface structures are sufficient hard to withstand the routine dehydration of electron microskopy. With the help of double adhesive tape, the selected pisces were mounted on brass strubs and sputter coated with gold in Edwards Vacuum Coater unit (Sharma 1988), examined in JEDLD model STEM at 20 KV.

RESULTS

In addition to the presence of adhesive papillae around mouth (M), on anterior labial fold (ALF), maxdillary barbel (MB), outer and inner mendibular barbels (OMB, IMB,) the principal adhesive area (AP) is well defined as a modification of integument on ventral side of thorax posterior to mouth, between opercular openings and bases of pectoral fins (Fig. 1). It is broader anteriorly and slightly narrower posteriorly. The integument in this organ is folded transversly into a series of prominent ridges (R) and grooves (G), 12–15 each, alternating with each other.

When examined for SEM, the surface of grooves appears to have integument irregularly. On ridges itself, there is further foldings revealing irregular pattern of small subridges (SR) and subrooves (SG) running transverse to the main axis of main ridges (Fig. 2). Under higher magnification (Fig. 3), glandular openings (arrows) have been observed in the subgroove zone. While on subdridges proper, innumerable spines oriented variously have been noticed (Fig. 3). Spines are of smaller size and thinly scattered in the transition region of grooves and ridges but densely distributed on the exposed ridge surface where these are much elongated and tapering distally (Fig. 4). The distal ends of spines are either bluntheaded or pointed or curved or hooked. Moreover, the surface of spines is quite rough.

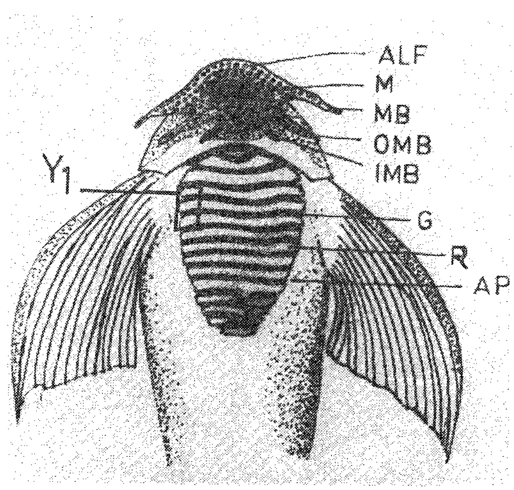

Fig. 1. Ventral side of head and thorax showing the position of adhesive organ (AP)

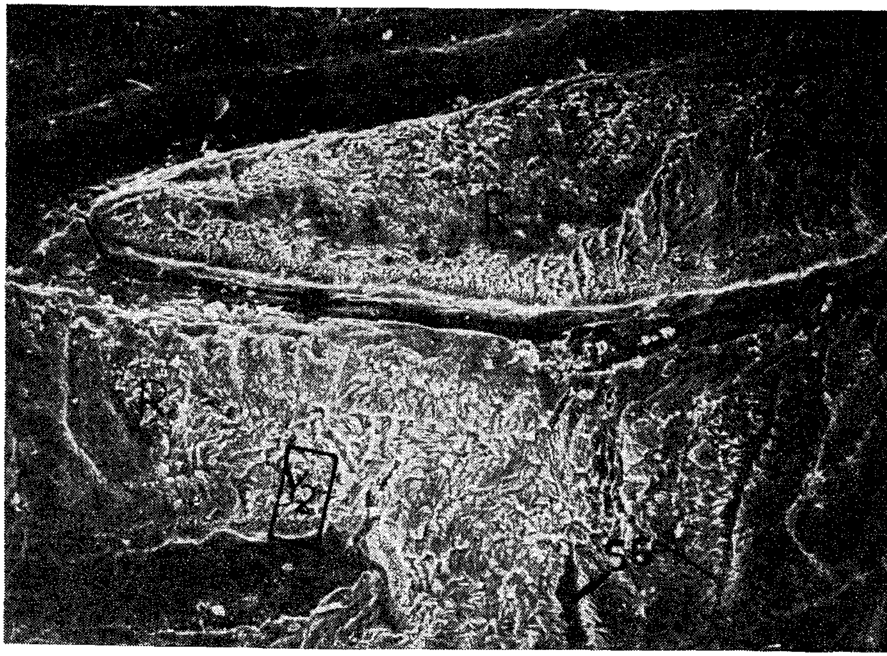

Fig. 2. Part of adhesive apparatus (Y_1 of Fig. 1) magnified, showing ridges (R) and grooves (G) and also present subridges and subgrooves (SR, SG) on ridges X 20

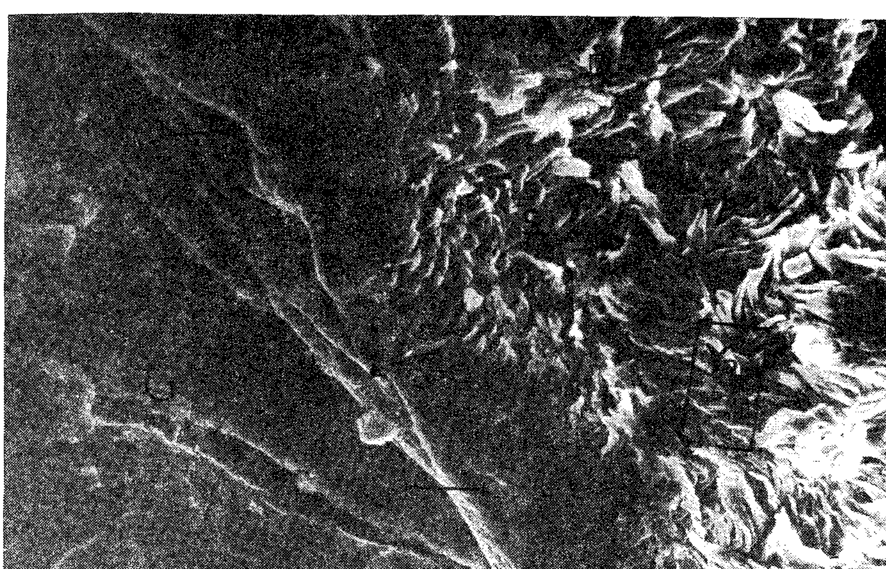

Fig. 3. Part of Fig. 2 (Y_2) magnified, note glandular openings (arrows) smaller and scattered spines on the transitional area between groove and ridge, dense and larger spines on grooves proper X 500

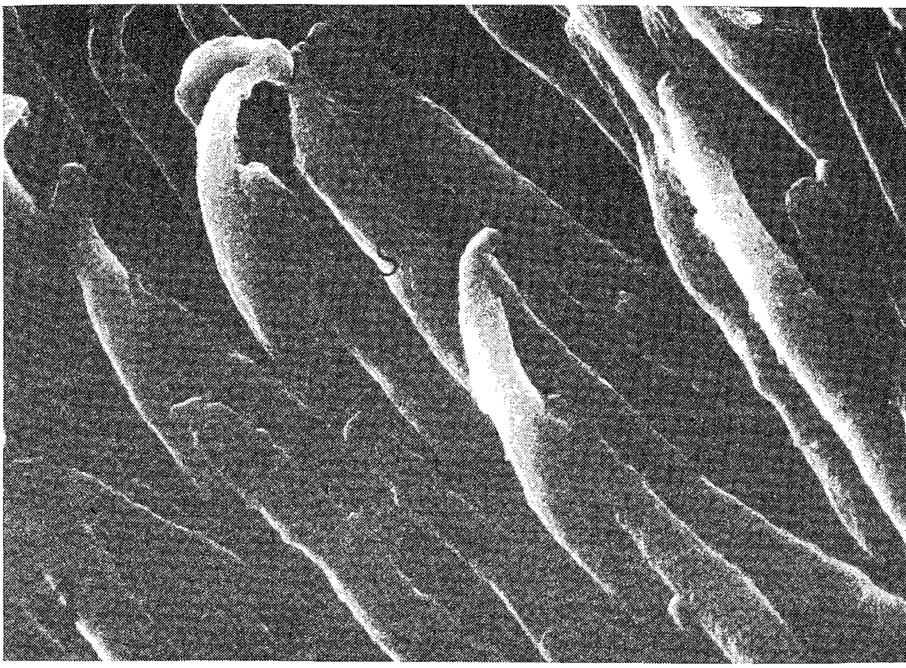

Fig. 4. Part of Fig. 3 (Y_3) magnified, spines are larger (S) with hooked, curved ends. X 4000

DISCUSSION

The adhesive organ in *P. sulcatus* differs from other hillstream fishes in the prominence and orientation of ridges and grovves and also in teh absence of turbercles on the adhesive organ proper. In *G. pectinopterus,* and *G. telchitta* (Bhatia, 1950; Lal et al., 1966; Sinha et al., 1990), adhesive apparatus comprise the longitudinal grooves and ridges but these are oriented parallel to long body axis. In other species – *Schizothorax plagiostomus, Crossocheilus latius latius* (Singh and Agarwal, 1990), adhesive organ consists of transverse band behind scrapping plate and provided with numerous tuberculated projections. While in *Bhavania annandalai* (Hora, 1922),*Garra annadalei* (Hora, 1923), *Garra mullya* (Saxena, 1959)and *Garra gotyla gotyla* (Singh and Agarwal, 1990), it is complex with marked anterior labial fold, posterior labial fold, callous portion of disc and posterior free margin of disc.

On SEM observations, the adhesive organ of *G. pectinopterus,* Sinha et al 1990) found elongated spines on the ridges as pointed earlier by Lal et al., 1966. The present study also reports the occurrance of long spines on morphological ridges but, in *P. sulcatus,* there is further subridge and subrooves pattern on morphological ridges itself and spines are largely populated on subridges region only. This way, *P. sulcatus* represents an extreme case of hillstream specialisation. Spines are the main structures involved in the process of adhesion. Glandular secretion (possibly mucous) in the transition region between grooves and ridges and in grooves obviously protects the mechanical abrasion of spines during adhesion.

Regarding the mechanism of adhesion, Hora (1922) and Bhatia (1950) opined that friction between spines and rough surface of rocky substrata accounts for adhesion proces while Saxena and Chandy (1966) attributed vacuum as the prime cause resposible for adhesion. He stated that the vacuum is being created in grooves by contraction of muscles attached to adhesive ridges. Contrary to this, the present study reveals that, at least in *P. sulcatus,* ridges are the main structures involved in adhesion. Since the ridges are adorned with long spiny structures, it is likely that pointed,- unidirectionally curved or hooked spines make some sort of pegs or anchors as mentioned by Lal et al., 1966 and Sinha et al 1990 in *G. pectinopterus.* During the proces, the innumerable spiny pegs jointly and collectively get anchored to the organic growth on rocky substrata of river bed to bring about the effective adhesion. Obviously, special sensory cells, neurons, muscles, blood circulation or adhesive cells play significant soles, during attachment. Any possible abrasion is minimised by glandular secretion.

According to Singh and Agarwal (1990), *P. sulcatus* with highly specialised extremely modified adhesive structure and bottom dwelling habit, is one of the earliest occupiers of unique hillstream habitat where such modifications are of vital importance for successful survival.

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STRESZCZENIE

Organ przyczepny ryby *Pseudoecheneis sulcatus* na stronie brzusznej w postaci poprzecznych fałdów skórnych, opatrzonych ponadto w mikrofałdy, wyposażone w nabłonkowe kolce, które załatwiają przyczepianie do powierzchni podłoża. Kolce ułatwiają ścisły przyczep do podłoża przy bardzo silnym prądzie. Fałdy mają powierzchnię nieregularną o drobnej strukturze i nierównościach przebiegających na ogół poprzecznie do kierunków głównych fałdów. (Ryc. 2), pod większym powiększeniem (ryc. 3) widoczne gruczołowe ujścia (strzałki) a ultrastrukturalne kosmki coraz mniejsze ale dłuższe (Ryc. 4) są na końcu tępo zaostrzone i często zakrzywione. Organ przyczepny tego gatunku różni się wydatnie od podobnych narządów u innych ryb sposobem ułożenia rowków i fałdów jak też brakiem guzków.

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