SEM STUDY OF ADHESIVE ORGAN OF TYPICAL HILL STREAM FISH GARRA GOTYLA (TELEOSTEI; CYPRINIDAE)

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Received: February 20, 2013; Accepted: March 8, 2013

Abstract: The study of adhesive organ (AO) of the typical hill stream fish Garra gotyla inhabiting the hill streams of South-eastern Rajasthan was carried out for surface image and morphological details. The scanning electron microscopy (SEM) revealed that the fish adhesive organ (AO) has upper and lower fringed lips bearing tubercles beset with two types of spines which are modified squamous epithelium cells. The adhesive organ (AO) secretes mucus which displaces water and air to create vacuum helping fish to fasten with substratum. From the study it appears that spine and mucus collectively function and realize adhesion in the speedier waters of the streams.

Key words: Garra gotyla, Adhesive organ

INTRODUCTION

Contrary to the placid waters of reservoirs and rivers, the flow of water in hill streams is generally quick, turbulent and rapid exerting influence on the inhabiting fishes to develop devices and mechanisms which confers endurance, dexterity and adaptability to maintain position in the aforementioned conditions with a modicum of effort. Garra gotyla (Teleostei: Cyprinidae) a typical hill stream fish, possess a highly specialized ventrally placed true adhesive apparatus (adhesive disc) of about 0.031 cm² dimension placed immediately behind lower lip. Integumentary modification in the form of adhesive disc is the life saving kit for most of the hill stream fishes [1]. The disc is composed of central callous portion and free tuberculated lateral and posterior borders. The callous portion of the disc forms an effective sucker. The adhesive organs are mainly cutaneous modifications manifest morphologically in various forms. In many fishes, the adhesive apparatus is found in the thoracic region of the body [2] while in Sisorid catfishes additional adhesive organs are found on the paired pectoral and pelvic fins [3,4]. Das and Nag [5] studied surface, histology and cytochemistry of the adhesive organ (AO) in the mountain stream Catfish; Pseudocheneis sulcatus, using light microscopy, SEM, TEM and immunohistochemistry. They found that adhesive organ (AO) is the modification of epidermis, which underwent prominent morphological and subcellular changes to perform the function of adhesive. The study aim to elucidate the structure of adhesive organ (AO) of Garra gotyla inhabiting the stream and tributaries of the Chambal river using scanning electron microscope.

MATERIALS AND METHODS

Garra gotyla was captured at various sites from the stream and tributaries of the Chambal river. The sections of adhesive organ were cut with help of a blade and washed with saline solution; fixed in cacodylate buffered Gluteraldehyde. 2.5% gluteraldehyde in 0.1 M sodium cacodylate buffer at
Fig. 1: Ventral part of the head showing various parts of adhesive organ in *Channa sp.*

Fig. 2: Ventral part of the head showing various parts of adhesive organ in *Garra gotyla*

Fig. 3: Ventral part of the head showing various parts of adhesive organ in *Noemacheilus botia*
mouth these divided lips acts as a channel for the
that when they are pulled outward away from the
lips are divided in the middle and greatly swollen so
adhesive organ (Fig. 3). Its mouth is ventral and small,
Noemechilus botia
also bears well developed
proportional to the vacuum created. Similarly,
water. The intensity of this force is directly
and pressed to create a vacuum by draining underlying
sticking force when applied against the substratum
adhesive disc is capable of generating formidable
gradient while anchoring to the substratum. The
adhesive disc and the specialised structure on the
groove (Fig. 2). The crescent furrow above the
lower lip and separated from it by a crescent shaped
shaped adhesive disc (about 0.031 cm
Garra sp.
is endowed with ventrally placed cup
observed in
[7]. During present
study such “irregular folds and ridges” were also
observed in Channa (Fig. 1), and as “true suckers”,
Garra sp. is endowed with ventrally placed cup
shaped adhesive disc (about 0.031 cm²) just behind
lower lip and separated from it by a crescent shaped
groove (Fig. 2). The crescent furrow above the
adhesive disc and the specialised structure on the
margin of crescent are used to regulate pressure
gradient while anchoring to the substratum. The
adhesive disc is capable of generating formidable
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Noemechilus botia also bears well developed
adhesive organ (Fig. 3). Its mouth is ventral and small,
lips are divided in the middle and greatly swollen so
that when they are pulled outward away from the
mouth these divided lips acts as a channel for the
water to enter the mouth opening. It is highly likely
that the fish use the lips both for adhesion and rasping
the algae and food material from the rocks. The mouth
of the Garra gotyla fish is inferior guarded by highly
fringed upper and lower lips. The area between the
lower lip and postero-lateral free margins of disc
swells to form callous pad (Fig. 2). Structurally, the
disc has four parts viz. the upper fringed lip (UFL,
Fig. 2), the posterior free labial fold (PFLF, Fig. 2),
The callous pad; central portion of disc (CP, Fig. 2)
and the postero-lateral free margins (PLF, Fig. 2).
The SEM study revealed that UFL (Figs. 4,5) and
the PFLF bears short stub shaped tubercles (ST, Fig.
6) which in turn bear numerous spines (S, Fig. 7).
The tubercles are covered with squamous epithelium
(SE, Fig. 2-E) indicating that spines are modified
squamous epithelial cells. The margins of stub-shaped
tubercles bear smaller spines; their size increases
from margin to the centre. A bit longer stub shaped
tubercles (LST, Fig. 7) with longer spines are also
present. Thus, there exists dichotomy as far as size
and shape of spines are concerned. The peripheral
spines are hook shaped and middle are straight one,
however both types are wrinkled (Fig. 10) for better
anchorage.

RESULTS AND DISCUSSIONS

Adhesive organs are developed from the modification
of skin manifests differently as “Ridges and
Grooves” as in Conta, Glyptothorax and Pseudecheneis
of the family Sisoridae of the order Siluriformers.” “Irregular folds and ridges” present on the
ventral side of head, supposedly creates partial
vacuum ensuring application of mouth at a desired
point on the substratum during feeding, observed in
Crossocheilus, Parapsilorhynchus, Schizothorax,
Dipthychus, Ptychobarbus [7]. During present
study such “irregular folds and ridges” were also
observed in Channa (Fig. 1), and as “true suckers”,
Garra sp. is endowed with ventrally placed cup
shaped adhesive disc (about 0.031 cm²) just behind
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All figures represent scanning electron microscopic photograph of adhesive organ of *Garra gotyla gotyla*.

**Fig. 4:** Upper fringed lip (UFL) with callous pad (CP).
**Fig. 5:** UFL with CP at higher magnification.
**Fig. 6:** Short stub shaped tubercles (ST).
**Fig. 7:** Short stub shaped tubercles (ST) bearing numerous spine (S).
**Fig. 8:** Tubercles covered with squamous epithelium (SE).
**Fig. 9:** Long shaped tubercles (LST) with longer spine.
All figures represent scanning electron microscopic photograph of adhesive organ of *Garra gotyla gotyla*.

**Fig. 10**: Hook shaped spine with wrinkled surface.
**Fig. 11**: The penta-hexagonal squamous epithelium (SE) cells at the interspace between tubercles.
**Fig. 12**: Spine with broad base, mucus opening (MO) and micro-ridge (MR).
**Fig. 13**: Equidistantly placed spines supported by fibrillar structure.
**Fig. 14**: Curvaceous peripheral spines; straighter central spines. Tubercles in various stages of development.
seems to regulate the pressure gradient to stick to the substratum.

The spread of mucus is facilitated by a network of canaliculi created by microridges. Henceforth, it can be clearly stated that the cumulative action of spines and mucus helps the fish to adhere the substratum. The findings of the study, however, do not support the findings of Hora [12]. Singh et al. [13] who were of the opinion that mucus secretion is the primarily function of adhesive organ and anchorage by the spines is secondary. Johal et al. [14] also concluded the same that the spines by interlocking with the rough surface of the substratum and mucus by strengthening adhesion to the substratum effects anchorage. Further, the number of spines on a tubercle and number of tubercles on a callous pad are not fixed. The peripheral spines are curved whereas spines at the centre of tubercles tend to remain straight (Fig 13). Probably, the tubercles/spines can be regenerated if lost due to wear and tear as shown by developing buds of tubercles and spines (Fig. 14). The adhesive pad is mucogenic and highly secretory reflected by microridges (MR) which increases the surface area, provides protection and increases the mobility of the mucus. The mucus lubricates the surface and protects the epithelia and spines from abrasions as these are frequently subjected to wear and tear due to friction with substrate. There is no major difference discerned in the basic structural plan of the adhesive organ of *Garra gotyla* of the Himalayan region and the region under study. However, the organ is more prominent in case of the Himalayan *Garra* owing to swifter water current this is suggestive of same genetic stock of *Garra gotyla* of both the region.

ACKNOWLEDGMENTS

Authors are thankful to Prof. M. S. Johal and their colleagues, Punjab University, Punjab for their kind support and help in photography of adhesive organ of *Garra gotyla* fish. We are obliged to UGC for TRF to realize the work.

REFERENCES


