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Electron Microscopic study of Adhesive organ of *Garra lamta* (Ham.)

Nagar K.C.[1], Sharma M.S.[2]. Tripathi A.K.[1] and Sansi R.K.[1]
[1]Department of Zoology, M.L.V. Govt. College, Bhilwara-Rajasthan, INDIA
[2]Vice-Chancellor, University of Kota, Kota-Rajasthan, INDIA

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Abstract

Hill streams are unique aquatic ecosystem characterised by shallow, narrow channels, low temperature. high altitude, different types of substratum, high current of water, hence the hill stream fishes develop mechanical devices to combat the force of water currents and are successfully adapted to this unique environment Development of various types of adhesive organs is one of the prerequisites for survival of these fishes, In Garra lamta the anchoring devices consist of true suckers. The Scanning Electron Microscopic structure of the adhesive disc of Garra reveals the presence of hexagonal epithelial cells with elevated cell boundaries. Scantly mucous gland openings have also been observed in the adhesive disc.

Keywords: Hillstream, Adhesive organ, *Garra* etc.

Introduction

Garra lamta commonly known as "*stone sucker*" or "*Patthar chatta*" is a hill stream fish and is predominantly adapted to the swift flowing waters. Behind the ventral mouth there is a sucking disc which enables the fish to hold fast in strong currents, mountain streams and rapids. Riverbeds comprising mainly rocks, boulders, stones and gravel form which are useful hiding and anchoring substrata for the fishes. These fishes have "stone clinging" and "stone licking" habit. Food mainly consists of algal felts, mats and periphyton that they scrape off stones. To study the exact mechanism of adhesion to the substratum, *Garra lamta* with excellent adhesive mechanism has been selected.

This fish is bottom feeder and well adapted to different kinds of habitat but its distribution depends upon the altitude, abiotic and biotic factors. An attempt to study its adhesive apparatus has been made using SEM.

However these are reports on "organ of attachment" modification of ventral fins to form a suction disc, depressed body form, rugosity or ventral surface of torrent fishes in Himalayas that permit its existence in rapid mountain streams[1].

In *Garra lamta* and *Labeo dero* the tail is forked (Caudal fin) and the pectoral fins are spatulated whereas in *Channa punctatus* the caudal fin and pectorals are rounded[2].

A relationship is found between oral stimulation and fin shape with hydrodynamics[3,4,5,]

SEM study of adhesive apparatus of *Garra gotyla gotyla* revealed that protrusions bearing spines present on both lips and disc and mucous pores on callous pad function based on the suction principle[6],and life sustaining mechanism in five fish species[7], *Glyptothorax pectinopterus*[8] (Teleostei: Sisoridae) and again *Garra gotyla gotyla*[9,10] is made.

Recently, the functional morphology of the anchorage system and food scrapers of *G. lamta* is described using SEM[11]. Again, a detailed report on lips and associated structures of the same fish *G. lamta* is made[12]. Also a brief report on the presence of unculi on the upper jaw epithelium of *Cirrhinus mrigala* [13] and More recently, a detailed report on lips and associated structures of the fish *Puntius sophore*[14], micro-structure consideration of the adhesive organ in doctor fish, *Garra rufa* (Teleostei; Cyprinidae) from the Persian Gulf Basin[15], scanning electron micrioscopic investigation of "Adhesive Apparatus Epidermis" Of *Glyptothorax pectinopterus* (McClelland) (Sisoridae)[16.]

Material and Methods

The collections were made of live adult specimens of *Garra lamta* from Banas River at Tirrol village Distt.Udaipur, Rajasthan. Specimens were maintained in laboratory at 25 ± 20^0C. The fishes were cold anesthetized, tissues 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 pH 7.4 for one night at 4^oC in Refrigerator. The tissues 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 with liquid carbon dioxide as the transitional fluid. Tissues were glued to stubs, using conductive silver preparation coated with gold using a sputter coater and examined in a scanning electron microscope at the Regional Sophisticated Instrumentation Centre, Punjab University Chandigarh. The results were recorded using Kodak T-MAX 100 professional film.

Systematics and Morphology: *Garra lamta* (Hamilton, 1822) belongs to the family Cyprinidae, sub-order Cyprinoidei and order Cypriniformes. It is commonly known as stone sucker and bears well developed adhesive disc on its ventral surface. It is an inhabitant of fast flowing streams and a bottom dweller fish. The mouth is inferior. Both lips are thick and have prominent tubercles. Upper lip is highly fringed. Behind the lower jaw, lower lip continues and its labial fold has free margin forming the circular disc. The space between the lower lip and postero-lateral free margin of disc becomes thickened and forms the callous pad(CP). Thus, morphologically the disc comprises four components *viz.* the fringed anterior labial fold of upper lip the posterior free labial fold of lower lip the central callous portion of the disc or callous pad and the poster lateral free margin of disc. The spines attached to the stub-shaped tubercles are very well marked on the upper fringed lip and lower free labial fold of the disc. It is evident that stub-shaped structures are covered with the squamous epithelial(SE). The spines on the circular margin of stub-shaped tubercles are small in size and their size increases from margin to the centre. Likewise, the lower lip bears elongated stub-shaped tubercles (ST) with longer spines on its surface. Posterior part of the lower lip is callous pad which is thick and hard.

The spines and tubercles of the upper fringed lip and free border of the disc are shorter in length as compared to those on lower lip. Each spine is attached to its base, which is much broader. Base of spine has pentahexagonal epithelial cells indicating that these spines or dentations are the modification of squamous epithelium. The teeth-shaped spines indicate that they can be used for firm attachment to the substratum and for scrapping the food present on the substratum. The inter space between the tubercles and its surface shows almost hexagonal epithelial covering. The callous pad bears numerous mucous openings on its surface. The epithelial layer present on the callous pad shows irregular formation of micro ridge with varying shape and size having elevations and depressions. The depressions may provide canal system for the distribution of mucous.

Results and Discussion

It appears that stub-shaped tubercles bearing spines of upper fringed lip, lower lip and lower free labial fold of disc come in contact with the substratum first which not only anchor to the substratum but also act as mechano-sensory organs. This process is followed by the secretion of mucous of callous pad, enabling the fish to make firm hold. The sudden spread of mucous of callous pad is facilitated by numerous canaliculi formed by epidermal micro ridges. Hence, cumulative action of spines and mucous enables the fish to make firm hold on the substratum. Thus main function of teeth-like spines (S) is the anchorage to the substratum whereas free ends act as neuromuscular organs because of the absence of special kind of mechano-receptors in pits[17] and the presence of cartilaginous jaw just below the lower-labial fold or lower lip is used to scrap the algal matter from stones or pebbles[18].

The interspaces between the tubercles provide continuous flow of water for aeration. Squamous epithelium is very much clear, in the interspace, on the muscular tubercles and as well as on the base of spines indicating that they are the epithelial modification. The micro ridges provide structural integrity to squamous epithelium of callous pad and increase the surface area and also prevent mechanical abrasions[19]. The mucous, which quickly spreads on micro ridges is immunological in nature and prevents any type of injury to the exposed parts[20].

Thus, there is no doubt that this fish possesses a perfect adhesive apparatus. Due to its adaptive features it has become a key-stone species in the hill streams.

Conclusion

True suckers are the characteristics of *Garra* species. The anchorage system of *Garra lamta* is in the form of a ventrally placed, cup-shaped adhesive disc (0.031 cm^2) just behind the arched lower lip and separated from it by a crescent-shaped groove. The adhesive disc is capable of generating formidable sticking force if applied against the substratum and pressed carefully to create a vacuum by draining the underlying water. The intensity of this force is directly proportional to the vacuum created. The total sticking force under absolute vacuum is about 34914.9 dyne (Pa = 101298 dyne/cm^2 + Ph = 9800 dyne/cm^2) X 0.031 cm^2 (A), where Pa = atmospheric pressure, Ph = hydrostatic pressure of 100 cm of water column on fish body and A = area of the anchorage (adhesive) disc[21]**.** Great muscular effort with higher energy expenditure is required to achieve a vacuum nearer to the absolute value. Under such circumstances the fish regulates muscular effort to achieve an adequate sticking force with a minimum energy expenditure. The crescent furrow above the adhesive disc, and the specialized globular structure on the crescent's margin, can be used to regulate the pressure gradient during the anchorage of fish to the substratum. The surface ultra structure of the adhesive disc of *Garra* reveals the presence of hexagonal epithelial cells with elevated cell boundaries. Scantly mucous gland openings are also discernible in the adhesive disc.

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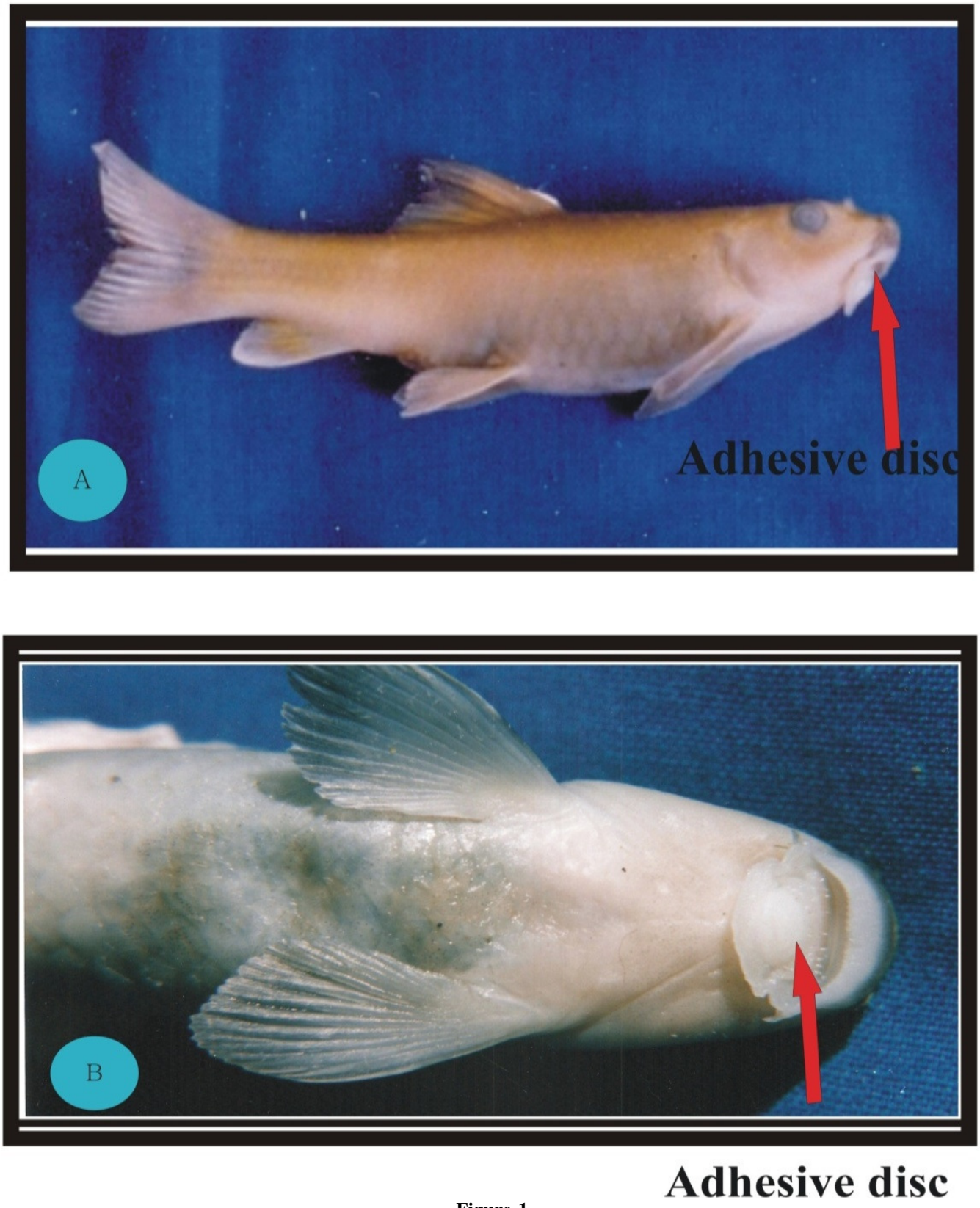

Figure-1
Adhesive disc of *Garra lamta* (A & B)

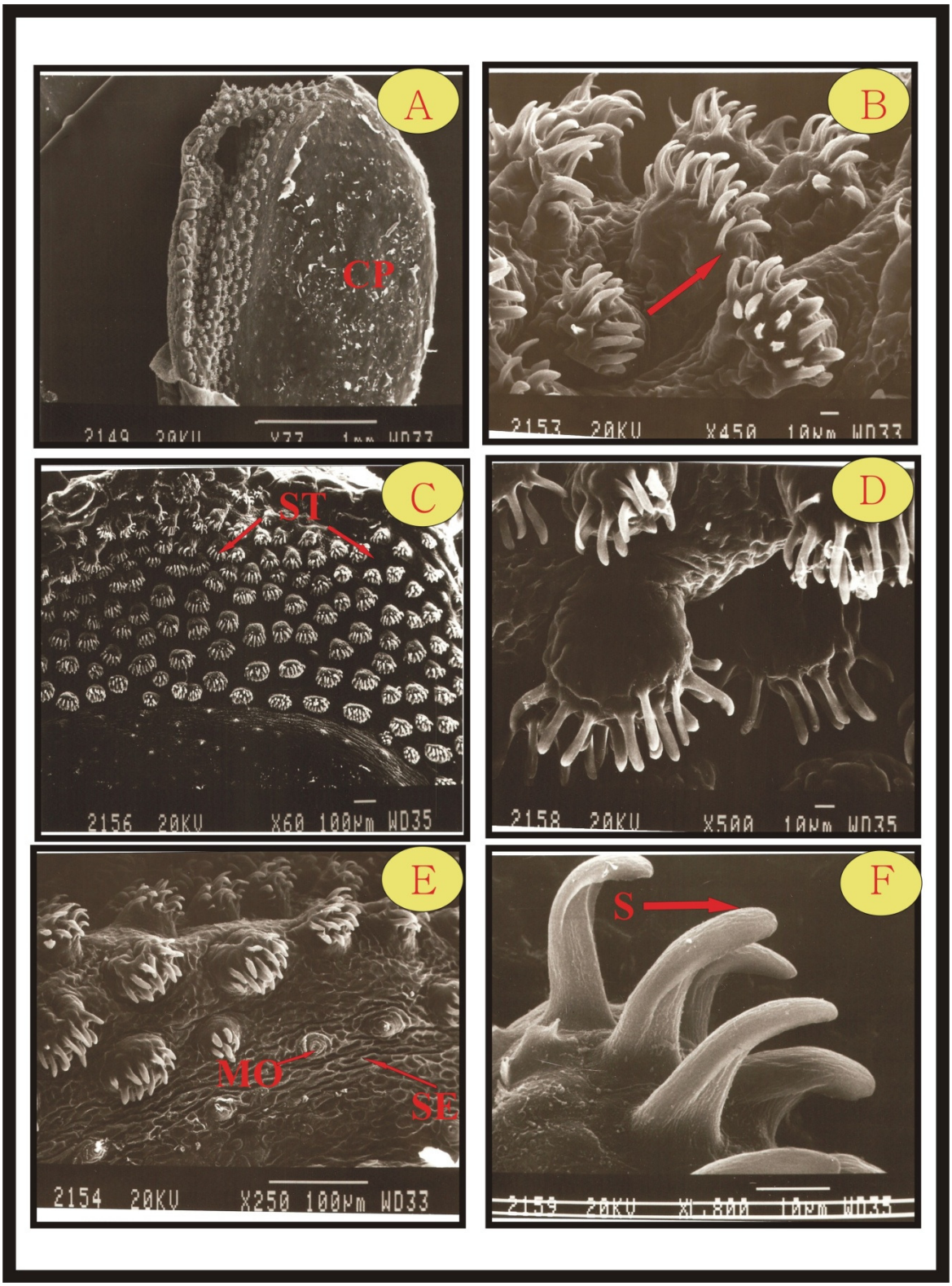

Figure-2
S.E.M. micrograph of adhesive organ of *Garra lamta* . ST (short stub shaped tubercles), CP (Callous pad), SE (squamous epithelium), S (spine), MO (Mucous opening)

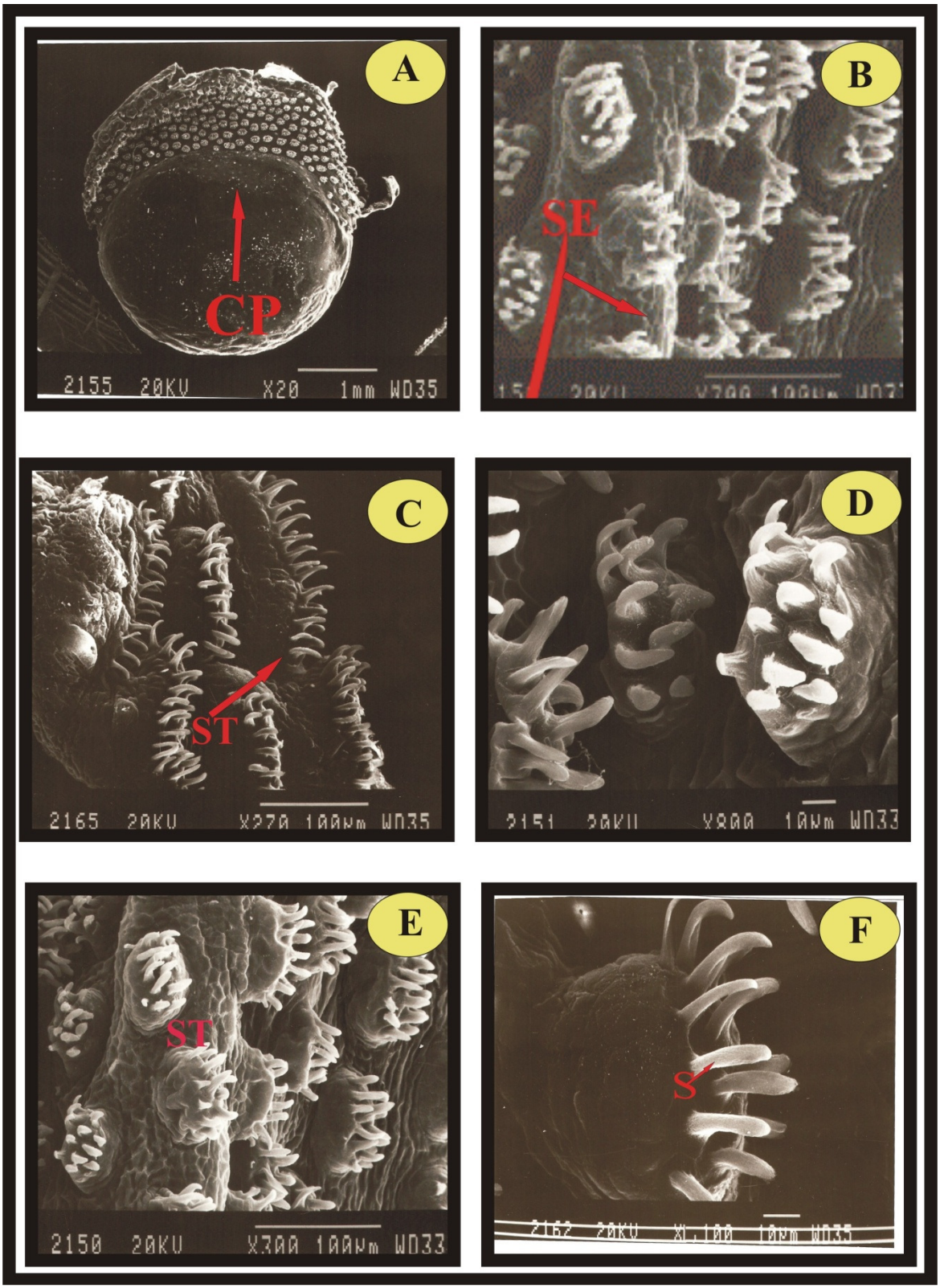

Figure-3
S.E.M. micrograph of adhesive organ of *Garra lamta* . ST(short stub shaped tubercles), CP (Callous pad), SE (squamous epithelium), S (spine)

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