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HOLOCENE HIMALAYAN BUG – A NEW HETEROPTERAN INSECT

PRABHAT KUMAR[1] and **ANIL K. MATHUR**[2]

1. ZOOLOGY DEPARTMENT, UNIVERSITY OF LUCKNOW, LUCKNOW 226007
2. GEOLOGICAL SURVEY OF INDIA, ALIGANJ, LUCKNOW 226024.
*E-mail: dr_anil_mathur@yahoo.co.in

ABSTRACT

A very well-preserved unique fossil apterous heteropteran insect whose thorax is the largest (dorsal: 1.04; ventral:0.80 mm) part of body, compared to head (0.11mm) and abdomen (dorsal: 0.47; ventral: 0.71mm), is considered here to be a true bug recovered from the Holocene sediments exposed near Uttarkashi, Uttaranchal, India. It has been studied systematically based on the characters of antennae and rostrum or beak (both consisting of 3 segments), lamellate extension of head and thorax as well as other morphological features which distinguish this Himalayan bug as an insect. It could belong to a new family. The surface features of the body and sensilla of the fossilized insect have been studied by scanning electron microscopy.

Keywords: Heteroptera, fossil insect, Uttarkashi (Himalaya), Holocene, India

INTRODUCTION

The Quaternary deposits of major tributaries of Ganga in Uttaranchal remained neglected for their palaeontological studies as no data on fossils or on correlation of these sediments were available, whereas their equivalents in plains of Uttar Pradesh had produced sufficient palaeontological records(Dean, 1833, 1835; Lyddeker, 1882; Pilgrim 1904; Chakraborty, 1932, 1935; Mukherjee 1949; Mathur, 2001; Mishra 2001). In order to fill in some of these lacunae, the palaeoecological studies were initiated on the terrace deposits of Bhagirathi valley in Uttaranchal during 2000. Mehra *et al.* (2003) recorded "thecamoebians" from near Netal. Subsequent examination of the material revealed the presence of an insect in association with "thecamoebians" in the Holocene sediments near Netal (30° 44' 35" N; 78° 29' 15" E), Uttarkashi district, Uttaranchal, India (Fig. 1). A brief note on the bug has been published recently (Mathur *et al.*, 2005). The present work is a detailed systematic account about the insect.

GEOLOGICAL SET-UP

Quaternary sediments unconformably overlie the rocks of the Central Crystalline, Tethyan sediments and Garhwal Group between Dharasu and Gangotri in sediments Bhagirathi Valley (Rawat and Gairola, 1999a, b). The general stratigraphic succession is as below:

Quaternary	Higher level Terraces T_4 to T_7 comprising glacial/periglacial/Glacio-fluvial sediments
	Terraces T_1, T_2, T_3 comprising periglacial, glacio-fluvial, fluvial sediments
	----------Unconformity----------
Pre-Quaternary	Central Crystalline rocks, Chandpur and Saknidhar formations

The glacial/glacio-fluvial deposits have been observed in the section along Bhagirathi River between Uttarkashi and Gangotri, whereas fluvial terraces are observed in the lower reaches of Uttarkashi. The glacial sediments at places are characterised by assorted angular to subangular rock fragments of heterogeneous composition derived from the older metamorphics and oxidised silt-clay. The present insect has been recovered from the sample NE 2 comprising light brown silt deposited with unsorted, variable sized boulders mapped by Rawat and Gairola (1999) as glacial deposits. The samples of the lateral equivalent sediments at Shiror close to Netal collected by one of us (AKM) have been dated at 6290-6000 B.P. (C^{14}) by the Birbal Sahni Institute of Palaeobotany, Lucknow (A. Sarkar, *personal communication*).

INTRODUCTION TO THE INSECT STUDY

The Order Hemiptera consists of Suborders Homoptera and Heteroptera, and includes a fairly large group of insects of varied sizes of true bugs. They are very common insects and are easily recognized by the form of their mouthparts developed as a distinct external tubular beak which is adapted for piercing and sucking but without palps. This is an important feature of hemipteran head which is an extended development of the gular region that results in the beak being borne by the front part of the head. With few exceptions compound eyes are large, antennae four to ten, segmented; individual segments are frequently long and two pairs of wings are present with relatively simple or reduced venation, some are apterous with abdomen bearing no cerci. The metamorphosis is gradual.

The Suborder Homoptera is a very diverse assemblage of plant feeders. In these, head is more or less deflexed in its form and in the inclination of its longitudinal axis, gular region small and membranous or wanting. Wings usually sloping over the sides of the body, fore pairs generally of uniform consistency throughout, apterous forms frequent. Base of beak or rostrum extending between anterior coxae. Pronotum small, trochantins usually large. Tarsi with 1-3 segments.

The Suborder Heteroptera bears beak which became anterior and the cheeks fused behind it, forming an extremely strong bridge or gula across the base of the head below occipital foramen. This results in evolutionary changes associated with a dietary change to a predaceous habit. All sclerites on head are compactly fused and porrect in most heteroptera. Pronotum is tolerably uniform, always large, rarely marked of into separate sclerites and forms larger part of the thorax, mesonotum presents maximum number of sclerites, prominent one is scutellum and is always well developed, metanotum is very variable, may be well developed or reduced to a small region concealed beneath mesoscutellum, never conspicuous and is covered by unexpected wings. The sternites for most part are fused with respective pleura. Cerci are never found in Hemiptera

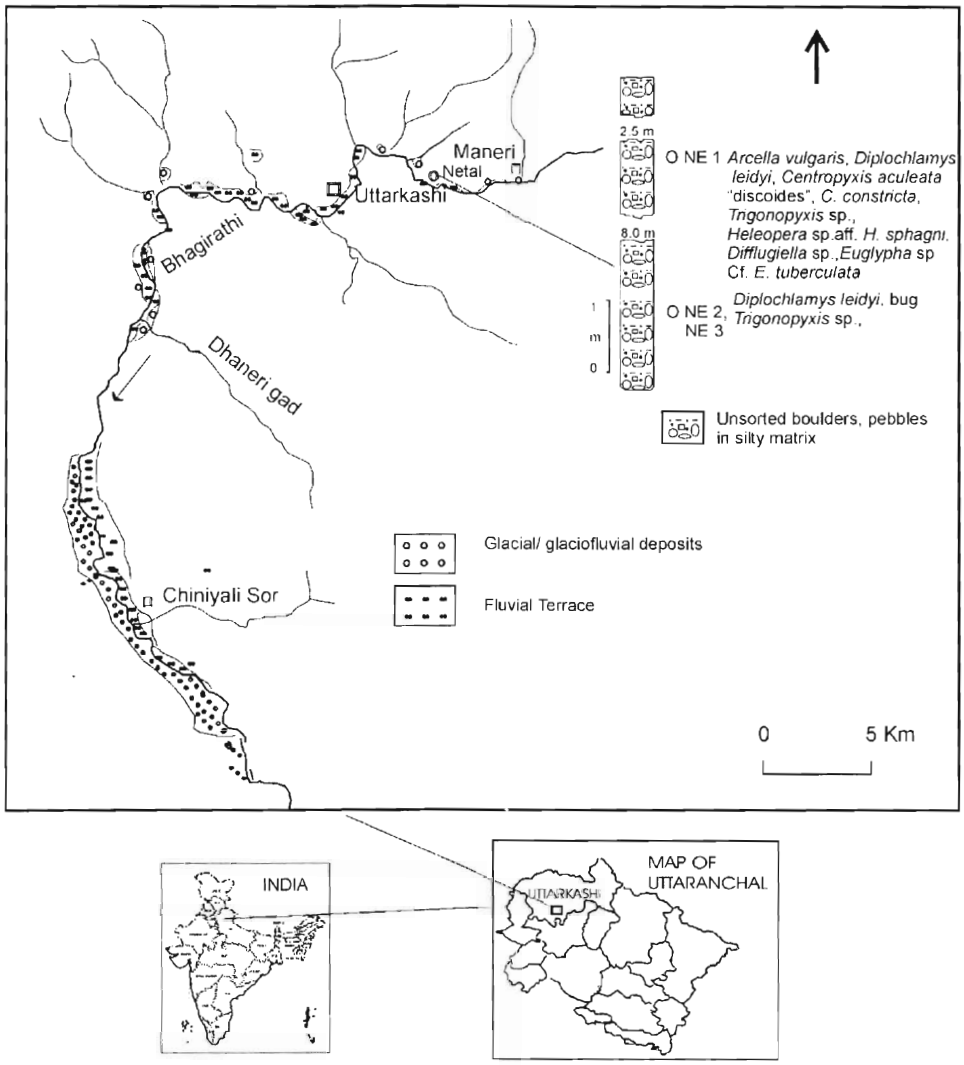


Fig. 1. The geological map of the area and location of the fossil bug-bearing section of the Quaternary in Uttaranchal and India (based on Rawat and Gairola, 1999 a,b).

but abdomen of most Pentatomomorphan Heteroptera bears trichobothria, groups of long sensory hair which are taxonomically important (Drastar, 1973). The base of forewings became thickened and antennae became reduced to four segments. Several insects are aquatic or amphibious. Some are highly destructive pests of plants (Metcalf and Flint, 1962).

The collected microscopic, apterous fossil specimen is an insect because it shows three distinct body regions, head, thorax and abdomen. Thorax bears three pairs of legs (only coxae are traceable). From this condition, evolved the term Hexapoda meaning six legged which is characteristic of the class of insects (Ross, 1965). Due to presence of opisthognathus head and well developed gula it belongs to Hemiptera and Heteroptera respectively. It is a long-horned bug with conspicuous antennae and capable of moving freely in front of head hence Gymnocerata.

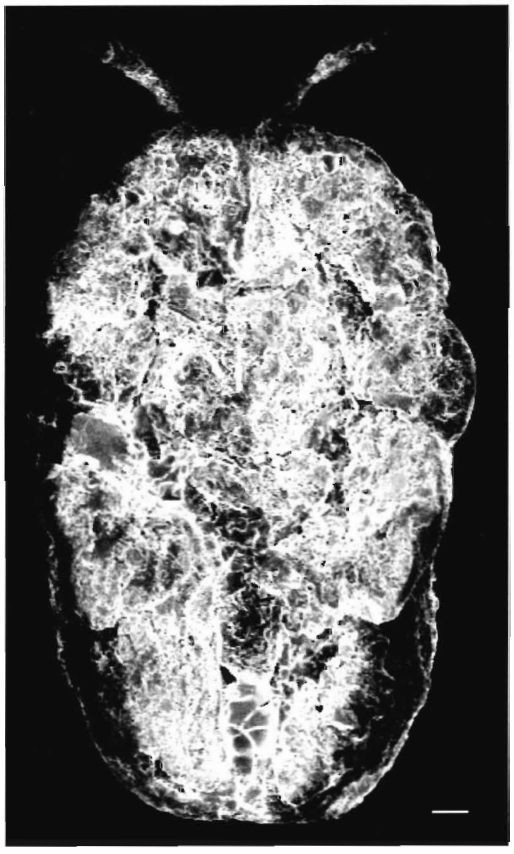
The fossil form described in this paper was earlier recorded as a bug belonging to Order Hemiptera and Suborder Heteroptera by Mathur *et al.* (2005) from the late Pleistocene-Holocene sediments of Uttarkashi district, Uttaranchal, India. In order to establish affinities of this fossil form with the Order Hemiptera, the detailed study of this specimen was carried out to clarify the interpretation of morphological features and its systematic position.

EXPLANATION OF PLATE I

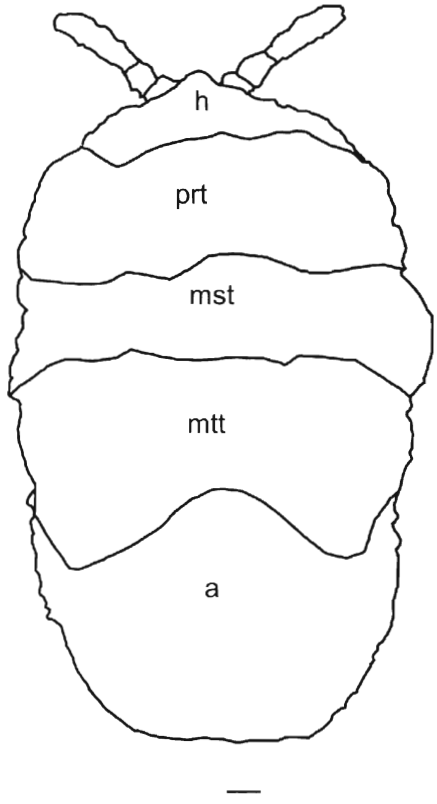
(Bar represents 100 μm)

1. ***Heteropteropsis indicus*** n.gen. and n. sp. Holotype. Geological Survey of India Catalogue No. 21343 (bar represents 50μm). A-dorsal view; B-ventral view .
2. Line diagram showing important morphological features: A-dorsal view showing head (h), prothorax (prt), mesothorax (mst), metathorax (mtt), abdomen (a). Metathorax partially overlapping the abdomen.
   B -ventral view showing antennae (an), head (h), eye spots (e), coxae (c), abdomen (a). Abdomen extending below metathorax.

Plate I

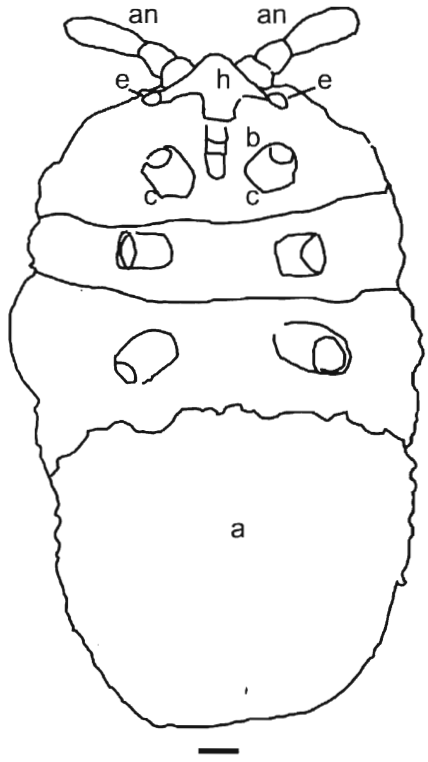


1A



2A

1B



2B

The new taxon of the present fossil insect differs from living heteropteran insects in having head and thorax with lateral lamellate extensions and closely compact segments of entire body. This specimen resembles the insects of Phloeidae family in lamellate lateral extensions where this extension is found in the entire body but differ in having extensions only in head and thorax. The thorax is usually small and sometimes indistinct in insects but in this case its thorax is largest and clearly distinct. Therefore, it is being described as a new genus and new species.

Architecture of the cuticle of this heteropteran Holocene fossil insect resembles the cuticle of creatures of Arthropoda especially, the insect group. Therefore, physiological significance of the surface features and the sensory system of cuticle are discussed. Surface features of the cuticle of head, thorax, abdomen and their appendages have been considered. Very few reports exist about this aspect for extant insects. Dey (1998) studied body cuticle and associated sensilla in social insects, ants. This is the first report on the study of cuticle and sensilla of a fossil insect by scanning electron microscopy.

The reticulate and granulate cuticle has been observed beyond the resolution limit of stereozoom light microscope Leica MZ 12 (structures separated by less than 200μm) under Scanning Electron Microscope Leo 440. The granules are irregular and may be connected with each other. This basic structure is found throughout the entire body of the insect. The reticulation is found to be formed in a variety of ways and differs in different parts of the body and its appendages. Normally, the cuticle is formed of a smooth base ornamented with differently developed granules connected with network. At certain places, the raised structures have been observed which may be the result of granular fusion over the network. The arrangement of cuticular ornamentation is not same different parts of body.

Minute spiniform, short, moderately long setae have been observed on the body of this fossil insect. Earlier they were observed in Phthirapteran insects by Kumar and Tandan (1971) and also in fossil Phthirapteran insect (Kumar, 2004). Setae are external receptors. The cuticular structures are of different types and differ from one sensillum to another. Sense organs have an external process, seta which is modified into different shapes.

SYSTEMATIC DESCRIPTION

Phylum **Arthropoda**
Class **Insecta**
Order **Hemiptera** Linnaeus, 1758
Suborder **Heteroptera** Latereille, 1810
Division **Gymnocerata** Fieb, 1861
Series **Geocorisae** Cobben, 1968
Superfamily **Pentatomoidea** Leach, 1815
Family **? Phloeidae** (Amyot & Serville, 1843)
Genus ***Heteropteropsis*** n. gen.

Type species: ***Heteropteropsis indicus*** n. sp.

Derivation of Name: Named after heteropteran insect.

Diagnosis: Flattened oval, with narrow head and lateral lamellate extension. Thorax is clearly demarcated into three regions, pro-meso- and metanotum or pro-, meso- and metathorax. Only two regions, head and thorax, are decorated with lamellate extension. (Pl. I, fig. 1) and abdomen is without lateral extensions. Head and thorax are closely compact as there is no neck and three regions of thorax are also closely compact. There is no trace of scutellum.

Remarks: The longest and the widest part of the body is thorax while in other insects (living and fossil) longest part of body is abdomen. In the extant bug of Phloeidae family, the lateral lamellate extensions occur in all the regions of the body but in the present specimen only head and thorax bear lamellate extensions. Therefore, this bug specimen may be placed under a new family. However, in view of insufficient number of specimens, it is presently described under the family Phloeidae.

Type locality: Near Netal, Uttarkashi District, Uttaranchal, India

Heteropteropsis indicus n. sp.
(Pl. I, figs. 1A, B, 2A, B; Pl. II, figs. 1A-G, 2A-C; Pl. III, figs. 1A-C, 2-3; Pl. IV, figs. 1-5; Pl.V, figs. 1A, B, 3-4)

Holotype: Geological Survey of India Catalogue No. 21343.

Derivation of Name: Named after India.

Diagnosis: Head is very small and triangular in shape due to the presence of lateral extension (Pl. I, figs. 1A, B, 2A,B). Rigid and short three segmented beak, not reaching up to the base of coxae of the first pair of legs. The free antennae are peculiar in having three segments. The distal longest third segment flagellum or clăvola is barrel shaped. Proximal first segment scape is toughest, shortest and thickest, second segment pedicel is longer than first one. Antennae are longer than head and beak. The three segments of beak are cylindrical, rod shaped, short, almost uniform, i.e. almost equal in length and breadth, not pointed.

Description: The study is based upon only one (Pl. I, figs 1A, B), very well-preserved small specimen (length 1.62 mm, width 0.96 mm) of isolated, wingless fossil insect which is of rare occurrence, especially the Himalaya. The three distinct body parts are head (0.11 mm), thorax (dorsal: 1.04 mm; ventral: 0.80 mm) and abdomen (dorsal: 0.47mm; ventral: 0.71 mm). In this way, the thorax overlaps the abdomen by 0.24 mm in dorsal view. The sides of body are not straight as there are protuberances as lamellate lateral extensions on both sides of head and thorax and more bulging protuberances in the mesothorax region. The body is flat, elongate, wide and oval in

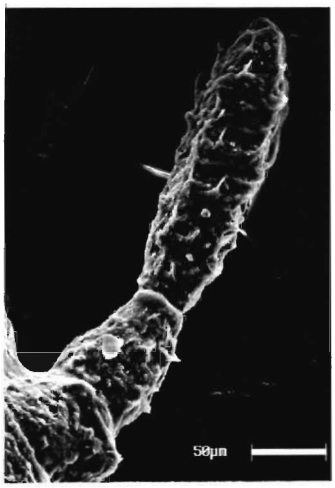
EXPLANATION OF PLATE II

(Bar represents 100 μm unless stated otherwise)

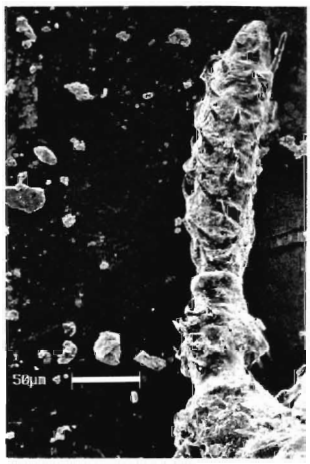
1-2 ***Heteropterosis indicus*** n. gen. and n. sp.

1. Enlarged view of Antenna. A, B - Three segmented antenna with cuticular structure. Proximal first segment has least number of setae distal scale shaped setae on second segment and, third segment showing maximum number of setae; B, C, D, E, F- enlarged views of antenna showing sensory setae. Minute, spiniform, peg-shaped and long setae, conspicuous triangular raised sockets, papillae shaped raised structures, one short straight seta without socket; G - More enlarged view of second and third antennal segments showing cuticular pattern and setae.
2. Enlarged view of head. A- Showing opisthognathus position of triangular head with epicuticular laminae, sensilla trichodea, sensory hair, minute spiniform setae; B - one chaetica seta between head and proximal first segment of antenna, sensilla placodea; C- cuticular structure of head

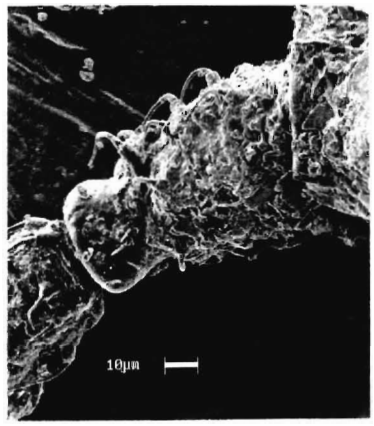
Plate II



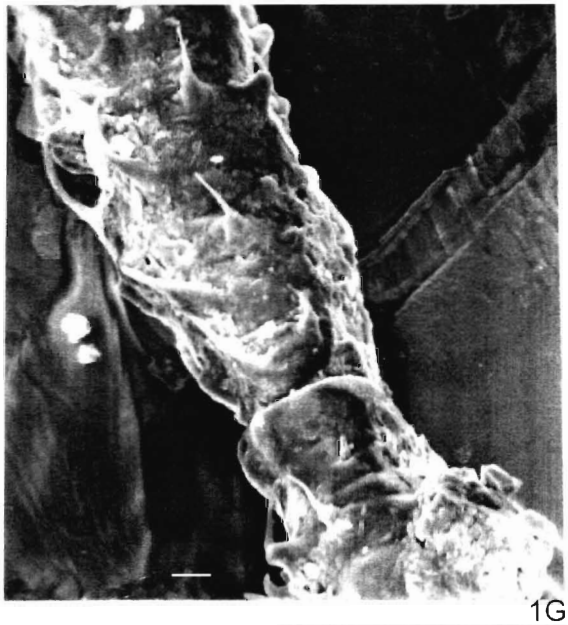
1A



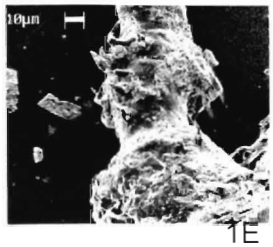
1B



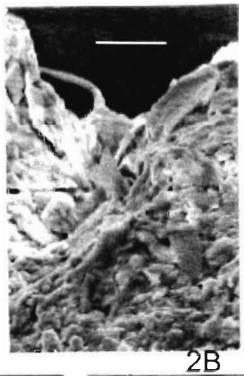
1C



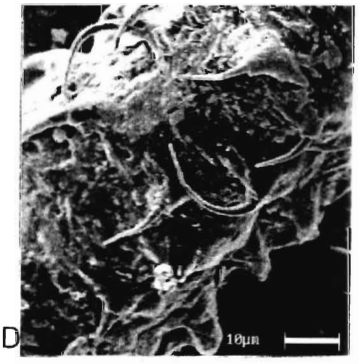
1G



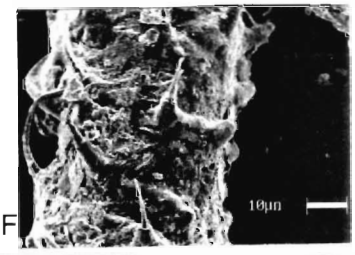
1E



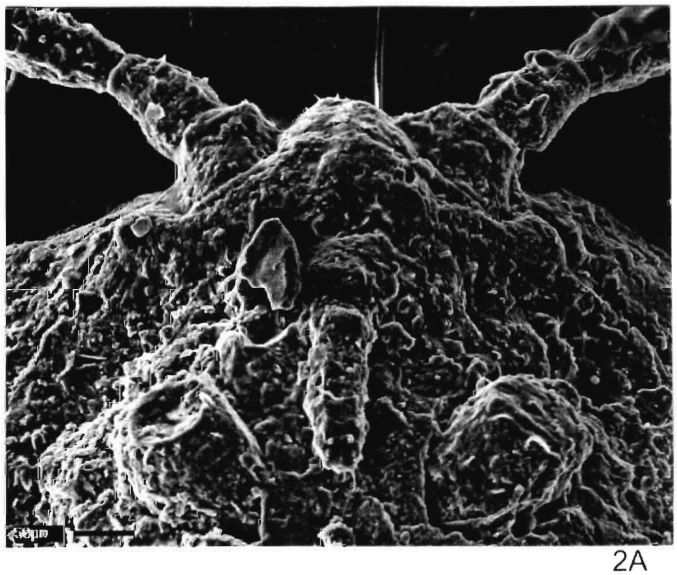
2B



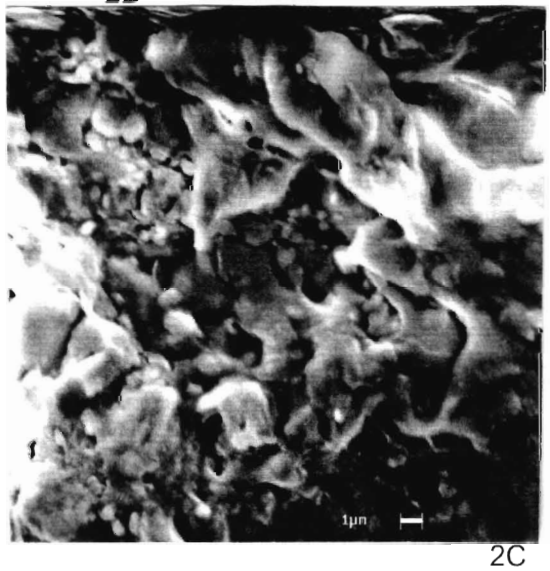
1D



1F



2A



2C

nature. The triangular head (Pl. I, figs. 1A,B, 2A,B) is short, down bent and its all sclerites seem to be fused. Gular region sclerotized and well developed, hence Heteroptera. The orientation of head with respect to thorax and abdomen is opisthorhynchous or opisthognathous, in which the elongate proboscis slopes backwards between front legs. The three-segmented, cylindrical and rod-shaped short, beak (Pl. I, fig. 2B; Pl. III, fig.1A) curving back from the ventral portion of the head, does not reach up to the base of coxae front legs. Beak (labium) or proboscis (rostrum) arise from the front cephalic part of head. The head bears two projecting, free, well-preserved, three-segmented, short, jointed appendages, the antennae (Pl. II, figs.1A, 2A) which are rare in hemipteran insects and arise from sides of head situated above the rudimentary eyes. In the specimen, both antennae and proboscis are three segmented. All the three parts, scape, pedicel and flagellum (clăvola) typical of the insect antenna, are discernible. The specimen shows only one segment in each part. The third flagellar segment is the largest, first segment scape is toughest as well as thickest and shorter than second segment pedicel. As antennae are feelers, they bear sensory setae to increase the sensory activities. Mouth parts are the piercing and sucking type. The venter of the head posterior to rostrum forms a sclerotized bridge or gula. Here the beak is anteriorly situated and strong gula lies behind it. Below the antennae lie two (one on each side) distinct slightly protruding eye spots.

Three distinct thoracic segments (Pl. I, figs. 1A, B, 2A, B) constitute the largest region of the body. Thoracic segmentation is typical and is not on heteropteron insect pattern. These segments are closely compact. Prothorax with narrow lateral lamellate extension, uniform, mesothorax is shorter than prothorax, apparently with uniform sclerites with lateral extensions and without scutellum, and its lateral margins clearly projected towards the outside; metathorax very conspicuous and the largest part projecting towards outside laterally and slightly overlaping the abdomen. All the three coxae of legs of each side are discernible on ventral side of the thorax. The position of coxae (Pl. I, figs. 1B, 2B) is of heteropteran type, distal position of coxae of prothorax facing upward while coxae of mesothorax and metathorax facing laterally and downward respectively. It means that the coxae articulate with thorax by a rotary or hinged joint in Heteroptera while in Fulgoroidea (Homoptera) the hind coxae are fused with the metathorax (Richards and Davies, 1983). Thoracic region is very peculiar as it covers the largest area of the body (Pl. I, fig. 2A). Head is the smallest part of the body and broad abdomen is smaller than thorax. Abdomen includes eight segments. No cerci observed and there is no trace of trichobothria. It seems to be a male bug as space for male genetalia is observed in dorsoposterior region of the abdomen. There are two spiracles in the abdominal region which are placed closer to anterior margin of segments than the posterior one.

As the present insect bug was recovered in association with thecamoebians in the late Pleistocene-Holocene sediments, changes might have taken place in the outer covering of the cuticle structure due to naturally occurring chemical reactions. The outer surface of the cuticle of this fossil insect is rough due to numerous protuberance and general colour is brownish. These protuberances occupy almost entire body of the insect, hence general surface is greatly reduced and compressed between them. The protuberances are greatly variable in size and shape. Each protuberance is a mound consisting of a central core or bump of the procuticle, over which the epicuticle fits snugly like a cap. In this way, endocuticle takes part in the formation of mound. These structures are also reported earlier by Tandan *et al.* (1977) in cuticular mounds of untreated normal and treated pleural cuticle of scorpion *Heteormetrus liurus* with different concentrations of alkali and acid. Due to naturally occurring chemical reactions, the highly resistant paraffin lamina (paraffin layer surmounted on cuticular layer) has been exposed from major parts of the body (Pl. I, figs. A, B).

Head cuticle: The head cuticle on dorsal and ventral surfaces are like epicuticular laminae. Each lamina presents a tripartite appearance of a raised structure (Pl. II, fig. 2A). The same structure has been observed on antennae (Pl. II, figs. 1A,B) and beak (Pl. III, figs.1A, B, C) also but differs in structure and type of sensory setae (Pl. II, fig. 1B). The cuticular surface is rough and same in all parts of the body. As the jointed appendages of this adult fossil specimen are conspicuous feelers projecting from the head (antennae and beak) and thorax (coxa in this case), they are responsible for increased sensory activities needed for specialized food and mate. Therefore, the sensory setae of antennae, beak and coxae are studied along with other setae present on different parts of the body. Minute, spiniform setae are located in the head region. Minute peg-like setae are also there, which may be sensilla trichodea sensory hair. It appears that in the cuticle of head, thorax and abdomen, antennae, beak and coxae the cuticle thickens and appears as a dome of sensilla campaniform, and as an oval or elliptical outer plate forming plate organs or sensilla placodea, usually olfactory in function. As there is no neck, rough thoracic cuticular surface is closely attached to head. Cuticular surface of thorax is similar to the head but is more densely reticulated. Some cuticular plates with tooth-like projections are found on thorax (Pl. IV, figs. 2,3,4,) and abdomen (Pl. IV, fig.1B). The surface of cuticular plates shows a few elongated protuberances (Pl. V, fig.2). The cuticular surfaces of coxae are same as of thorax but differ in a structure that has been shown in Pl. III, fig.2. On the ventral surface of thorax, some almost hexagonal, tetragonal and oval plates have been observed which may contain campaniform sensilla. Surface pattern of abdominal cuticle is same as that of thorax but its rough surface contains numerous protuberances, greatly variable in shape and size (Pl. IV, fig. 4); being set close together, the intervening

EXPLANATION OF PLATE III

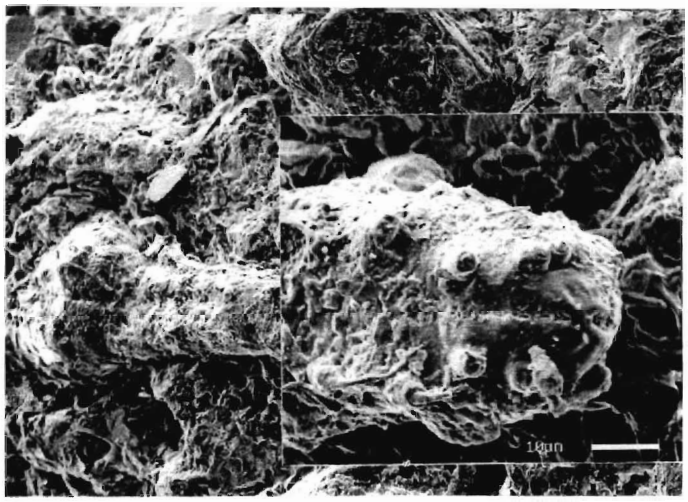
(Bar represents 100 μm unless stated otherwise)

1-3 ***Heteropterosis indicus*** n. gen. and n. sp.

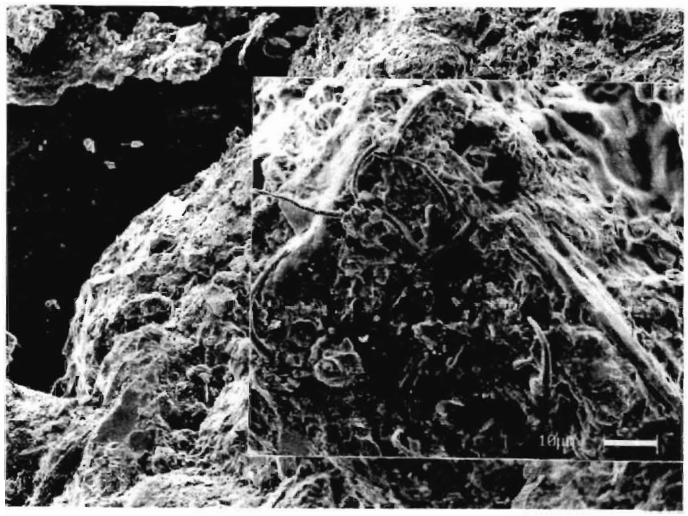
1. Enlarged view of beak. A- Showing three-segmented beak with six peg shaped short thick distally located sensory setae on third segment; B- showing enlarged view of third segment of beak with double walled socket ; C- sensilla trichoidea moderately long setae, long ridged setae, thicker at base and tapering at tips.
2. Enlarged view of coxa with different types of setae.
3. Enlarged view of prothorax with short, moderately long setae without protruded socket and one claw-shaped short seta with raised sockets, tactile in function and many raised papillae or warts.

Plate III

1A



1B



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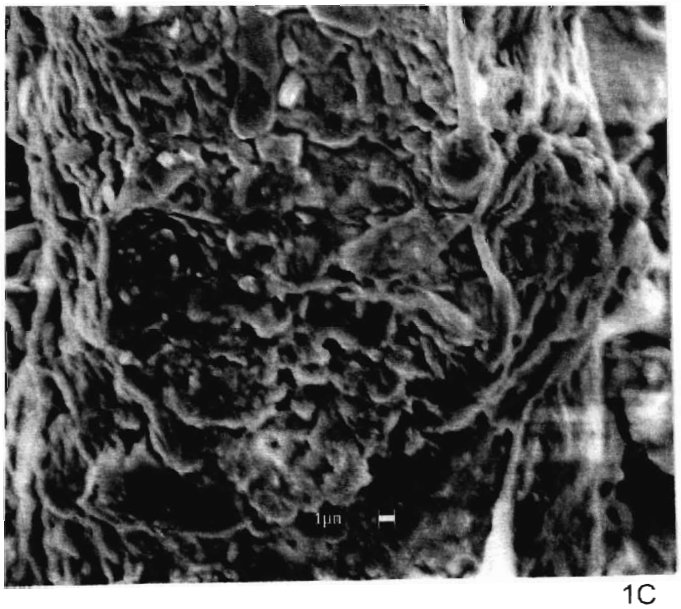
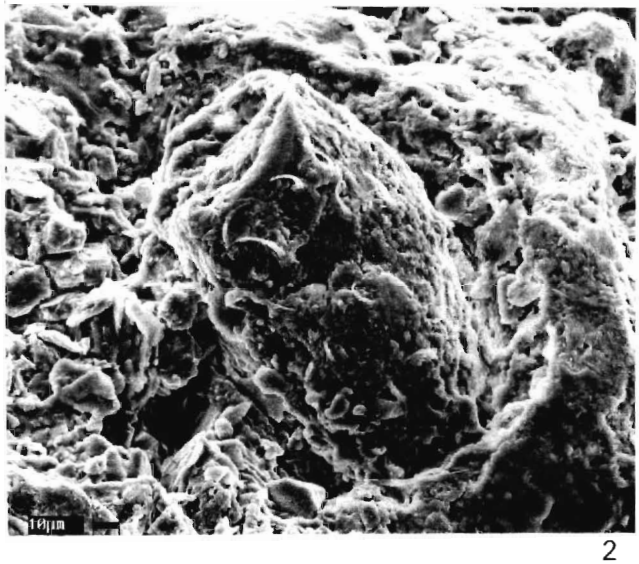


1C



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or general surface is greatly reduced and compressed between them. The cuticle of head, thorax, abdomen and appendages shows at places the presence of some small cuticular openings which may act as receptors for humidity, temperature and carbon dioxide (Pl. V, fig. 3). One chaetica seta is present in between head and proximal first segment of antenna (Pl. II, fig.2 B). Minute, spiniform and peg-shaped basiconica setae occur on head (Pl. II, figs. 2A, C). Four types of setae have been observed on the ventrally located beak (Pl. III, figs. 1A, B, C) - Type I: Six peg-shaped, short and thick, distally located sensory setae are present on third segment of the beak (Pl. III, fig.1B). These are sensilla basiconica chemoreceptor for taste and odour. Only two are visible (four are broken), only alveoli are seen and they all show double-chambered sockets (Pl. III, fig.1B. Type II: Minute and spiniform spine-shaped setae are located on the terminal tip of the beak (Pl. III, fig. 1A, B). Type III: Sensilla trichoidea type, moderately long setae occur on second segment of the beak. The surface setae are smooth and the swollen tip is round in shape. The external wall of socket is protruded above the cuticular surface (Pl. III, fig. 1B). Type IV: Long-ridged setae, thicker at the base where they are articulated as ball and socket joint and tapering at tips. They seem to be grooved and may be sensilla chaetica (Pl. III, fig. 1C). In addition, several projected wart or papilla-like structures are also visible. There are openings in the form of cavities on the cuticle which may contain coelomic pegs, a kind of sensilla. Just above the proximal end of beak on the head, one short and one moderately long setae are ventrally located; these may be mechanoreceptors (Pl. III, fig. 1A).

Antennae cuticle: Antennae bear the maximum number of different kinds of sensory setae which are external processes modified into different shapes (Pl. II, figs. 1A, B). Proximal first segment has least number of setae while distal third segment shows maximum number of setae. Minute peg-shaped and scale-like setae on short first segment (Pl. II, fig. 1C). Minute, spiniform, peg-shaped, long setae but some are broken and all (except minute setae) are with conspicuous triangular, raised sockets (Pl. II, fig. 1D). Scale-like setae are also present (Pl. II, fig. 1C) on the longer second segment. Very conspicuous, broken and long, claw-shaped setae are located on the longest third segment (Pl. II, fig. 1). The smooth-surfaced spiny setae are sensilla chaetica (tactile in function), which are short, moderately long, with highly raised triangular sockets. Besides these setae, all antennal segments bear warts or raised papillate structures (Pl. II, figs. 1A, 2A). Probably plate organs or sensilla placodea in the form of raised plates are also visible, which may be olfactory in function.

Thorax cuticle: Setae on prothorax are short, moderately long, sensory setae spiny in nature. These articulated sensory organs are without protruded sockets on cuticle (Pl. III, fig. 3). One short seta with a raised socket is also present and in between the two setae a pentagonal raised seta is visible. Peg shaped, minute, seta and papillae are clearly located. These are mechanoreceptors, the tactile organ. Setae of coxa (Pl. III, fig. 2) are claw shaped, minute, spiny, with raised sockets, tactile in function.

Abdomen cuticle: Only one visible abdominal short seta with a socket on the level of cuticle (Pl V, figs. 1 A, B,). Some setae, chaemoreceptors, have been observed on the abdomen with minute pores, through which molecules can pass and contact the internal sensory cells (Pl. IV, fig. 4) as earlier reported by Elzinga (1978) on maxillary palp of a cutworm caterpillar. On lateral margins of both sides, triangular projections are visible (Pl. V, fig. 2). All parts of the body enjoy the presence of special structures of different shapes, e.g. plate, triradiate granule, pentagonal or irregularly shaped, finger-like projections (Pl. II, fig. 1A, Pl. V, fig. 3). These structures may be formed by fusion of several granules. Projected tips of cuticle and folds are caused by the shrinkage of cuticle. The tubercles are characteristic features and may prove helpful in determining the phylogenetic and taxonomic relationship (Pl. V, fig.2).

Remarks: The present insect specimen may be a terrestrial predaceous bug belonging to Order Hemiptera and Suborder Heteroptera as head shows opisthognathus condition with respect to rest of the body parts and also shows the presence of extremely strong bridge or gula across the back of head. Beak arises from the front part of head. Antennae are free, prominent and longer than head. The SEM stydy of this insect has revealed reticulate type of cuticle with different types of sensilla on different parts of the body.

Type Locality: Near Netal, Uttarkshi district, Uttaranchal, India.

Type Horizon: Light brown silt associated with unsorted boulders and pebbles (Holocene).

Repository: Geological Survey of India, Kolkata Catalogue No. 21343.

Key for extant and fossil Hemipteran insects

Extant insects: Compound eyes are large. No lamellate lateral extension in body except in Phloeidae family where lateral extensions of head and body occur (Richards and Davies, 1983). Antennae 4 to 5 segmented (rarely 3 segmented), may be shorter than head and concealed on the underside of head (in short horned bug – Cryptocerata) or may be as long as head and plainly visible at its sides (in long-horned bug – Gymnocerata). They arise from sides of head situated above, beneath or behind eyes or arise from front of head in between eyes. Variation in segments of antennae and beak. Scutellum large and may be 'U' or 'V' shaped covering most of the abdominal part. Beak 3-

EXPLANATION OF PLATE IV

(Bar represents 1 μm unless stated otherwise)

1-5 ***Heteropterosis indicus*** n. gen. and n. sp.

1. Enlarged view of prothorax showing moderately long sensory setae, spiny in nature, without protruding sockets on cuticle; pentagonal raised peg-shaped seta with opening and a large dome shaped structure can be seen.
2. Enlarged view of abdomen showing fused triangular granules, tooth like structure.
3. Enlarged view of thorax showing finger tips (may have several fused granules) and triangular spiny projected structures.
4. Abdomen showing finger tip, triangular granule and setae chaemoreceptors with pores.
5. Enlarged view of abdomen showing granular structure in a linear pattern and projected tips.

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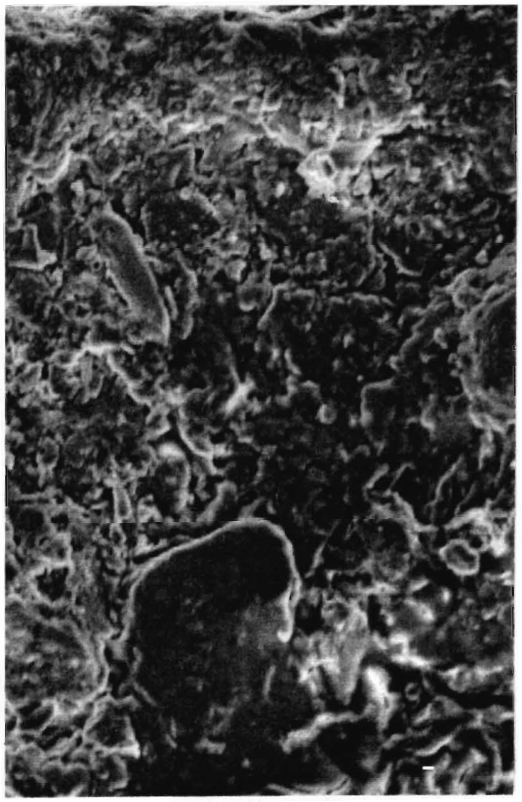
Plate IV



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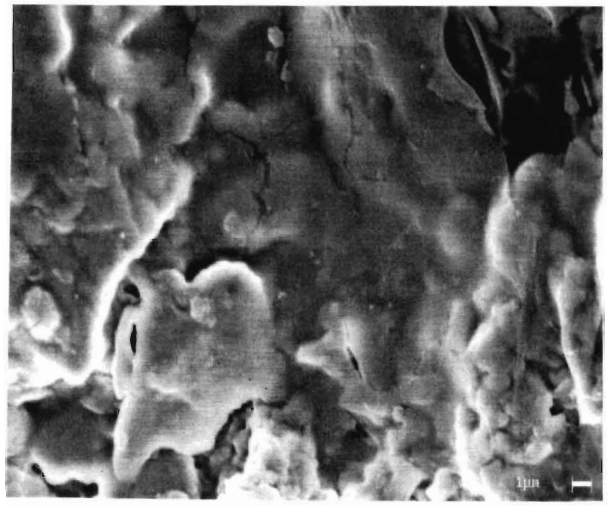

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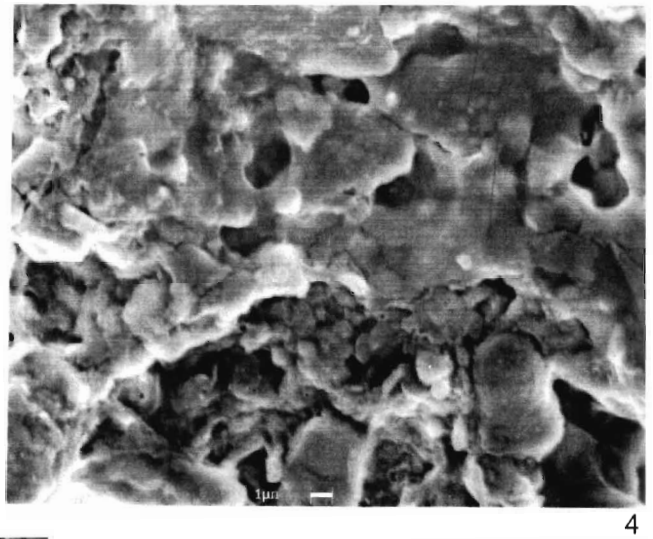

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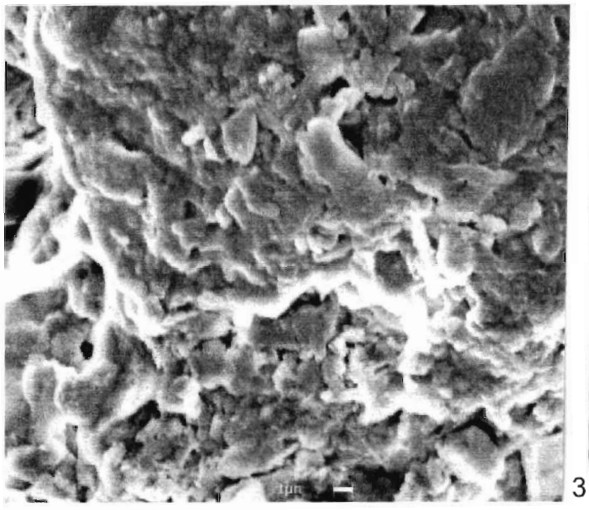

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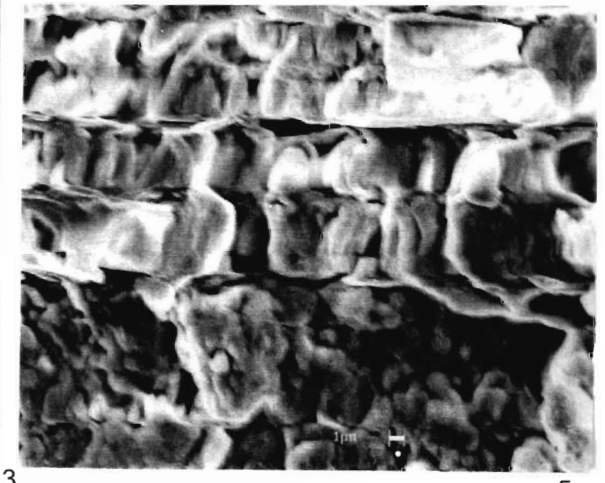

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5 segmented and pointed, reach beyond coxae of first pairs of legs. Abdomen is the largest part of the body.

Fossil insect: Rudimentary eyes, deflexed head and thorax with lamellate lateral extensions. All the three segments of thorax resemble other groups of insects than Hemipteran insects. Metathorax partially covers the abdomen. There is no trace of scutellum. Beak is not pointed and 3 segmented. Plainly visible three-segmented antennae arise from sides of head, situated above the rudimentary eyes. Thorax is the largest part of the body, e.g. *Heteropteropsis indicus* n. gen. and n. sp.

DISCUSSION

The existing fauna of insects is the result of eons of change and evolution among insects. Insect group evolved with biological and physiological characteristics enabling them to become adapted to new ecological niches. Though their fossil remains have been found in rocks of different ages, insect fossils are not easily preserved because of their small size, delivery of their structure and minute nature of identification criteria; they need special conditions to ensure adequate preservation, i.e. there must be a medium of extremely fine nature providing a grain-less matrix (Ross, 1965).

Wing impressions of many Hemipteran insects are known since Permian and belong to families Archescytinidae, Prosbolidae and Scytinopteridae (Evans, 1964). The modern Peloridiidae are probably survivors of early Proto-Homopteran stock, from which a major evolutionary line perhaps radiated into Fulgoroidea, though these fossils are not known until the Triassic. A separate second line led to cicadomorph Auchenorhyncha. The known fossil aphidae are from the Tertiary amber and this stock may have arisen in Permian or Carboniferous times (Heie, 1967). Heteropteran insects probably are from an early Proto-Homopteron pre-Permian ancestor but details of their origin are not clear. Schless (1969) considers that Peloridiidae and Heteroptera had a common ancestry. Earliest Heteropteran fossil insects do not contribute much to the theories of Heteropteran phylogeny. Terrestrial Heteroptera are widely polyphyletic, hence the concept of a single group of land bugs, Geocorisae is rejected (Cobben, 1968). He pointed out that Pentatomomorpha, Cimicomorpha (in a strict sense), Reduvioidea, Sadidae and their allies and some smaller superfamilies have all evolved independently as major groups of terrestrial Heteroptera. These, along with monophyletic Hydrocorisae and modern Amphibicosae, all radiated from an extinct ancestral Amphibicrisan stock. We agree with this view and believe that the present fossil Heteropteran Himalayan bug evolved from Amphibicoriscan stock as it shows characters of these insects.

The orientation of head with respect to rest of the body parts is of advanced type in Hemiptera, i.e. opisthorhynchous or opisthognathous condition. The hypognathous condition where mouth parts are in a continuous series with legs, is probably primitive and occurs mostly in vegetarian species living in open habitat. In prognathous condition, the mouth parts point forward and are found in carnivorous species which actively pursue their prey. The opisthognathous condition, with elongate proboscis, suits both vegetarian and carnivorous insects of Hemiptera order (Chapman, 1973).

In insects, the cuticle reveals a laminate condition which is an important taxonomical character (Elzinga, 1978). Exoskeleton or cuticle is a remarkable characteristic feature of arthropods but insects seemingly have fully exploited its mechanical advantages. The cuticle not only provides a much larger area for muscle attachment but also protects the muscles from mechanical injury and affords desiccation. Smaller size of insects leads to a greater efficiency but shows larger surface area per unit body weight which means greater vulnerability not only to mechanical injury but also to desiccation; however, they have successfully overcome both difficulties due to their exoskeleton. The cuticle has turned appendages into a tool useful for different functions. The definite shape of insect is due to cuticle. The cuticular structure of snow flea, *Anchorutes nivicola* (Order Collembola, Suborder Arthopleora) which occurs abundantly in winter on the surface of snow is usually granulated according to Comstock (1984, p. 223). The snow flies, *Chionea* (Order Diptera, family Tipulidae) are most often seen in winter crawling on the snow and have granular cuticle (Comstock, 1984, p. 799). Relatively similar granular cuticular structure of the present fossil Heteropteran insect, found among thecamoebians typical of cold environments of the Arctic region, could be interpreted to indicate that this bug was a snow inhabitant.

The diversity and adaptation in insects are best expressed by the chemical and structural specialization of the chitinous cuticle covering the entire body that is different in different species and in different body parts of the same individual. Extensive work on sensilla of outer cuticular covering of different extant insect groups has been done under scanning electron microscope. This kind of study has shown that different groups of sensilla perform a variety of functions. However, nobody has reported the scanning electron microscopy of body cuticle of a fossil insect. This is the first detailed report of a fossil insect about its body cuticle of different parts (head, thorax, and appendages) and different types of sensilla.

The rough surface of cuticle of the present fossil insect may help absorb heat from outside and thus maintain its body warmth in the cold region. The reticulate pattern of cuticle of the entire body has not been observed in other insects, hence it seems to have a greater taxonomical value. This type of pattern has been reported in cerci of a dipteran insect *Eristalis arvorum* by Sareen *et al.* (1990). The cuticular openings on body may be the openings of pits which may function as receptors for humidity, temperature and carbon dioxide. A similar role has been suggested for circular pits of worker ants (Dey, 1998). The sculpturing of cuticle with raised edges may assist an insect in

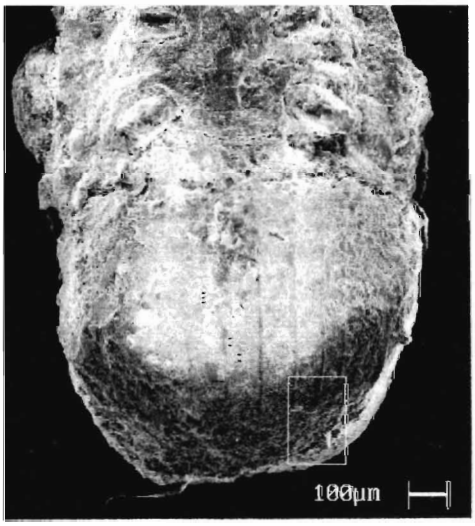
EXPLANATION OF PLATE V

(Bar represents 100 µm unless stated otherwise)

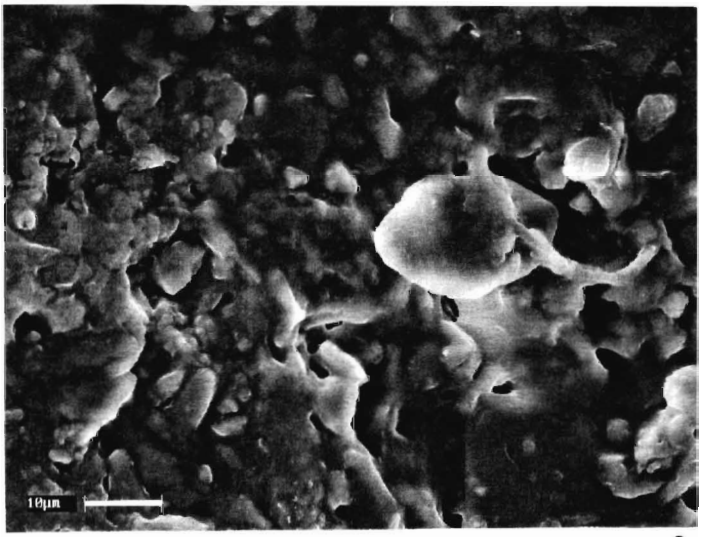
1-3 ***Heteropterosis indicus*** n. gen. and n. sp.

1. Showing ventral part of abdomen. A - surface pattern of abdominal cuticle which is rough with numerous protuberances, greatly variable in size and one short seta; B - Enlarged view of the selected area of 1A (x10.24 of 1A) showing bulging protuberances and one short seta.
2. Enlarged dorsal view of abdomen showing space for male genetalia, triangular spiny structure, spiracle, projected tips on its both lateral sides.
3. The cuticle of abdomen showing cuticular opening and different shapes of granules.

Plate V



1A



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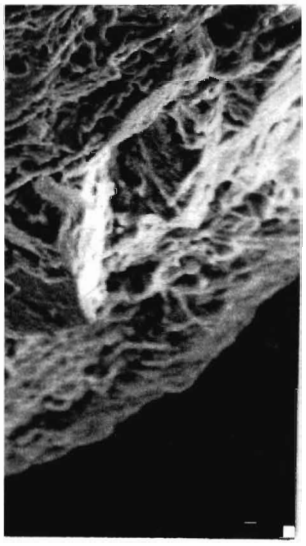
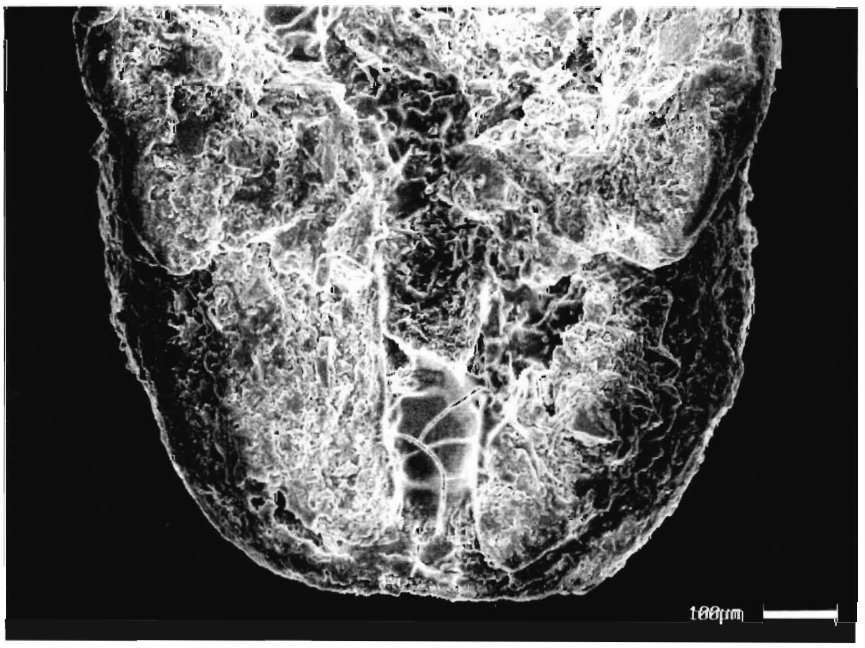


1B



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dissociating itself from any foreign body possessing electrostatic charges accumulated in dry air; the cuticular plates differ in morphological features probably related to movement of different body parts (Dey, 1998). The tooth-like projections on different parts of body may also have a protective role.

Sensory receptors or sense organs develop on part of the integument and several of them appear as hair in the form of setae and most are tactile receptors, e.g. movement indicates touch as in coxae of the present specimen (Pl. III, fig. 2) but some modify into chemoreceptors and respond to odour and taste (Elzinga, 1978). The diffused and scattered nature of sense organs are advantageous because it reduces chances of all organs receiving injury at the same time.

At some places, the cuticle thickens and appears as a dome or bell called the sensilla campaniform and occurs on head, thorax, abdomen and also on appendages. Sometimes, they are covered by an oval or elliptical plate forming a ring known as plate organs or sensilla placodea which usually is olfactory in function. They have been observed in the fossil specimen. As *Eciton* species (ants) are essentially blind and utilize their antennae to follow chemical trails, the majority of sensory setae are located ventrally, where they constantly touch the substrate as the insect moves about (Elzinga, 1978). Since the present insect has rudimentary eyes, these may be true in the present case also. All kinds of setae present in the fossil specimen are found in extant (modern) insects. Warts or papillae-like structures are also found both in the extinct and extant insects.

CONCLUSION

The present microscopic apterous, long-horned hemipteran fossil insect is unique in the sense that the earlier reported fossil hemipteran insects do not show the characters found in the studied insect, though both are hemiptera, as they have opisthognathous orientation of head in which ventrally located proboscis (rostrum or beak) lies in between the legs. Here, in this case head is very small, triangular due to lamellar extension; the rudimentary eyes are situated on this extension towards ventral side and are in somewhat hidden condition. All the three simple cuticular segments of thorax (tergite) are long and transversely placed on the body. The broadest metathoracic tergite appears as two elephant ears on both sides, which are fused medially to form a continuous transverse cuticular plate that overlaps a small portion of the abdomen (Pl. I, figs. 1A, 2A; Pl. V, fig. 2). The thorax is larger than the abdomen with lateral lamellate extensions; it is very remarkable in view of its simple structure resembling other groups of insects but not the hemipteran insect pattern. Plate-like simple prothorax is larger than the plate-like mesothorax and smaller than the plate-like metathorax. This is found in the extant insects but not the hemipteron insects where thorax is modified.

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