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Dr. RAMAKRISHNA
Director
Zoological Survey of India

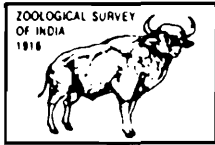
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These specimens will be registered and their data will be computerised. *They are further requested to deposit their type collection positively of ZSI and use the Registration number in their publication of the new taxon.*

Dr. RAMAKRISHNA
Director
Zoological Survey of India



Rec. zool. Surv. India : 107(Part-4) : 1-5, 2007

A NEW SPECIES OF *POROPOEA* FÖRSTER (HYMENOPTERA : TRICHOGRAMMATIDAE) FROM INDIA WITH A KEY TO ORIENTAL SPECIES

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INTRODUCTION

The genus *Poropoea* was described by Förster (1851) with *Poropoea stollwerckii* Förster as the type species from Europe (Germany). Subba Rao (1969) reported the genus for the first time from the Oriental region by describing two new species. Luo and Liao (1994) described one new species and Lin (1994) described two new species from China. In this paper we describe a new species from India. A key to species of the Oriental region is also provided.

The following abbreviations are used in the text : F1-F4 = Funicular segments 1 to 4; OOL = Ocellocular distance; POL = Postocellar distance; STV = Stigmal vein. *Depositories* : IARI = National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, New Delhi. ZDAMU = Department of Zoology, Aligarh Muslim University, Aligarh.

Key to Oriental Species of *POROPOEA* Förster

(Based on females)

1. Ovipositor not exerted beyond apex of gaster; clava 1.77x as long as broad, pedicel a little longer than F1; F2 equal to F1; forewing vein with 6 dorsal setae; marginal fringe 0.54x as long as STV; ovipositor not exerted beyond apex of gaster (China) *P. brevituba* Lin.
- Ovipositor exerted beyond apex of gaster; other characters partly or completely different 2
2. Ovipositor sheath as long as or longer than head and body; discal cilia on upper surface of forewing with only 6 rows; arc shaped row of discal cilia basad of STV absent (Indonesia) ..
..... *P. orientalis* Subba Rao

*Department of Zoology, Aligarh Muslim University, Aligarh-202 002, India

- Ovipositor sheath shorter than head and body; other characters partly or completely different 3
- 3. STV without any row of cilia starting from parastigma; forewing vein with 8 dorsal setae; antennal formula 11232; clava a little less than 3x as long as broad; body dark brown with tibiae and tarsi luteus (China) *P. longicornis* Viggiani
- STV with a row of cilia starting from parastigma; other characters partly or completely different 4
- 4. Forewing with 6 or 7 rows of dorsal cilia on disc 5
- Forewing with more than 7 rows of discal cilia on dorsal side 6
- 5. Ovipositor sheath much longer than dorsal length of gaster; OOL half or shorter than half as long as diameter of hind ocellus; F2 much longer than F1; body mostly black (India)
..... *P. baleena* Narendran & Hayat sp. nov.
- Ovipositor sheath shorter or as long as dorsal length of gaster; OOL as long as diameter of front ocellus; F1 almost equal to F2; body mostly brown (India) *P. indica* Subba Rao
- 6. Ovipositor as long as ovipositor sheath; F1 about 1.3x as long as its width; clava (excluding spicula) a little longer than scape, a little longer than 2.8x its basal width; pedicel about 5x length of F1 (China) *P. tomapoderus* Luo & Liao
- Ovipositor longer than ovipositor sheath; F1 1.7x as long as its width, clava (excluding spicula) subequal to scape; pedicel about 0.9x length of F1 (China) *P. duplicata* Lin.

(The above key is mostly based on published information)

***Poropoea baleena* Narendran & Hayat sp. nov.**

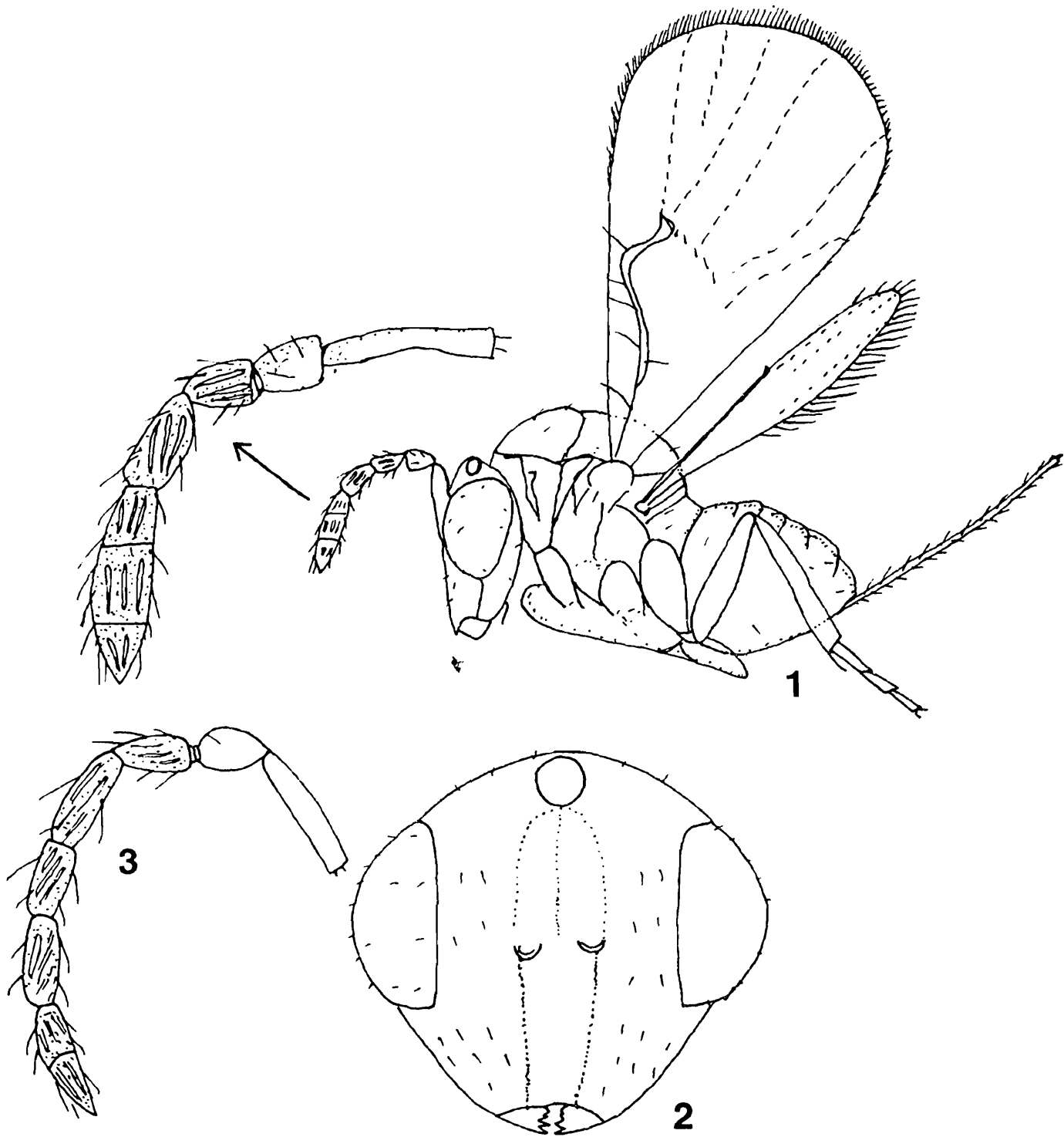
(Figs. 1-3)

Holotype : Female : Length (excluding ovipositor sheath) 0.89 mm. Ovipositor sheath 0.37 mm (Total length 1.26 mm). Head black with slight metallic blue refringence on frons and gena; vertex with a brown cross band; antenna pale brown; eye greyish yellow; ocelli pale brownish yellow. Mesosoma and gaster (excluding ovipositor sheath) deep black with slight bluish tinge; ovipositor sheath dark brown. Legs blackish brown with apices of femora, bases and apices of tibiae and tarsal segments pale yellow or pale whitish yellow; pretarsi brown. Wings hyaline, with veins and pilosity brown.

Head : (Fig. 2) Width in anterior view 1.1x as broad as long; frons with sparse pilosity; scrobe deep reaching front ocellus, margins ecarinate; frontoclypeal area with 2 longitudinal grooves; vertex with cross striations; POL 5.5x diameter of a hind ocellus; OOL half or less than half diameter of hind ocellus; antenna inserted close to each other and in the middle of face. Antennal formula 11223. Relative length : width of antennal segments : scape = 30 : 5; pedicel = 12 : 9;

F1 = 12 : 8; F2 = 19 : 8; clava = 35 : 10. Mandibles with two distal pointed teeth, inner teeth not distinctly visible (probably as in *indica*).

Mesosoma : Well arched in side view (Fig. 1), not laterally compressed. Mesoscutum with 2 pairs of setae; scutellum with 2 pairs of setae, anterior pair far behind middle level of scutellum



Figs. 1-3. : *Poropoea baleena* Narendran & Hayat sp. nov. 1 & 2. Female, 1. Body profile in part, 2. Head in front view; 3. Antenna of male.

and posterior pair at posterior margin of scutellum; scutellum with faint median groove. Forewing 1.9x as long as broad (including marginal fringe); upper side with 6 rows of discal cilia; lower surface with 7 rows of cilia including one arch shaped row basad of STV (in *indica*, Subba Rao (1969)) has shown this arch as on upper surface of wing). The veins with 5 upper and 1 lower setae as in figure 1. Marginal fringe in maximum with 0.085 x maximum width of forewing, closely spaced. Hind wing length (excluding marginal fringe) 6.44x its maximum width, marginal fringe a little less than three-fourths as long as breadth of the wing (5-9).

Gaster. Compressed from sides in dried specimens, shorter than mesosoma in dorsal view (30 : 38) (excluding ovipositor sheath); ovipositor sheath curved upwards at rest, longer than dorsal length of gaster; gaster ventral part extended anteriorly upto basal level of fore coxa (Fig. 1).

Male : Essentially similar to female except for measurements of antennal segments (Fig. 3).

Host : Unknown.

Material examined : Holotype : Female, INDIA, Punjab, PKT [Pathankot] : Dodhpur Kulian, 11.vii.2006, coll. S.M.A. Badruddin & F.R. Khan (IARI). *Paratypes* : 1 Female and 1 Male, INDIA, Uttar Pradesh, Shrawasti, Chakra Bhandar, 3.x.2006, coll. F.R. Khan (ZDAMU).

Remarks : *P. baleena* sp. nov. (females) comes close to *P. indica* Subba Rao (females) in the key to the world species of *Poropoea* by Subba Rao (1969), but differs from *indica* in the following characters :

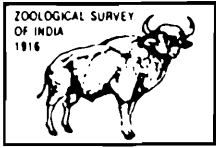
- (1) Ovipositor sheath much longer than dorsal length of gaster in *baleena* (in *indica* ovipositor sheath distinctly shorter than dorsal length of gaster) or at the most as long as.
- (2) OOL half or shorter than half of diameter of hind ocellus (in *indica* OOL as long as diameter of hind ocellus).
- (3) Scape 2.5x as long as pedicel (in *indica* scape about 3x as long as pedicel).
- (4) F2 much longer than F1 (19 : 12) (in *indica* F1 almost equal to F2).
- (5) Body black (in *indica* head mostly brown, concolorous with antenna, sides of mesosoma and gaster brown).
- (6) Male antennal measurements differ in both species.

ACKNOWLEDGEMENTS

The first author acknowledges the University of Calicut for facilities. The second author acknowledges the Aligarh Muslim University, Aligarh for facilities, and the ICAR and Dr. V V Ramamurthy of the Division of Entomology, IARI, the National Coordinator of the Network Project on Insect Biosystematics, for financial assistance.

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Rec. zool. Surv. India : 107(Part-4) : 7-12, 2007

ON A NEW SPECIES OF *DUTA* NIXON (HYMENOPTERA : SCELIONIDAE) FROM INDIA

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INTRODUCTION

Duta is rather a small scelionid genus, with just 12 species reported globally (Johnson, 2006). It was erected by Nixon (1933), with type species as *Holoteleia tenuicornis* Dodd. No significant host data is available, other than a report by Masner (1991) as Gryllids being the hosts of *Duta*. This genus is known from Australian, Nearctic, Palearctic, Afrotropical and Oriental Regions (Johnson, 1992). The four species hitherto known from the Oriental Region are *D. tenuicornis* (Dodd 1920), *D. indica* Mukerjee (1994), *D. xyphona* Kozlov & Le and *D. typhona* Kozlov & Le (Le, 2000). A new species, namely, *D. tuberculata* is described here. With the description of this new species we now have two species of *Duta* known from India. The paratype of *Duta indica* Mukerjee, deposited at the Northern Regional Station, Zoological Survey Of India, Dehradun, was examined for a comparative study.

An identification key to all the five species of *Duta* Nixon of the Oriental Region is provided.

KEY WORDS : *Duta*, Scelionidae, Hymenoptera, India, New species, Key.

ABBREVIATIONS

OOL – Ocellocular length

pm – Post marginal vein

sm – Submarginal vein

OD – Ocellar Diameter

m – Marginal Vein

T1 to T9 – Metasomal tergites 1 to 9

POL – Post Ocellar Diameter

stg – Stigmal Vein

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NEW DESCRIPTION

Duta tuberculata sp. nov.

(Fig I. a, b, c, d)

Holotype : Female : Length = 1.5 mm.

Head blackish brown; eyes and ocelli silvery; mandibles yellowish brown; antennal scape, pedicel, mesosoma and pleura brownish yellow; funicular segments and clava black; legs including coxae, concolorous with mesosoma; scutellum, except at its rim, tegulae and metasoma from posterior three-fourth of T2 onwards brownish black; dorsal prominence of T2 blackish brown; last tarsal segments and claws brownish black. Wings sub hyaline; veins brownish black.

Head : Frons, gena and cheeks evenly reticulate. Eyes sparsely hairy. Minimum distance between inner orbits on frons, lesser than maximum length of orbits (12 : 15). Malar sulcus distinct. Mandibles tridentate. Interantennal process well developed. Head dorsally transverse, with width a little less than twice its length. Lateral ocelli wide apart, separated from lateral orbits by nearly half its diameter. Frons with coriaceous reticulations; OD : OOL : POL = 3 : 13 : 8. Occipital carina distinct. Occiput emarginate; vertex, occiput and ocellar triangle with same reticulate sculpture as frons, but more hairy. Antennal formula : 1.1.4.6. Antenna clothed with fine pilosity; funicular segments and clava contrasting in colour with scape, pedicellus and radicle; scape as long as combined length of next 3.2 segments; pedicellus subequal in length to F2; F1 longest among funicular segments; F4 transverse (F1 : F2 : F3 : F4 = 10 : 8 : 6 : 3); funicular segments nearly subequal in width; clava abrupt, 6 segmented and transverse; medially twice as wide as funicular segments.

Mesosoma : Width including tegulae almost subequal to dorsal width of head. Mesoscutum, scutellum and propodeum, with sparse, long hairs as on vertex. Metanotum bare. Skaphion distinct, smooth and shiny, wide medially. Notauli distinct as two narrow grooves, impressed and diverging in front; distance between notauli at its apical margin, nearly 2x distance between its lower margins. Trans-scutellar sulcus as wide as notauli. Scutellum, with reticulations distinct than that on vertex. Scutellum finely reticulate; anterior and posterior margins bordered by foveae. Metanotum simple, smooth medially, with a convexity medially at lower border, with a row of small foveae bordering anterolateral margins and traces of a pair of lateral carinae; propodeum excavated medially, lateral subtriangular area foveolate-striate. Netrion distinct; mesopleural depression present. Forewings at rest, extending beyond tip of metasoma; forewing with *sm* extending nearly half of wing length; *pm* well developed, more than twice *m*; *pm* : *m* : *stg* = 13 : 5 : 4. Basal and median veins distinct in forewings; *stg* oblique and knobbed.

Metasoma : Excluding extended ovipositor system, metasoma, longer than combined length of dorsal head and mesosoma (50 : 45). T1 to T3 smooth and shiny; T1 1.5x as long as basal width, with a slight but distinct anterior mid dorsal tubercle-like prominence, with 3 long setae on lateral

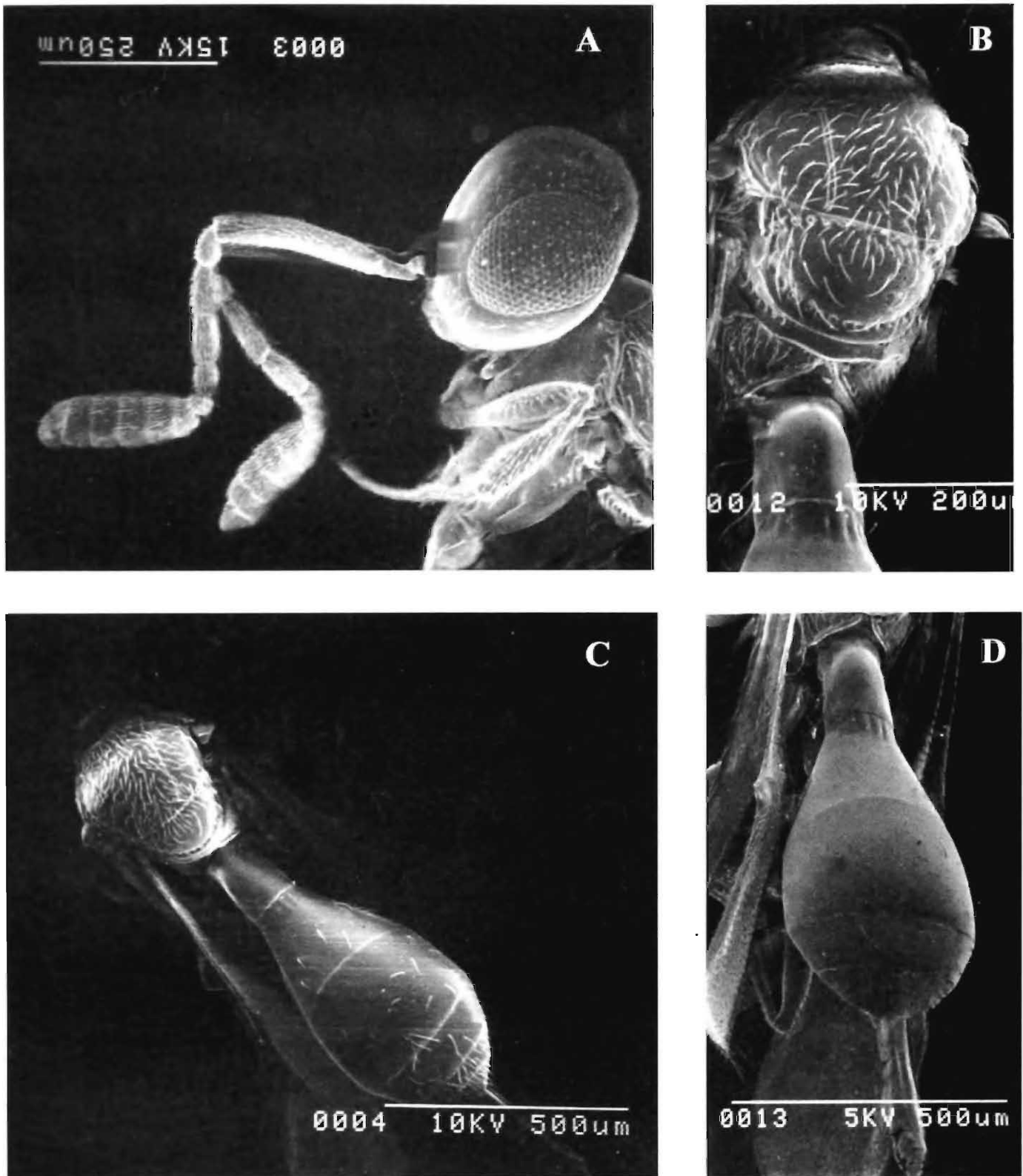


Fig. 1. : SEM of *Duta tuberculata* sp. Nov.

A. Head (profile) with antenna;

B. Mesosoma and T1 with tubercle;

C. Body (dorsal view);

D. Metasoma showing tubercle on T1 and striae on T2.

margin; with one or two short longitudinal striae laterally. T2 to T6 transverse; T2 apically with fine short striae, T3 only 1.2x longer than T2 (22 : 18); T4 and T5 with scattered, where as T5 and T6 with dense setigerous pin punctures.

MATERIAL EXAMINED

Holotype : Female, INDIA : Kerala : Calicut : Tiruvannur (11°13.6' N and 75°47.9' E) 7.x.2005, Mohana, Yellow pan trap (placed among homestead vegetation). *Paratypes* : 15 (4 females and 1 male with same data as that of the holotype; 3 males collected on 27.ix.05, 2 males on 15.xi.05 and 5 males on 4.xii.2005).

(The types are deposited at Zoological Survey of India, Western Ghats Field Research Station, Calicut, Kerala, India)

Etymology :

The species name '*tuberculata*' is derived from the anterior mid dorsal prominence on T1.

Variation :

Hardly any noteworthy variations were observed among females.

Males resemble females in characters, but for those stated here. In general, males are smaller in size (1.2 mm), deeper in colour, almost blackish brown to black, except T1 being yellowish brown. Antennal segments twelve, all of uniform colour, brownish black, except for the lighter distal half of scape; F1, F2 and F3 subequal; F4 to F9 subequal, 0.8x F1, F10 longest, 1.18x F1; ocelli separated by almost their own diameter from the orbits; only two lateral setae present on T1 T1 without a median prominence; T1 and T2 apically with incomplete traces of longitudinal striae.

DISCUSSION

Only one species viz. *D. indica* Mukerjee was hitherto known from India. The most striking distinction between *D. indica* and *D. tuberculata* sp.nov. can be made by a comparison of their metasomal characters. While T1 of *D. tuberculata* is with an anterior mid dorsal prominence and T2 with a very short stretch of a few dorsal apical striae, T1 of *D. indica* is simple, without any dorsal prominence, but with longitudinal striae extending almost fully on both T1 and T2.

While eyes of *D. indica* are densely pubescent, eyes of *D. tuberculata* are only very sparsely pubescent. While in the latter, funicular segments and clava contrast in colour with scape and pedicel, in the former, antennal segments are almost of uniform blackish brown, but for the distal half of scape. The apical divergence of notauli in *D. indica* is much less, compared to that in *D. tuberculata*.

From *D. tenuicornis* (Dodd) too, *D. tuberculata* sp.nov. can be differentiated by the anterior mid dorsal prominence on mid T1 and extent of striae on T1 and T2.

The two Vietnamese species namely *D. xyphona* Kozlov & Le and *D. typhona* Kozlov and Le are distinct from all other Oriental species by the possession of a median keel on frons (Le, 2000).

The following key to species differentiates *D. tuberculata* from all other species known from Oriental Region.

Key to Oriental species of *Duta Nixon*

1. T1 as long as T2; frons with a central keel 2
 - T1 distinctly shorter than T2; frons without a central keel 3
2. Eyes not hairy; *m* as long as *pm* *D. typhona* Kozlov & Le
 - Eyes hairy; *m* shorter than *pm* *D. xyphona* Kozlov & Le
3. In females, T1 without any dorsal prominence, but only with longitudinal striae medially ..
 - In females, T1 with a distinct anterior mid dorsal prominence and also with very feeble impressions of 1 or 2 striae laterally *D. tuberculata* sp. nov.
4. Eyes densely pubescent; T3 twice as long as T2 *D. indica* Mukerjee
 - Eyes sparsely pubescent; T3 only a little longer than T2 *D. tenuicornis* (Dodd)

SUMMARY

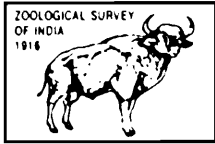
The paper describes a new species of *Duta Nixon*, viz., *D. tuberculata* from India, along with a discussion on its affinities with other species from the Oriental Region. A key to Oriental species of *Duta Nixon* is also provided.

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**A NEW SUBSPECIES OF THE GENUS *GALUMNA* HEYDEN, 1826
(ACARINA : ORIBATIDA : GALUMNIDAE)
FROM UTTARAKHAND, INDIA**

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INTRODUCTION

von Heyden (1826) established the genus *Galumna* with *Notaspis alata* Hermann, 1804 from Germany as the type under the family Galumnidae Jacot, 1925. The super family Galumnoidea Jacot, 1925 is one of the superfamilies under suborder Cryptostigmata of the order Acarina. These mites are commonly known as galumnid mites. The “characteristically-shaped” galumnid mites possess two wing-like “pteromorphae” at both sides of notogaster giving them a conspicuous look. Most of these mites are highly pigmented and heavily sclerotized.

They are inhabiting in all types of soil but predominantly found in soil litter, humus and compost heaps. Galumnids have a worldwide distribution including Antarctica (Subias, 2004).

In India, a total of 13 species of *Galumna* are known till date. Of these, six species have been described from India as new to science (Pearce, 1906; Ewing, 1910; Deb and Raychaudhuri, 1975; Haq and Adolph, 1980). The present report is based on the material collected from Uttarkashi, Uttarakhand during the taxonomic survey of oribatid mites in the area.

The measurements of the specimen have been given in micron (μm). The type-specimen on which the description of new taxa is based, is deposited in the National Zoological Collection, Zoological Survey of India, Kolkata.

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DESCRIPTION OF SUBSPECIES

Galumna (G). crenata uttarkashii ssp. nov.

(Figs. 1-3)

Colour : Reddish brown.

Measurements : Length of the body : 370; width of the body : 296; length of lamellar setae : 7; length of bothridium : 19; distance between lamellar setae : 93; distance between inter-lamellar setae : 63; length of genital plate : 56; length of anal plate : 67; width of genital plate : 63; width of anal plate : 78; distance between aggenital setae : 67.

Prodorsum : Conical in shape with indistinct rostral setae; lamellar setae simple, situated at the tip of lamella and clearly visible; interlamellar setae visible by pits only; both *L* and *S* lines are present; hysterosoma covered with granulated areas having light chitinization; bothridium elongated, sensillus long, spatulated and smooth (Figs. 1, 2).

Dorsosejugal suture incomplete; pteromorph with prominent median ridge, few slits and pit of *ta* present; notogaster with 4 pairs of clearly visible area porosae (Fig. 1); *Aa* largest and elongated but slightly curved in shape, 10 pairs of notogastral setae present; *mp* very small, circular in shape.

In ventral region, a crenate line present across hypostome; 3 pairs of epimeral plates distinct.

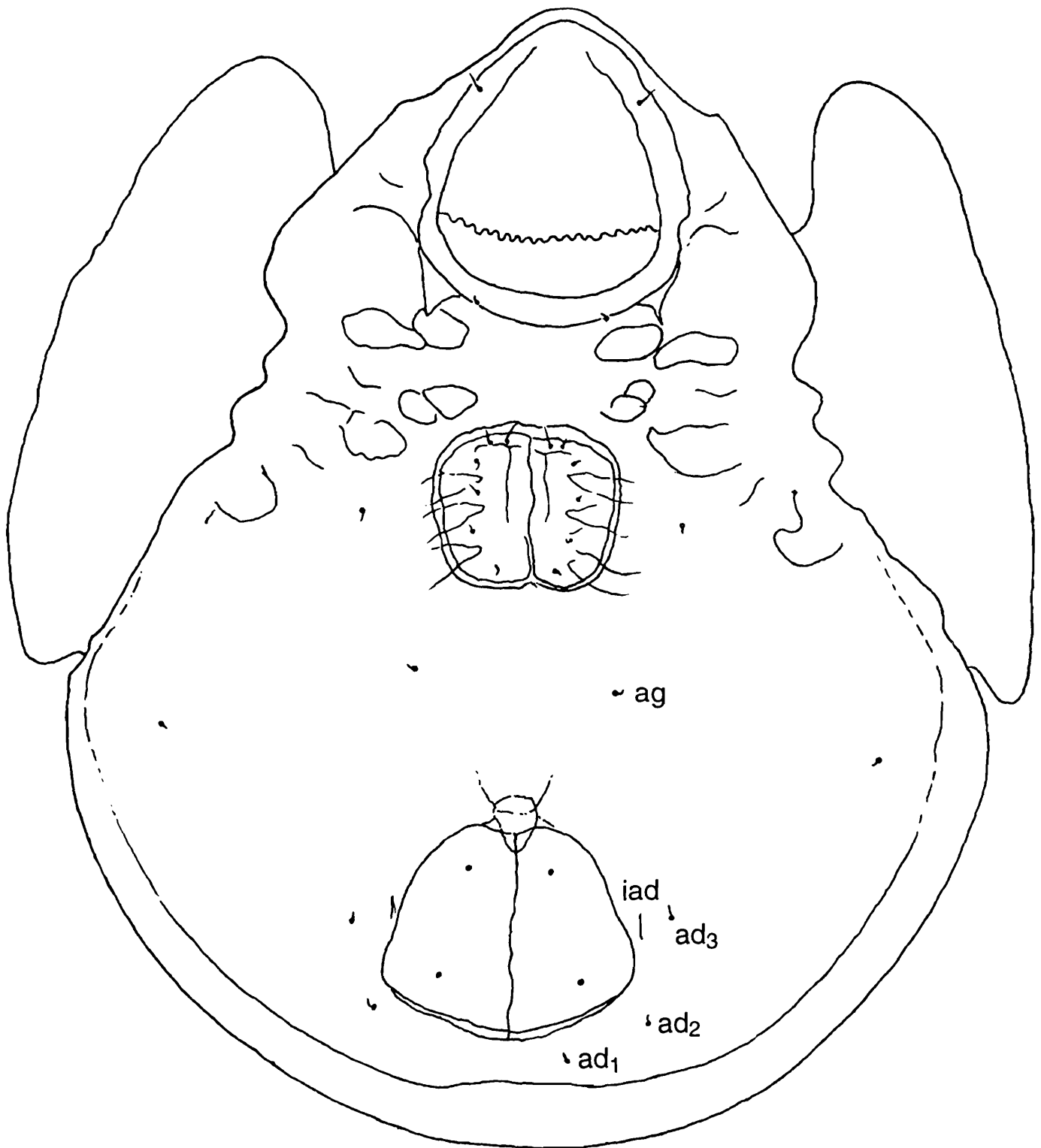
Genital plate with 6 prominent simple setae among them anterior two sets are closely situated (Fig. 3); aggenital setae very prominent, present at equal distance between genital and anal plates.

Material examined : HOLOTYPE : Adult female, India : Uttarakhand, Uttarkashi, Kutali village, on 7.4.2006, from humus under apple tree, coll. B. J. Sarkar & party.

PARATYPE : One adult female, data same as for holotype.

Distribution : Uttarakhand, India.

Remarks : The present specimens come close to *Galumna (G). crenata* Deb and Raychaudhuri, 1975 in general body shape, position of lamellar setae, indistinct rostral setae, position of areae porosae *Aa*, notogastral setae and crenate structure. The new subspecies however, differs from *Galumna (G). crenata* by incomplete dorsosejugal suture, well observed lamellar setae and smooth spatulated sensillus.



3

Fig. 3. : *Galumna (G.) crenata uttarkashii* ssp. nov.
1. Dorsal view; 2. Sensillus; 3. Ventral view

SUMMARY

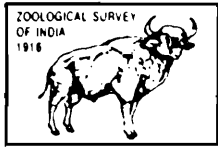
The new subspecies *Galumna (G). crenata uttarkashii* ssp. nov. from Kutali village, Uttarkashi, Uttarakhand, India is described and illustrated along with affinities with *Galumna (G). crenata* Deb and Raychaudhuri, 1975. The new subspecies differs from *crenata* by incomplete dorsosejugal suture, distinctly present lamellar setae and smooth spatulated sensillus.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, Zoological Survey of India, Kolkata for providing laboratory facilities. They also express thanks to the Head of the Department of Zoology, University of Kalyani for providing necessary infrastructural facilities.

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NEW RECORD OF BIRDS FROM KOLKATA METROPOLITAN AREA AND ITS ENVIRONS

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INTRODUCTION

The city of Kolkata is one of the important metropolises of India. Over the years this city has undergone an immense metamorphosis from being an area surrounded by marshes and jungles interspersed by human habitations, to a concrete jungle of the modern Kolkata. In the process it has lost a large part of its natural habitat mainly during the development of the human settlement in the area. Whatever greenery that could be found, within the city limits and its adjoining areas, at present are primarily attributed to the parks, gardens, orchards and roadside plantations.

The natural history of Kolkata and its surroundings have been a point of immense interest among naturalists since eighteenth century. The faunal lives of the region have been reviewed by a number of scientists, from time to time, during the past three centuries. In our present effort, we had undertaken a project to register the diversity of plants and animals that are available to us in the present day conditions. Emphasis was given to specific groups of flora and fauna, such as angiosperms among floral segment and Lepidoptera (butterflies mainly), Aves and Mammals in faunal part. The project was funded by University Grants Commission entitled "Urban Biodiversity Study in and around Calcutta" and the study was conducted between April, 2002 and March, 2005.

During our study we came across some new species of birds, which were recorded for the first time from Kolkata and its surroundings (20 km in the south, 18 km in the south-south-east, 10 km in the east, with Raj Bhaban, Kolkata). In this communication we would like to bring our findings to the notice of birders (the followers of avian biology) as we feel these records are of great

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interest as well as significant ones. These birds were recorded from seven of the seventeen sites we had selected for the project work, such as—Shyamkhola, Chintamani Kar Bird Sanctuary, IIMC, Joka, East Kolkata Wetlands (in part), Banobitan (Salt Lake City), Brace Bridge Wetlands and Tollygunge Club. The birds were identified in the field on the basis of description provided by Ali and Ripley (1986, 1987 & 1997) and Grimmett *et al.* (1999), while the common English and scientific names follow Manakadan and Pittie (2001). A couple of birds mentioned here (No. 9 and 10) were identified before the start of the project which were new records from Kolkata urban area.

Though the birds (no. 1-10) were sighted for the first time by the authors from the Kolkata urban area and the record, provided by them, was incorporated by Sri Kushal Mookherjee in his article—*Birds in and around Kolkata*—in Naturalist III published by Prakriti Samsad, 2004. The article, however, does not include a detailed note on the birds with regard to sighting and other relevant data; hence this note was prepared.

STUDY AREA

1. Shyamkhola (22°25.24' N – 88°23.32' E) :

This area to the west of Narendrapur, and almost adjoining it, in Dakshin Jagatdal, consists of villages with dense orchards, open croplands and ponds of different sizes. It also has recently formed wetlands created owing to removal of soil from croplands for brick fields. There are several old bamboo groves which attract many birds. When the trees are in flower or with fruit, many nectar eating birds and butterflies as well as fruit eating birds and even few mammals congregate, this is unique to this place. The small and medium sized ponds and a few large pools attract water birds. Trees are mostly old ones; palm and coconut trees are old and fairly tall.

2. Chintamani Kar Bird Sanctuary (Narendrapur Wildlife Sanctuary) (22°25.70' N – 88°24.15' E) :

This area in Narendrapur south of Kolkata, still has about 6.88 ha of fruit orchards with densely vegetated undergrowth, with the further ten acre encroached by human habitation. The area has groves of old mango *Mangifera indica* trees interspersed with other fruit bearing trees.

3. IIM-C, Joka (22°36.49' N – 88°23.02' E) :

The area studied is the compound and adjoining area of the Indian Institute of Management, Kolkata. The IIMC campus (54.63 ha area) has many wetlands and densely planted areas with good ground cover but lot of buildings are coming up, decreasing the area of vegetation. Some of the wetlands are leased out for intensive fishery. Still the *Typha* bed that remains helps several

birds and few mammals to take shelter. This unique *Typha* bed does not exist anywhere else in the city where we have conducted our biodiversity study. Behind the IIM, Joka campus, the area is also a marshy land where not only migratory ducks and storks forage and roost, but birds of prey also congregate there for hunting, at least in winter. New buildings which are coming up now, both inside and outside IIMC are interfering with the wild flora and fauna and these are depleting day by day.

4. East Kolkata Wetlands–Part (22°34.00' N – 88°26.09' E) :

The main area of what was the north Salt Lakes at present in the Nalban Bheri to south of and east of Nicco Park (Jhilmil). This bheri, owned by the Fisheries Department of the Government of West Bengal, has an area of 152 ha and, like all other bheries of the area, is a sewage-fed fish farm. The maximum depth of water is c. 1.6 m. The central part is devoid of any emergent vegetation and the fringe has water hyacinth stretches controlled by bamboo barrier. We generally concentrated on Teener Gheri, Charnumber Bheri, Sardar Bheri, Matar Bheri, Chintasingh Bheri and Munsir Bheri.

5. Banobitan (Salt Lake city) (22°35.38' B – 88°25.15' E) :

This is a sprawling park with lots of trees, some open areas, wetlands and manicured garden. Many tall trees are used by birds like Green Pigeon or Large Indian Parakeet or Indian Roller to nest. The garden being well maintained, it attracts a large number of butterflies. The Bottle Brush trees are the feeding ground of the Purple as well as the Purple-rumped Sunbird. The old trees attract Woodpeckers. The lake, although primarily meant for fishing, attract quite a few water birds. The south and the south-eastern part of the lake have water hyacinth. The eastern canal that connects the southern part of the lake has been choked with water hyacinth. To everybody's utter dismay, the southern periphery of the lake is used for washing clothes and for bathing which is likely to disturb the roosting as well as nesting of water birds. The nursery is well tended and location-wise remains undisturbed in the south-western border of the garden. Here the shy Ground Thrush has been seen to nest. Along the western periphery of the garden there is a large unused area where in the evening mammals like jackal are seen regularly. This land belongs to Kolkata Metropolitan Development Area and is now being cleared. This will affect the jackal and other mammals.

6. Brace Bridge Wetlands (22°31.24' N – 88°17.63' E) :

The marsh west of the Brace Bridge railway station is now a very changed environment from what it was twenty years back. The Mudiali Ecological Park or the Nature Park, as it is now known, is under intensive fish culture so most of the water body is devoid of any vegetation, either floating or emergent. There are embankments crisscrossing the whole area, which have dense plantation of trees. There is no shallow water habitats left which the waders used to visit. However,

the trees do attract many arboreal birds, which were not present in such numbers and variety in the past.

7. Tollygunge Club (22°29.44' N – 88°20.37' E) :

The 40.47 ha premises of the club in south Kolkata is an eighteen-hole golf course that has tree lined golfing fairways, groves of interesting trees and the club house. The undulating grassland (at places) is picturesque and *Lantana* bed here attracts many butterflies during flowering season. It has a resident pack of jackals (10-12 are often seen). Besides it harbours some small mammals like civets as well as several interesting bird species.

SYSTEMATIC ACCOUNT

Periodic studies were conducted in these above mentioned localities which have yielded some valuable information regarding the general bird life of these areas. During the course of the study we also came across some species of birds which were recorded for the first time from the city limits of Kolkata and its adjoining localities. They are—

1. *Butastur teesa* (Franklin, 1832)

White-eyed Buzzard

Butastur teesa (Franklin) (family : Accipitridae) is a resident bird, cosmopolitan in distribution, to be found throughout the subcontinent, though less common South of Madhya Pradesh (Ali and Ripley, 1987). As far as West Bengal is concerned, there are sporadic records of this bird from different areas of the State (Majumdar *et al.*, 1992). However, a White Eyed Buzzard had never been identified from the environs of Kolkata before we did it at Shyamkhola on 24 November, 2003. We found it resting on a coconut tree in the areas adjoining to an orchard at Shyamkhola. (A photograph by digital camera – DIGI-LINK Model SSC 350F – is enclosed).

2. *Hieraaetus pennatus* (Gmelin, 1788)

Booted Eagle

Hieraaetus pennatus (Gmelin) (family : Accipitridae) is a smallish eagle, with long wings and long square-ended tail. It has an overall brown coloured head-body in darker morph. The pale morph, however, is whitish in overall appearance. The tail in both morphs greyish on the underside, with darker at the centre and at the edge. The remiges are black with a pale wedge on the inner primaries (Grimmett *et al.*, 1999). In addition, the darker morph has characteristic white shoulder patches, pale median covert pannel and a pale crescent on the upper tail coverts. A bird belonging to this species was recorded, flying overhead, for the first time while conducting field survey at Indian Institute of Management, Joka on 17 January, 2004. This species is a regular winter migrant to India, and is found almost throughout the subcontinent from the Himalayas – c. 2400 m in the

north, through the Gangetic Plains to Deccan and Kanyakumari in the south (Ali and Ripley, 1987). However, booted eagle has not been recorded from the environs of Kolkata, prior to the record made during our study.

3. *Xenus cinereus* (Guldenstadt, 1774)

Terek Sandpiper

Though breeding grounds of *Xenus cinereus* (Guldenstadt) (family : Scolopacidae) extends from Finland to Lake Baikal, it winters in East Africa, Madagascar, Mauritius, Pakistan, Bangladesh, Burma, Malayan Archipelago, Australia and Tasmania (Ali and Ripley, 1987). This species is a common migratory wader to India that affects coastal and tidal areas. *Xenus cinereus* may be sighted occasionally in the inland water bodies at the time of migration to and from their wintering grounds. The Terek Sandpiper is a regular winter visitor to coasts of West Bengal too (Majumdar *et al.*, 1992). However, there were no previous sighting records of this bird from the environs of Kolkata till it was sighted during our field survey, on 29 February, 2004, at East Kolkata Wetlands. (A photograph by digital camera – DIGI-LINK Model SSC 350F – is enclosed).

4. *Calidris ferruginea* (Pontoppidan, 1813)

Curlew Sandpiper

Calidris ferruginea (Pontoppidan) (family : Scolopacidae) is a bird breeding in the Palaeartic Region and winters along the coastal belt of Indian Subcontinent, including that of West Bengal (Ali and Ripley, 1987; Ripley, 1961; Majumdar *et al.*, 1992). This species usually affects sea-shores, lake-shores and adjoining inland mudflats and agricultural fields. *Calidris ferruginea* was recorded for the first time from Kolkata and its adjoining areas on 01 May, 2003 at East Kolkata Wetlands. A second bird was observed from the same locality on 29 February, 2004. (A photograph by digital camera – DIGI-LINK Model SSCF – is enclosed).

5. *Cacomantis passerinus* (Vahl, 1797)

Indian Plaintive Cuckoo

An Indian Plaintive Cuckoo, *Cacomantis passerinus* (family : Cuculidae) is found throughout the subcontinent, affecting well-wooded environs. It has also been recorded from Nepal, Sikkim and Bhutan reaching an altitude *c.* 2700 m in the Himalayas (Ali and Ripley, 1987). There are no records of this bird from Western Rajasthan, Northern Gujarat and the Andaman and Nicobar Islands. Though an India Plaintive Cuckoo may be present in West Bengal, we do not have any document confirming this bird's occurrence. This may be attributed to the fact that the bird being very cryptic during the non-breeding season it is easy to overlook it during other seasons. We recorded this bird for the first time from Banobitan on 23 June, 2003. There are no earlier records of this bird from the environs of this city, and the bird that we had seen may have been a drifter, which probably fits well with their nomadic nature (Ali and Ripley, 1987).

6. *Pitta brachyura* (Linnaeus, 1766)**Indian Pitta**

Pitta brachyura (Linnaeus) (family : Pittidae) is a cosmopolitan bird and can be found almost throughout the subcontinent except the arid regions of Rajasthan (Ali and Ripley, 1987). Occasionally it may reach up to an altitude of 1700 m. Though Majumder *et al.*, (1992) said that this bird had been recorded from Darjeeling and Jalpaiguri districts of West Bengal, we would like to mention that an Indian Pitta is common seasonally throughout the state. The first record of this bird from the environs of Kolkata was made during our project survey at Shyamkhola on 12 May, 2002. This bird had probably halted here on its way during the summer migration.

7. *Phylloscopus occipitalis* (Blyth, 1845)**Western Crowned Warbler**

The breeding range of *Phylloscopus occipitalis* (Blyth) (family : Sylviinae) extends between subtropical dry and tropical forests of Pakistan, India and Nepal. But, this bird winters throughout the Peninsular India, having a preference for the hilly areas (Ripley, 1961). Though, eastern range of this bird may extend up to Bangladesh and Burma (occasionally) through UP, Bihar and West Bengal (Ali and Ripley, 1987; Majumder *et al.*, 1992), *Phylloscopus occipitalis* was never recorded from Kolkata and its surroundings till we observed one bird from of this species, hopping among branches of a Mango tree *Mangifera indica* in search of insects, about 5 to 6 meters from the ground, at Chintamani Kar Bird Sanctuary on 12 February, 2005.

8. *Muscicapa sibirica* Gmelin, 1789**Sooty Flycatcher**

The breeding range of *Muscicapa sibirica* Gmelin (family : Muscicapinae) extends from West Pakistan to Burma, through Safed Koh in NWFP, Chitral, Gilgit, Kashmir, Garhwal, Nepal, South-eastern Tibet, Sikkim, Darjeeling and Assam (Ripley, 1961). This is an altitudinal migrant that, usually shuttles between c. 2100 m–3300 m (timber line) and occasionally coming down to c. 1200 m (Ali and Ripley, 1987); optimum zone being 2400–3000 m (Ali & Ripley, 1996). In eastern India they are known to spend their winter in the Duars region and hilly tracts of Khasi Hills, Shillong and Cachar Hills and Manipur (Ripley, 1961; Ali and Ripley, 1987). Here it can be stated that there were no earlier instances which would suggest that this bird has been recorded from a locality like Kolkata that is situated so far down in the plains. We recorded one *Muscicapa sibirica* at Nature Park, Brace Bridge Wetlands on 25 February, 2004 and in March, 2005.

The bird was perched on a branch of *Caesalpinia pulcherima* Swartz, c. 30 feet from the ground. The bird displayed a curious behaviour as it got air borne to hawk on flying insects. It would leave its perch in search of prey, catch it with a looping flight and return to the branch, almost at the same spot from where it had taken off. This seems to be a characteristic of this

species, as our observations tally with the behaviour depicted by Ali and Ripley, 1987. As far as their migratory nature is concerned, it seems that *Muscicapa sibirica* is, primarily, a species that sticks to the northern and eastern hilly tracts of the country and the adjoining foothill areas. However, occasional stragglers may drift farther from their usual migratory hunts in quest of food and refuge during the winter months, as it seems to have occurred in case of the individual we had recorded at Brace Bridge. (A photograph by digital camera – DIGI-LINK Model SSC 350F – is enclosed).

9. *Tarsiger cyanurus* (Pallas, 1773)

Orange-flanked Bush-Robin

The bird, *T. cyanurus*, (family : Turdinae) inhabits the western Himalaya from Safed Koh, Swat and Gilgit to Garhwal; and is very common in Kashmir. It breeds between 3200 and 4600 m; winters between *c.* 2600 and 1200 m, occasionally down to *c.* 750 m. It affects undergrowth in open forest of oak, pine, fir, birch or rhododendron, and thickets of barberry, *Viburnum* etc. along edges of heavy forest. In winter frequently to be seen on road side wire fences in quiet wooded hill stations. Downward movement noted in September at 1800–2400 m but arrives at lower elevation (*c.* 1200) only in November (Ali and Ripley, 1997).

As a rule it is very shy and secretive. It hunts in shrubbery and low trees as well as on the ground catching insects while hopping about like a robin or by launching sorties in the air after them (Ali and Ripley, 1997). “Very fly-catcher like in its movement” (Stanford). As we were proceeding south along the east wall of Tollygunge Club grounds on the afternoon of 27 November, 1999 a tiny bird flew past and very quickly went into a bush. After scanning with binoculars we saw it was sitting on branch of a bush. After each sally it returned to its perch on the same bush. The bird was brown with pale white eye ring with sides of throat and abdomen grey brown the colour of which become lighter towards the mid-ventral line and the vent remaining brownish. White supercilium and triangular white patch on throat could be seen distinctly. Pale orange flanks could be seen while flying from one place to the other being disturbed by our presence. Leg looked deep brown or blackish. It was identified as Orange-flanked Bush Robin. Kolkata is not included in its area of distribution in the available literature on birds. (A photograph by digital camera – DIGI-LINK Model SSC 350F – is enclosed).

10. *Dicrurus remifer* (Temminck, 1823)

Lesser Racket-tailed Drongo

The distribution range of *Dicrurus remifer* (Temminck, 1823), the Lesser Racket-tailed Drongo (family Dicruridae), starts from the lower Himalayas from Garhwal eastward through Kumaon, Nepal, Sikkim, North Bengal (Darjeeling dist.), Bhutan and NEFA, Assam north and south of Brahmaputra River, Nagaland, Manipur, Mizoram. East Pakistan (hill tracts); from the edge of the

plains, through the foothills up to c. 2000 m. Affects heavy moist-deciduous and evergreen forest (Ali and Ripley, 1986). This bird was never reported from South Bengal. A loud metallic whistle from a very close distance in the Chintamani Kar Bird Sanctuary attracted us on the post-monsoon morning of 12 November, 1997 on our way back at around 10'clock. All of us focussed our binoculars towards the source of the whistle and to our utter surprise we found it to be a lesser racket-tailed drongo. We were thrilled and kept it within the view of our binoculars. It was sitting on a horizontal branch of a very old mango tree on the left side (from the entrance) of the main walk of the sanctuary. It was sitting at a height of around 3.5–4 meter from the ground amid fern fronds growing on the tree. It whistled once more, turned its back towards us and the squaretail was clearly visible confirming its identify. We could see the glossy metallic black drongo with two elongated outer tail-feathers ending in spatula-like rackets and square tail. Initially we could only see the elongated tail-feathers and not the square tail. The conspicuous backward-curving tuft or crest on forehead was missing in this bird eliminating the possibility of its being a Greater Racket-tailed Drongo. This lone *Dicrurus remifer* was subsequently spotted by our fellow birders three-four times from the same sanctuary in that particular season.

SUMMARY

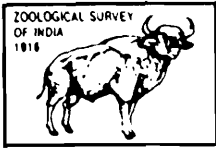
The bird diversity study within Kolkata Metropolitan area has generated a comprehensive baseline data, which may help future assessment of biodiversity and any impact on the habitat of the urban Kolkata. The avifauna of Kolkata included 292 species up to 1992 (ZSI records). Compared to this we recorded fewer number of birds (2002-2005). The present study revealed at least 10 new records of birds from the Kolkata Metropolitan area. The habitat which is generally free of anthropomorphic disturbances was found to harbour the species that were new to Kolkata Metropolitan area. Some of them are not only new to Kolkata but also to south Bengal. However, drastic change in land use pattern associated with urbanization of Kolkata or of such areas may result in significant impact on the bird life of the area.

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DESCRIPTION OF A NEW SPECIES OF *BRACHYDANIO* WEBER AND DE BEAUFORT, 1916 (PISCES : CYPRINIFORMES : CYPRINIDAE) FROM MEGHALAYA, NORTH EAST INDIA WITH A NOTE ON COMPARATIVE STUDIES OF OTHER KNOWN SPECIES

NIBEDITA SEN

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INTRODUCTION

While studying some fishes collected from Jaintia Hills district, Meghalaya during June, 2005, the author came across a good number of *Brachydanio* specimens which on examination proved to be new to science. Seven species, namely *B. acuticephala* (Hora), *B. albolineatus* (Blyth), *B. choprai* (Hora), *B. nigrogasciatus* (Day), *B. rerio* (Hamilton-Buchanan), *B. shanensis* (Hora) and *B. sondhii* (Hora and Mukherjee) have so far been reported from India and adjacent countries namely Myanmar, Bangladesh, Nepal and Pakistan (Jayaram 1999), Talwar and Jhingran 1991). Out of these *B. acuticephala* is having its restricted distribution in North East India and *B. rerio* throughout India, Bangladesh Nepal and Pakistan. The rests are from Myanmar region.

Though the present specimens shares some similarity with *B. acuticephala* and *B. rerio* but the differences reveals it's separate identity. Comparative charts of different species of Indian region have also been incorporated.

MATERIAL EXAMINED

21 examples (28-46 mm TL)

Holotype : 1 ex., (42 mm TL), locality : The Rangriang Jowai, Jaintia Hills district, Meghalaya, Coll. J. Lyngdoh and party, 17.06.2005 (Long. 92°11'8.7" Lat. 25°26'11.9"; alt. 1234 mts.), Reg. No. V/A/ERS/1933.

Paratype : 15 exs., (32-46 mm TL), locality : Tre Rangriang, Jowai, Jaintia Hills district, Meghalaya, Coll. J. Lyngdoh and party, 17.06.2005 (alt. 1234 mts.), Reg. No. V/A/ERS/1934.

Paratype : 5 exs., (28-31 mm TL), locality : Thlu Muwi, Amlarem road, Jaintia Hills district, Meghalaya, Coll. J. Lyngdoh and party, 17.06.2005 (Long. 92°08'37.55" Lat. 25°20'48.6" alt. 1248 mts.), Reg. No. V/A/ERS/1935.

***Brachydanio jaintianensis* sp. nov.**

(Plate I, A)

D.ii.7, P.i.9-10, V.i.6, A.ii-iii.9-10, C.18-19.

Description : Body elongate, laterally compressed its depth 3.8-4.2, head length 3.6-4.0 both in standard length; snout length 3.2-3.9, eye diameter 3.2-3.9 both in head length. Mouth oblique, barbels two pairs, well developed; rostral barbels extends to middle of eye, sometimes end of eye (in bigger specimens), maxillary barbels extends generally upto preopercle, occasionally upto opercle. Caudal fin deeply emarginated; lateral line absent; scales along normal course of lateral line 31-32; predorsal scales 16-17.

Colouration : Back grey in colour, belly creamish white. Laterally two dark bands; one broader band from behind opercle to base of caudal fin; another thin band above it. Dorsal, anal or caudal fins are without any band.

Affinities : In fin formula and colouration it is closer to *B. acuticephala* but differs in presence of two pairs of well developed barbels (absent in *acuticephala*).

The present specimens differs from *B. rerio* in colouration; branched anal fin rays (10-13 in *rerio* var. 9-10), caudal finrays (16 in *rerio* var. 18-19); lateral line scales (26-30 in *rerio* var. 31-32) and length of barbels (Plate I B, Plate II A, B).

Etymology : The species has been named *B. jaintianensis* after the district from where the collections were made.

Remarks : Barman (1991) and Menon (1999) kept both the species *acuticephala* and *rerio* under the genus *Danio*. As per current online information the species *acuticephala* is under the genus *Devario* and the species *rerio* is under the genus *Danio*. Until further studies of both the genera *Devario* and *Danio*, the present new species is kept under the genus *Brachydanio*.

ACKNOWLEDGEMENTS

The author is grateful to Director, Zoological Survey of India, Kolkata for permission to publish the same. Thanks are due to Miss J. Lyngdon and party for their collection and Barry Mathew for taking photographs.

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COMPARATIVE CHARTS FOR DIFFERENT *BRACHYDANIO* SPP FROM INDIAN REGION

		<i>B. acuticephala</i>	<i>B. rerio</i>	<i>Brachydanio</i> n. sp.	<i>B. choprai</i>	<i>B. nigrofasciatus</i>	<i>B. albolineatus</i>	<i>B. shanensis</i>	<i>B. sondhi</i>
1.	Barbels	Absent	Present : well developed 2 pairs; rostral considerably longer than eye diameter; maxillary extends beyond half of pectoral fin. In N.E. specimen length sometimes smaller.	Present . well developed 2 pairs; rostral extends to middle of eye; sometimes end of eye; maxillary generally upto preopercle, occasionally upto opercle.	Present : well developed 2 pairs; rostrals about equal to eye diameter; maxillary upto preopercular region.	Present 1 pair of maxillary only.	Present · well developed 2 pairs; rostral longer than eye diameter; maxillary extends considerably beyond base of pectoral.	Generally absent; if present short maxillary pair only.	Absent
2.	Lateral lines	Absent	Usually absent, if present incomplete or rudimentary; often extends upto base of pelvic fins.	Absent	Absent rarely present on anterior few scales	Absent	Incomplete, extending upto base of pelvic fins	Incomplete, usually end near or slightly beyond anal fin.	Incomplete, piercing only anterior 7-8 scales
3.	Lateral line scales	30-32	26-30	31-32	32-33	28-32	30-32	33-34	32-34
4.	Fin formula	D.ii.6-7, A.ii.9-10, P.i.10-11, V.i.6	D.ii.6-7, A.ii-iii.10-13, P.i.9-12, V.i.6	D.ii.7, A.ii-iii.9-10, P.i.9-10, V.i.6	D.ii.6-7, A.iii.12-13, P.i.11-12, V.i.6	D.ii.7, A.ii.11, P.i.14, V.i.6	D.ii.7, A.iii.13-14, P.i.11-12, V.i.6	D.ii.7, A.ii-iii.11-15, P.i.11-12, V.i.6	D.ii.7, A.ii.10-11, P.i.11-12, V.i.6
5.	Body depth	3.2-4.0 in SL	3.4-4.2 in SL	3.8-4.2 in SL	3.2-3.5 in SL	3.0 in SL	3.7-4.2 in SL	3.3-3.7 in SL	3.5-4.0 in SL
6.	Head length	3.7-4.0 in SL	3.8-4.5 in SL	3.6-4.0 in SL	3.5-3.8 in SL	4.6 in SL	4.0-4.3 in SL	3.6-4.1 in SL	3.7-4.2 in SL
7.	Snout length	3.7-4.5 in HL	3.0-4.7 in HL	3.2-3.9 in HL	5.0-6.0 in HL	6.0 in HL	4.7-6.0 in HL	4.5-5.5 in HL	3.2-4.5 in HL
8.	Eye diameter	3.0-3.5 in HL	3.0-3.5 in HL	3.2-3.9 in HL	2.5-3.0 in HL	5.0 in HL	2.8-3.0 in HL	3.0-3.7 in HL	2.7-3.6 in HL
9.	Predorsal scales	16-17	15-16	16-17	14-15	12	16-17	15-16	14-15

(Cont'd.).

		<i>B. acuticephala</i>	<i>B. rerio</i>	<i>Brachydanio</i> n. sp.	<i>B. choprai</i>	<i>B. nigrofasciatus</i>	<i>B. albolineatus</i>	<i>B. shanensis</i>	<i>B. sondhi</i>
10.	Caudal fin shape	Deeply emarginate	Forked	Deeply emarginate	Emarginate	Lunate	Emarginate	Forked	Emarginate
11.	Colouration	Brownish with a longitudinal broad band along side; a black narrow streak along dorsal surface extending from head to caudal fin base.	Back silvery grey; belly yellowish white; flanks shining prussian blue; 4 well defined beautiful shining gold stripes from head to end of caudal fin. Blue stripes on anal and dorsal fins also.	Back darker; belly whitish; laterally 2 bands; 1 broader band from behind opercle to base of caudal fin; another thin streak above it. No bands on anal and dorsal fins.	Olivaceous with several dark, broad, vertical bars in anterior half which gradually reduces to mere rows of dots at the posterior half; 2 indistinct longitudinal bands in upper half of body & a black streak along the back. Dorsal & anal fins with longitudinal bands. Caudal fin with a longitudinal band on each lobe.	Nape & back olive brown; belly orange to yellowish white; a golden to brownish longitudinal stripe on flanks from behind head & tapers to a point at the end of caudal fin; bordered above & below by a blue black band; beneath the lower dark band a series of bluish dots run for much of its length extending on to anal fin. Ventral fins yellowish brown to yellowish	Dark brown, lighter on flanks and belly; 2 distinctive scarlet longitudinal bands from base of caudal fin to a point under or before dorsal fin.	Silvery with occasionally a metallic patch on gill-cover; a dark broad lateral longitudinal band narrows posteriorly; with growth, anterior half of band breaks up into 5-10 dark green iridescent crossbars with lighter interspace, ultimately narrow posterior half of the lateral band only persists.	Back dark greenish, flanks silvery with an iridescent lateral band which is almost indistinguishable in anterior part of body; a dark prominent spot near upper angle of gill-opening; edges of scales on back with small dark spots; fins without colour markings.

PLATE I



A. Lateral view of *Brachydanio jaintianensis* sp. Nov.



A



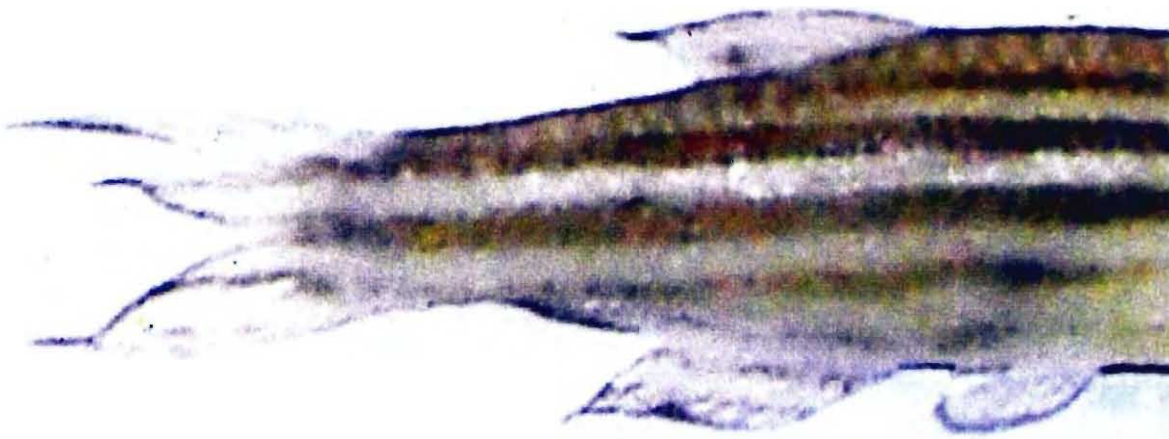
B

Lateral view of A) *B. Jaintianensis*, B) *B. rerio*

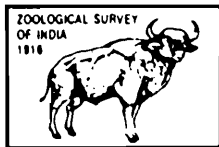
PLATE II



A. Bands in *Brachydanio jaintianensis* n. Sp.



B. Bands in *Brachydanio rerio* (Hamilton)



Rec. zool. Surv. India : 107(Part-4) : 33-42, 2007

REPRODUCTIVE BEHAVIOUR OF THE ASSAMESE MACAQUE (*MACACA ASSAMENSIS*) IN DARJEELING DISTRICT, INDIA

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INTRODUCTION

Population growth and survival of any species are closely related with its reproductive abilities. Like many other primates, the Assamese macaques (*M. assamensis*) form bisexual, multimale groups of varying sizes where adult males are always larger than the adult females. They are found in India, Nepal, Bhutan, Bangladesh, Myanmar, China, Thailand, Vietnam, Cambodia and Laos. In India this species is confined to Uttaranchal, Sikkim, West Bengal, Assam, Arunachal Pradesh, Mizoram and Meghalaya. The present study was carried out on *Macaca assamensis pelops*, one of the two subspecies of Assamese macaque occurring in India (West Bengal, Sikkim and as far east at the great bend of the Brahmaputra river flowing through Assam and Arunachal Pradesh), Bhutan and Nepal. This subspecies prefers broad-leaved evergreen forests of high altitudes, whereas the *M. assamensis assamensis* occurring in China, North and East Myanmar, North East India, Northern Laos, Northwest Thailand and North Vietnam (Jones *et al.*, 2004) prefers to inhabit plain lands. There are several studies on the reproductive behaviour of rhesus (*Macaca mulatta*) and bonnet (*Macaca radiata*) macaques (Lindburg, 1971; Drickamer, 1974; Simonds, 1965; Rahaman & Parthasarathy, 1969) but no such record exists for the Assamese macaque from India.

In *M. radiata* copulation occurs all around the year with a peak during September to November and births recorded from March to July (Simonds, 1965). Fooden (1971) found the peak birth season of Assamese macaque from April to June in Thailand. Prakash (1958) claimed that

KEY WORDS : *Assamese macaque, reproduction, consort, mating, copulation, Darjeeling.*

M. mulatta from Rajasthan had two distinct breeding seasons in a year. Southwick, Beg and Siddiqi (1961) found the greatest frequency of sexual behaviour occurring from October to December in *M. mulatta*. In Lindburg's (1971) view, mating in *M. mulatta* begins in September, reaching its peak during November to first half of December. He also recorded a mating season from early July to end of January in Uttar Pradesh, India. Bernstein and Cooper (1998) also contributed their observations on some of the behavioural peculiarities like male and female taking male ejaculate and vaginal plug formation by male semen in reproduction of *M. assamensis*. The present study is based on the reproductive behaviour of free ranging Assamese macaques from the Darjeeling district of West Bengal, India. The study also helped in comparing the seasonality of mating and birth in other macaque species with that of *M. assamensis*. The results indicated a distinct breeding season from September to February with a peak from October to December. Majority of the births were recorded between March and June which was in confirmation with the findings of Fooden (1971) in Thailand.

STUDY AREA

Natural populations of the Assamese macaque occur in the submontane areas of Darjeeling district in West Bengal. This area consists of the lower Himalayan mountain ridges and foothills with deep gorges and steep slopes covering a geographical area of nearly 3149 sq. km. The district lies between 26°31'–27°13' N latitude and 87°59'–88°53' E longitude. The study was conducted on 13 free ranging groups in different parts of the district ranging from an altitude of 180–2270 m. The rivers and their tributaries are shallow and become turbulent during monsoon. Climatic conditions are variable from humid subtropical to temperate depending on the elevation. Summer lasts from April to mid June followed by the monsoon that extends till September. Maximum temperatures range between 18.5° and 37°C depending on the elevation, while the minimum is between 0° and 8.5°C. Humidity is very high and thick clouds with moisture prevail through the greater part of the year. Annual rainfall varies between 250 and 320 cm.

Survival of this species is threatened due to habitat loss and the increase in human-animal conflicts. Several mortality factors like trapping, landslides, road kills and intentional poisoning have been identified in the study area. A total of 27 groups have been recorded from this area, of which 13 were monitored for 3 successive years. Mean group size was 19.48 ± 2.28 . Of the two focal groups studied, Group A with 17 monkeys was located near Rambhi on the bank of river Teesta at an elevation of 231 m. The other Group (B) with 23 monkeys inhabited an open valley land with steep slopes, 6 km away from Kurseong town at a height of 1370 m. Group B inhabits a site close to human habitation and frequently comes to the road that leads to Kurseong town and is highly vulnerable to human-monkey conflicts.

Overall flora in this zone represents Himalayan subtropical wet hill forest the composition changing with altitude and climatic conditions.

METHODS

Data for this study was obtained from observations on diurnal activities on two focal and 11 other free ranging groups for three successive years (1997-1999). The natural cycle of 3 seasons (summer, monsoon and winter) was considered to describe the activity pattern throughout the year. All analysis and interpretations were based on diurnal observations undertaken from 0500 hrs in the morning till 1700 hrs, which was around the time of sunset. Scans were repeated at every 15 minute intervals on all the members of a group hence one-hour recording involved 4 scan results. The number of records per activity in each scan was expressed as the percentage of total number of records made in each scan (Clutton-Brock, 1974) This was followed to treat the collected data in each scan equally. Biases due to visibility differences, distribution of scans, variable daylight etc could not be avoided. However, for each attribute the mean number of records was considered and variations were confined to a very small portion of all the records to remove the influence on the overall activity budget.

All of the 10 categories of behaviour recorded were estimated on the basis of relative distribution of their percentages. Each activity record was analysed by summation of all records of all categories and expressing them as percentage of the total number of records collected per day by scan sampling method.

$$Ac = (A_i / A) \times 100$$

where Ac = Percentage of activity (any one of the ten selected activities) recorded.

A_i = total scan records of that activity in a day

A = total scan records of all activities observed in a day.

During the study period a total of 14180 scan records of all activities were analysed. Group A averaged 82.32 scans daily and Group B 74.35. Distinct seasonal variations were noticed in few of the selected 10 categories of activities. Observation hours per day were 11 and mean contact hours ranged between 6.01 and 9.1. Average observation days for each season in a year were 12.

Only the data on mating frequencies are presented here. However reproduction also involves many other associated incidents, which were collectively termed as reproductive behaviour. A combination of group scan and ad-libitum sampling (Altmann, 1974) was used during field observation. The significance of the variations in percentage of scanned activities in different seasons, zones and time period of the day were examined from the results by Three way-ANOVA at 5% level. Chi-square (X^2) test was also applied to estimate the significance wherever required. Quantitative analysis by ANOVA and Chi-square methods were applied to scan sampling data and not to Ad libitum sampling, which came mostly from informal observations. Almost 72% of the data were from scan sampling. Age-sex composition was decided following the description of Southwick, *et al.*, (1961).

RESULTS

Observations were made for 1650 hours involving 1081 contact hours and 14180 scan records, of which mating incidents and other reproductive activities involved a total of 128 scan records. Seasonal variations were recorded in the proportion of different activities in 10 categories (*e.g.*, resting; grooming; feeding; locomotion, play, agonistic interaction, reproductive activities, vocalisation, sleep and drinking,) for daily observation. Daily activity used to start between 0530–0550 hrs in Group A, as recorded in the maximum number of scans. Group B began their day during 0540–0600 hrs slightly later than Group A.

The sagging of the testis and redness in the sexual skin easily identified adult males participating in copulatory acts. Adult females also have the prominent reddish swelling or bulbous outgrowth in the perineal region. This perineal swelling or sexual skin change was observed in the breeding season. From the observations it was noticed that sexual maturity was attained at about 4 years in females and nearly 4.5–5 years in males.

Juveniles were not dependent on their mothers, and neither do the mothers nurse them. Their scrotum and teats were not very prominent but visible externally. Infants were much smaller in size and nursed by the mothers. Average sex ratio of adult male to adult female was 0.48 ± 0.08 in group A and 0.34 ± 0.06 in group B.

Table 1. : Age sex composition of Group A.

Category	1996	1997	1998	1999	Mean
AM	3	3	3	3	3.00
AF	6	5	7	8	6.50
JJ	4	5	2	6	4.25
II	4	3	5	4	4.00
Total	17	16	17	21	17.75

Table 2. : Age sex composition of Group B.

Category	1996	1997	1998	1999	Mean
AM	3	3	2	2	2.50
AF	8	7	7	7	7.25
JJ	9	5	4	2	5.00
II	3	4	0	6	3.25
Total	23	19	13	17	18.00

[AM = adult male; AF = adult female; JJ = juvenile; II = infant]

Breeding Season

The mating season was usually observed to be from post monsoon (September) to late winter (February) and in rare instances extended till May-June. The peak breeding season was noticed between October and December (Fig. 1). Maximum mating records (95.6%) were obtained during this period which was much lower during January and February (3.1%) recording a minimum in May-June. These observations were consistent with the findings of Southwick, Beg and Siddqi (1961) in *Macaca mulatta* where the highest frequency of sexual behaviour also occurred during October-December. Prakash (1958) however claimed that Rhesus breeds twice in Rajasthan, India. Observation during monsoon yielded negligible results on this aspect.

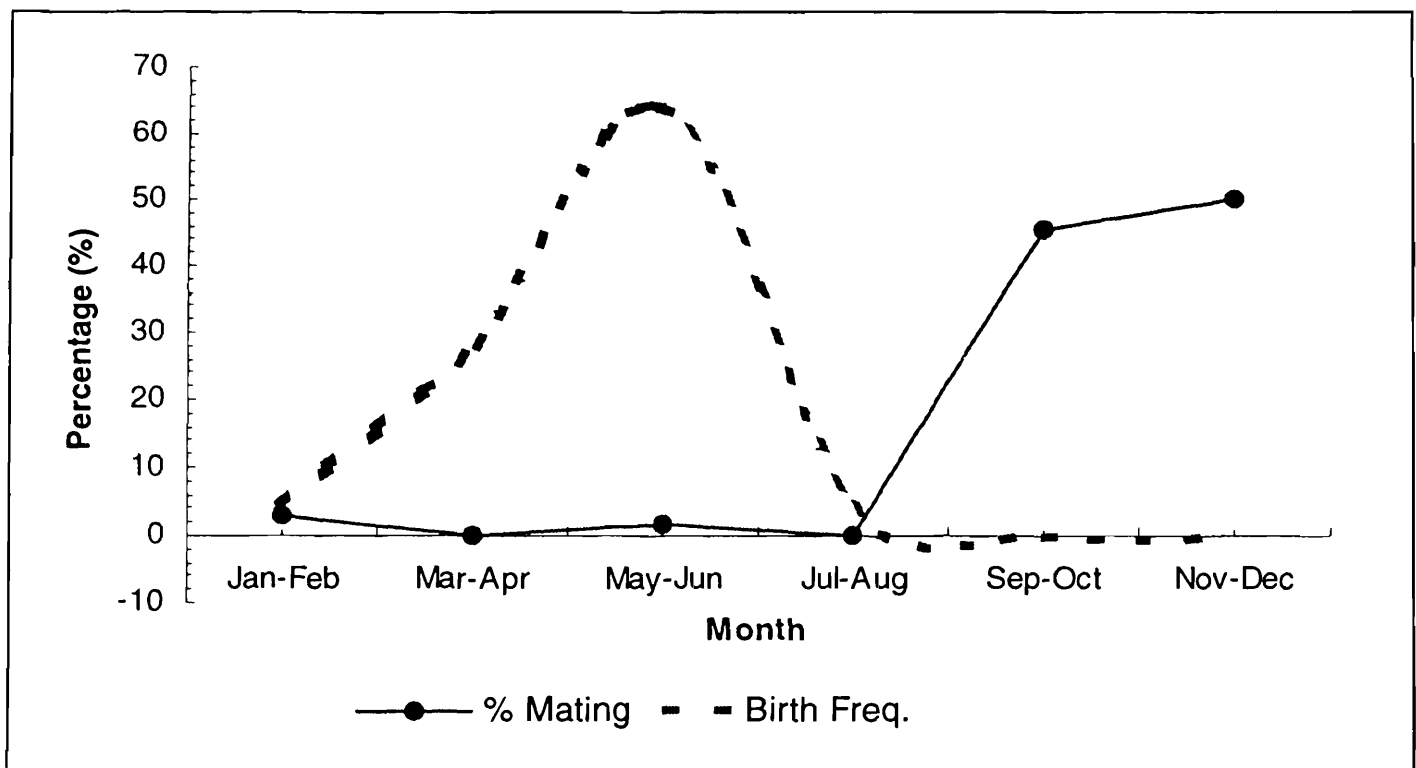


Fig. 1. : Relationship between mating pattern and birth.

Birth season

Most of the births were recorded between May and June, but newborns were seen during the period from March to June every year. Though very low in percentage, instances of birth were also noticed in July-August suggesting a bimodal curve in the birth season. Data obtained in this study was insufficient to confirm the possibility of two birth seasons in the Assamese macaque. One case of twin birth was also recorded in 1999 with both infants surviving. Total recorded births in group A and B were 10 and 12 respectively during the study period. Cases of mortality were observed in almost all the groups. Human-monkey interaction was greater in Group B where 7 deaths were recorded of which 6 were accidental. Group A had 4 deaths in which one was by predation of a dog.

The reproductive rate was determined from the ratio of newborn infants to mature females. It varied between 37.5% (lowest) and 85.7% (highest) for the two study groups. However, Group A had comparatively a stable rate varying between 50% and 71%. The average reproductive rate for all the groups (N=13) was around 53.1%. Viability of the offsprings effected this ratio much more in Group B due to its proximity to human habitation and resultant conflicts. Reproductive rate in Group B was highest (85.71%) in 1999 though it varied only from 37.5% to 57.14% during the entire study period.

Correlation between the timing of birth season, mating and various environmental factors were also examined. Breeding occurred during a period of decreasing day length and birth took place when day length increased gradually. Low temperature, moisture, rainfall and moderate fruiting in the trees were characteristics of the breeding season. Significant variation was noticed in the seasonal distribution of mating events in the focal groups ($\chi^2 = 34.9$, $P < 0.05$) as they are concentrated during winter season between Sept-October and Jan-Feb. However differences between the two focal groups in different seasons and time periods of the day were statistically insignificant ($F = 0.87$, $P < 0.05$). Both the groups revealed a similar pattern of seasonality in copulation and birth irrespective of their differences in habitat utilisation and interaction with humans.

COPULATION

The entire process of copulation is spread over three main phases of activity *viz.* (1) precopulatory, (2) copulatory and (3) postcopulatory. Of a total of 157 mating events from the focal groups, 128 were recorded from direct scan results and the remaining 29 were from other scans.

The precopulatory period included consorting, soliciting and the associated activities. Adult males were seen to mate with several females and consorting was often noticed during the breeding season, which lasted for even up to 36–40 hours at a stretch. The dominant male usually shows more consistency in maintaining the consort pair. In one focal group, a female was seen mating with more than one male within 5–6 hours of duration. But majority of the associations lasted from a few minutes to a few hours. Instances were there when the female of a consort pair was noticed pulling the tail of its male partner, which in turn examined the genitalia of this female and mating took place eventually. Sometimes these acts started with solicitation by the female moving around a male with her raised tail and the male licking her vaginal exudate. Males in all the study groups usually emitted a pre-copulatory sound or call like *kharrrr....* in a low and intense tone at the onset of mating (in 73% of total mating records) or even during the process. This sound was clearly audible from a distance of 10–15 yards and easily distinguishable from other vocalisations.

Copulation : Almost 79.7% of the total mating events recorded occurred during 0600–1000 hours. The interval between two subsequent mating in the same pair was observed to be at least

5–7 minutes and in rare instances after 18–20 minutes. In this macaque species males are generally single mount ejaculators. On an average 1.6 matings occurred everyday in each group. However, during the breeding season Group A recorded 2.5 matings/day and Group B 4.1 matings/day. Females were often seen grimacing at her partner. The other members of the group had the tendency to interrupt or chase the pair engaged in mating. Aggression towards a mating pair occurred in nearly 73 mating events. Most of the time adult males were targeted. A maximum of 11 mounts were observed among different partners of a group in a single day during a breeding season. Male to male mounting, juvenile male mounting adult female and infants mounting juveniles were considered as play behaviour. The mating partners utilised ground surface, tree branches, rocks and hilltops as their mating places but the maximum time they mated near the ground (49.6%) and much less on the tree branches (10.2%).

The most common Post-copulatory behaviour was a subsequent grooming between two partners. Often the female groomed the male (63%). Males were seen examining the flow of ejaculate and even tasting it while females also inspected their genitalia. There were several agonistic interactions between adult males of a group after mating. The female partner was often chased and harassed by the other male members. Among the total aggressive interactions in the study group 31.4% was associated with sexual behaviour. Among them, adult and sub-adult males were involved in 67% incidents. There were frequent intra-group clashes.

Inter specific breeding

In the present study incidents of penetration by *Macaca mulatta* individuals in the group of Assamese macaque living in the transitional zone were recorded. Hence chances of interbreeding could not be ruled out. Some earlier field evidences (Bernstein, 1968) of occasional entry by extraspecifics have been recorded and hybrids within the genus *Macaca* were also observed in captivity. Home ranges of *M. mulatta* and *M. assamensis* overlap near the foothills where troops of both the species have chances to interbreed, but is yet to be confirmed.

DISCUSSION

The major part of this work was based on two focal groups located in two different locations, one inside the forest and the other close to the human settlement. The study revealed that mating attempts and antagonistic reactions were much higher in the group near human habitation. No substantial growth in the troop size because of the anthropogenic pressures of various forms was also observed. This study established that *M. assamensis* has a close similarity with the breeding seasons of *M. mulatta*. Viability of infants was so variable that it effected the reproductive rate of Group B. It has also been observed that forest groups are more stable and less aggressive than the groups living in close proximity to human beings.

Much of the sexual behaviour displayed by *M. assamensis* was similar to that in *M. mulatta* and *M. radiata*. Some workers found uninterrupted breeding cycle in *M. radiata* throughout the year (Sugiyama, 1971; Parthasarathy, 1972) whereas *M. assamensis* has a definite breeding season. However, the peak breeding period is identical in both the species. Malik (1992) found mating in rhesus monkey restricted between October and February. *M. assamensis* resembles many other species of this genus with respect to the reproductive season.

Bernstein (1980) reported mounting at the rate of 0.3/hour in *M. arctoides* which was slightly higher (0.2–1/hour) as seen in in this study. Lindburg (1971) recorded antagonism related with sexual behaviour comprising about 22% of the total agonistic interactions, while this study showed a higher aggression (31%). Aggressiveness and mounting frequencies were higher in the group having direct interaction with humans.

Imanishi (1960) reported the association of reddening in face and genital regions with the mating period in both male and females of Japanese macaque (*M. fuscata*). This was clearly observed in the females from the study area, and it was associated mostly with lactating females. Bernstein and Cooper (1998) commented on the activities like females taking male exudate as an unsuitable occurrence for any biological explanation. They did not find the grooming of male just after or before the mating to have any direct relation with the copulatory act, because males use coercive mating tactics in general (Cooper & Bernstein, 2000). But this opinion is not fully consistent with the findings of present study. Allogrooming was observed between the partners in around 70% of the mating events.

Possibility of interbreeding with other rhesus monkeys needs to be studied extensively. This population occupies the western most limit of Assamese macaque's range in India. Further study on both the subspecies of Assamese macaque is necessary considering its fragmented population and data deficiency in various aspects.

SUMMARY

The present study is based on the observations made on the seasonality of breeding and birth; sexual maturity; copulatory process and related activities in the Assamese macaque (*Macaca assamensis*) in Darjeeling. The intensive study was conducted for three years on two free ranging groups inhabiting different locations. The main objective was to identify the reproductive strategies in the wild, which could help in designing a future management plan for the population and help in the conservation of this species.

Groups found near human settlements had higher mating frequencies and antagonistic interactions between the members, but vulnerability of the immature individuals prevented any substantial increase in population during the study period.

ACKNOWLEDGEMENTS

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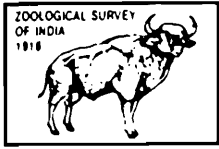
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PLATE I



Fig. 1. : Mating in *Macaca assamensis*.



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DIVERSITY AND DISTRIBUTION OF SOIL ARTHROPOD COMMUNITIES IN RELATION TO ALTITUDE AND EDAPHIC FACTORS OF DIFFERENT ALTITUDINAL ENVIRONMENTS OF DARJEELING HIMALAYAS, INDIA

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INTRODUCTION

The soil microarthropods in general and Collembola and Acari in particular play an important role in the decomposition of leaf litter to organic matter and its nutrient cycling (Scastedt and Crossley, 1981; Faber, 1992; Bardgett *et al.*, 1998). Various workers like Christiansen *et al.*, (1961), Yosii (1966), Crossley *et al.*, (1992), Badejo and Straallen (1993), Choudhuri and Roy (1967), Prabhoo (1976), Choudhuri and Pande (1979), Hazra and Choudhuri (1983), Mitra (1993), Hazra and Sanyal (1996), Ghosh and Roy (2004) in abroad and India have studied the soil arthropod population in relation to different biotic and abiotic factors particularly either in grassland, forest, cultivated, uncultivated fields or in a particular altitude in hilly region. So far no study has been undertaken in a consolidated way on the occurrence and ecology of soil arthropod fauna in different altitudinal ranges in Darjeeling Himalaya, India. To fill up these lacunae the present investigation has been undertaken with the objectives to determine what groups of soil arthropod communities inhabit in different altitudinal sites, a record of seasonal abundance of the groups in these areas, and to investigate distribution, dominance and diversity of different soil arthropod communities; to ascertain the effect of altitude and some important edaphic factors on the soil arthropod communities; and also to compare similarity and equitability of different group of soil arthropods in different altitudinal sites of Darjeeling Himalaya.

KEYWORDS : *Soil arthropods; Distribution; Diversity; Altitudes; Edaphic factors; Darjeeling Himalaya.*

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MATERIALS AND METHODS

Study sites :

The study was conducted at four different altitudinal sites (A, B, C, and D) of Darjeeling Himalaya (India). The sites are montane at an altitude 161–3636 m a.s.l. with an annual average precipitation in the region ranges from 300–400 cm. The entire area under investigation is made up of different types of metamorphic rocks, chiefly gneiss and soil was mixed with humus and grains of degraded rocks. All the sites were undisturbed, uncultivated and vegetated with herbs, shrubs and large woody plants. The site A (Sukna) was the foothill site of Darjeeling Himalaya with an approximate altitude of 161 m a.s.l. and was covered with *Shorea robusta* as the dominating tree. This site also contained trees like *Tectona grandis*, *Saraca indica*, *Bauhinia sp.* The soil was grayish black in color and loamy clay in texture. The site B (Kurseong) was at an approximate altitude of 1478 m a.s.l. The site was dominated by plant species like *Cryptomaria japonica*, *Betula alnoides*, *Phobea sp.* The soil was light brown in color and sandy clay in texture. The site C (Tiger Hill) was at an altitude of about 2573 m a.s.l. The site was well vegetated with a number of herbs and shrubs like *Pteris quadriaurita*, *Euphorbia sp.*, *Anaphalis contorta*, *Rubus lineatus*, *Arsaema specioussum* and trees like *Pinus Longifolia* and *Cryptomeria japonica*. The soil was dark grayish in color and sandy loam in texture. The site D (Sandakphu) was at an approximate altitude of 3636 m a.s.l. and was characterized by evergreen oak forest with *Quercus lamellose*, *Q. pachyplla* along with *Engelhardia gardneri* and *Acer camllii*. *Rhododendron lepidotum* was very common in this site. In addition, mosses, ferns, herbs and shrubs were also present. The soil was moderate dark gray in color and sandy clay in texture. The soil characteristics of the sampling sites are presented in Table 1.

Table 1 : Soil characteristics of sampling sites A–D in Darjeeling Himalaya, India.

Characteristics	Sampling Sites			
	Site A	Site B	Site C	Site D
Coarse sand (%)	12.6	8.2	4.1	7.4
Fine Sand (%)	19.1	47.2	56.1	55.1
Silt (%)	45	17.8	21.1	22.1
Clay (%)	23.3	26.8	18.6	15.4
Mean pH	5.33	5.68	5.17	4.67
Mean Temperature (°C)	23.91	16.75	12.08	8.91

Sampling procedure and laboratory analyses :

Each site was divided into three quadrates (5m × 5m) and three soil samples were drawn per month at random from each quadrate for a period of 12 months (May, 2005–April, 2006). Altogether

432 soil samples were drawn by using a stainless steel corer (inner cross sectional diameter 8.5 sq. cm.) from a depth of 5 cm. The corers were then carried in polythene bags to laboratory and placed on the expedition type "Expedition Funnel Apparatus" modified by Macfadyen (1953). A 40 watt electric bulb was used for heat and light source. Collection jars (100 ml) with approximately 50 ml 70% ethanol plus 5% glycerin were attached below the funnels and the extraction period was 3 days. Specimens collected were identified to order level and quantified to estimate soil arthropods distribution and diversities of these sites.

Separate soil samples were taken in polythene bags from each site for the chemical analysis of soil parameters. The temperature of the soil was measured by a soil thermometer. The relative humidity of surface soil was recorded by using a dial hygrometer. Soil moisture was determined by an oven dry method (Dowdeswell, 1959). The electrical conductivity was measured by Conductivity Bridge. The pH of the soil in solution was measured by a glass electric pH meter. Organic Carbon content was estimated by the rapid titration methods of Walkley and Black (1934). International pipette method was employed for carrying out mechanical analysis of soil for the determination of soil texture.

Statistical treatments of data :

To analyze order wise dominance in distribution of soil arthropod communities in four altitudinal sites of Darjeeling Himalaya, index of dominance was used. The group wise index of dominance was calculated on the basis of relative abundance which is expressed as

$$RA = n_i / N \times 100$$

Where RA = relative abundance, n_i = number of individuals of i th group, N = total number of individuals of all the groups.

The Sorensen coefficient of similarity was used to compare soil arthropods diversity between different altitudinal sites of Darjeeling Himalayas. The formula is

$$C_s = 2a / (2a + b + c)$$

Where C_s is Sorensen coefficient, 'a' is the number of group C_s common to both sites, 'b' is the number of groups in site second site but not in the first site, 'c' is the number of groups in the first site but not in the second site.

The diversity of soil arthropod group was calculated by the Shannon's equation (*e.g.*, Magurran, 1988). It was calculated by the following equation :

$$H' (G)_y = - \sum P_{gy} \ln P_{gy}$$

Where $H' (G)_y$ is the Group diversity per year, $P_{gy} = N_{gy} / N_y$ is the yearly proportion of individuals of each group per year, N_{gy} is the group abundance per year and N_y is the yearly arthropods abundance.

Regarding the uniformity of distribution of different orders of soil arthropods in different altitudinal sites, we compared a community's actual group diversity, $H'(G)_y$, to the maximum possible diversity, H_{max} , by using a measure called evenness index (E):

$$E = H'(G)_y / H_{max}$$

Data pertaining to the soil factors and population density were subjected to statistical correlation with the number of soil arthropods in relation to each of six variables [*e.g.*, temperature, relative humidity (RH), pH, moisture, electrical conductivity (EC) and organic carbon] considered in this investigation.

RESULTS

Faunal composition :

A total of over 4079 soil arthropods were collected from 432 samples in the four different altitudinal environments belong to 11 orders and 4 classes were recorded throughout the survey period. Of which Sandakphu contained 851 individuals of soil arthropods belonging to 7 orders, Tiger Hill having 892 individuals represented by 8 orders, Kurseong having 1100 individuals represented by 9 orders and Sukna having maximum 1236 individuals with 10 orders. In all the sites order Acari had maximum dominance (47.04%), followed by Collembola (38.68%), Hymenoptera (3.40%), Coleoptera (3.3%), Diplura (1.81%), Diplopoda (1.49%), Isopoda (1.27%), Aranea (1.20%), Chilopoda (1.00%), Dermaptera (0.49%). The order Diptera had minimum dominance (0.26) [Table 3]. From a total of 1957 soil insects, over 84% belonged to the subclass Apterygota and remainder to the subclass Pterygota. The majority of apterygotes were Collembola and most of the pterygotes were endopterygotes. A total of 1938 arachnids were collected, over 98% belonged to the order Acari.

Monthly fluctuation of soil arthropods :

The total soil arthropod population showed fluctuations from month to month and from one site to other during the period of study. The peak of total soil arthropod population in all the sites was observed during March (12.38%) and minimum during May (4.43%). The soil arthropod population showed irregular trends of fluctuation in different altitudinal sites being maximum in December at site A and B and in March at site C and D and minimum in May at site A and B and in July at site C and D (Fig. 1). The faunal orders encountered in this study showed that only two orders namely Acari and Collembola had considerable population and occurred consistently in different month and from all the sites. Other orders had either low population or irregular occurrence (Table 2). The two predominant orders as stated above Acari and Collembola when analyzed their population fluctuation, the population of Acari in site A and B showed their peak in the month of December (1.59% and 1.44% respectively) and the peak population in the site C and D were in the month of March (1.27% and 1.44% respectively). The order Collembola had also population peak

in the month of December in site A and B (1.44% and 1.22% respectively) and in March in site C and D (1.12% and 1.05% respectively).

Table 2 : Order wise index of dominance of soil arthropod population of Darjeeling Himalaya, India.

Classes	Orders	Site A	Site B	Site C	Site D	Total
Arachnida	Aranea	0.5	0.46	0	0.14	1.2
	Acari	13.28	12.62	10.39	10.73	47.04
Myriapoda	Chilopoda	0.39	0.61	0	0	1
	Diplopoda	0.41	0.34	0.51	0.22	1.49
Hexapoda	Coleoptera	1.12	1.1	0.56	0.51	3.3
	Collembola	10.93	10.24	8.89	8.6	38.68
	Dermaptera	0.22	0	0.26	0	0.49
	Diplura	0.95	0.49	0.36	0	1.81
	Diptera	0	0	0	0.26	0.26
	Hymenoptea	1.74	0.71	0.56	0.39	3.4
Crustacea	Isopoda	0.63	0.36	0.26	0	1.27

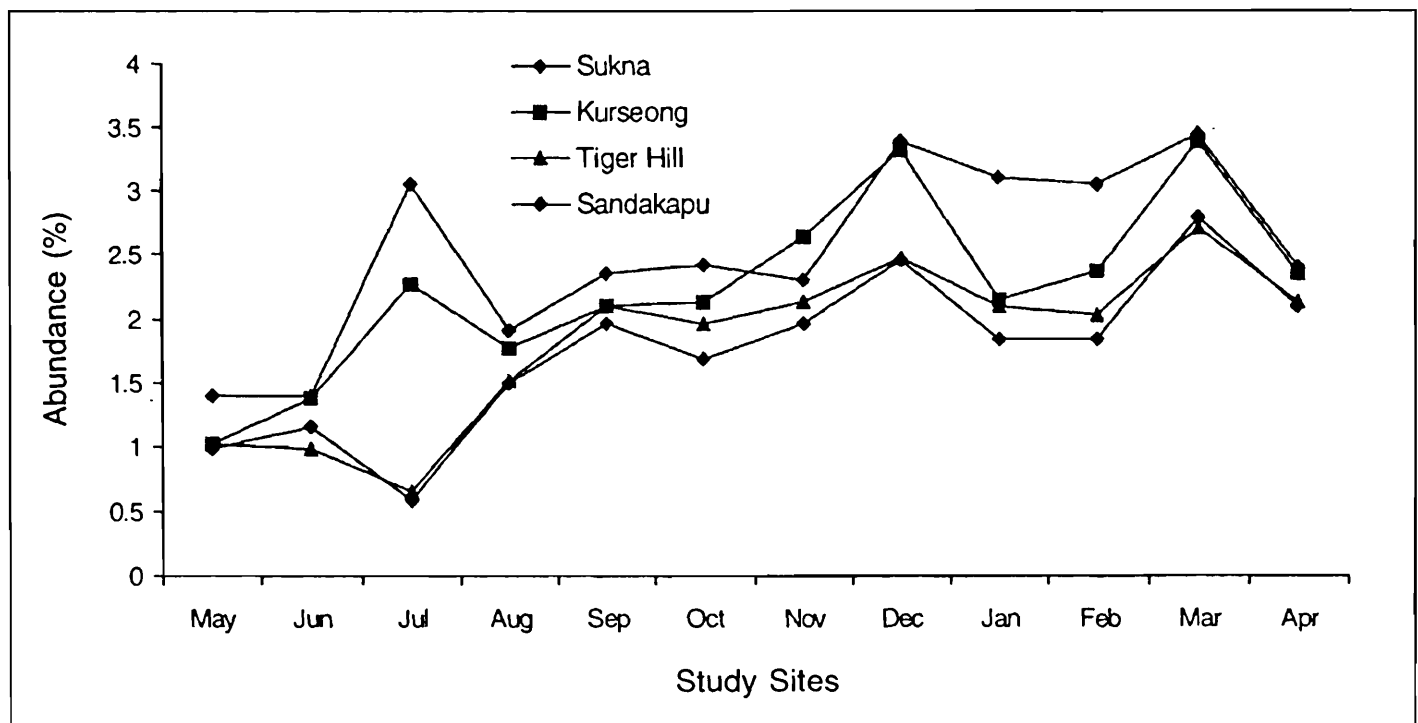


Fig. 1 : Showing the monthly variation of abundance (in %) of soil arthropod population in four altitudinal sites of Darjeeling Himalayas, India.

Table 3 : Monthly abundance (%) of soil arthropods fauna in four altitudinal sites of Darjeeling Himalaya, India.**(i) AT SITE A**

Arthropod group	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
ARACHNIDA													
Aranea	–	–	0.14	0.02	0.02	0.04	0.07	0.02	0.12	0.02	–	0.09	0.58
Acari	0.63	0.73	1.1	0.83	0.88	1.05	0.98	1.59	1.44	1.39	1.49	1.12	13.28
MYRIAPODA													
Chilopoda	0.07		0.09		0.02	0.04	–	–	0.07	0.02	0.02	0.02	0.39
Diplopoda	–	–	0.17	0.02	0.12	–	0.02	0.04	–	0.02	–	–	0.41
HEXAPODA													
Coleoptera	–	0.02	0.19	0.02	0.17	0.04	0.07	0.14	0.07	0.29	0.02	0.04	1.12
Collembola	0.46	0.56	0.75	0.8	0.85	0.98	0.88	1.44	0.95	0.98	1.27	0.95	10.93
Dermaptera	0.02	–	0.02	–	–	–	0.09	–	–	0.04	–	0.02	0.22
Diplura	0.02	–	0.22	–	–	0.02	–	0.12	0.29	0.02	0.19	0.04	0.95
Diptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Hymenoptera	0.12	0.07	0.29	0.17	0.22	0.09	0.14	0.02	0.09	0.22	0.19	0.07	1.74
CRUSTACEA													
Isopoda	0.04		0.04	0.02	0.04	0.12	0.02	–	0.04	0.02	0.24	–	0.63
TOTAL	1.39	1.39	3.06	1.91	2.35	2.42	2.3	3.4	3.11	3.06	3.45	2.4	30.3
(ii) AT SITE B													
ARACHNIDA													
Aranea	–	–	0.02	–	–	–	0.02	0.04	0.02	0.04	0.24	0.04	0.46
Acari	0.58	0.75	0.9	0.93	0.93	0.98	1.2	1.44	1.2	1.12	1.34	1.2	12.62
MYRIAPODA													
Chilopoda	–	–	–	–	0.02	0.02	0.26	–	0.04	0.02	0.22	–	0.61
Diplopoda	–	–	–	–	0.04	–	–	0.12	–	–	0.09	0.07	0.34

Table 3 : (Cont'd.).

Arthropod group	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
HEXAPODA													
Coleoptera	–	–	0.12	–	0.14	0.12	0.09	0.22	0.04	0.22	0.09	0.02	1.1
Collembola	0.36	0.53	0.88	0.8	0.75	0.93	0.88	1.22	0.83	0.85	1.17	0.98	10.24
Dermaptera	–	0.02	–	–	–	0.04	0.07	0.19	–	0.07	0.07	–	0.49
Diplura	–	–	–	–	–	–	–	–	–	–	–	–	–
Diptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Hymenoptera	0.04	0.02	0.34	–	0.09	–	0.04	0.02	–	–	0.09	0.02	0.71
CRUSTACEA													
Isopoda	0.02	0.02	–	0.02	0.09	0.02	0.04	0.04	–	0.02	0.04	–	0.36
Total	1.02	1.37	2.27	1.76	2.1	2.13	2.64	3.33	2.15	2.37	3.4	2.35	26.96
(iii) AT SITE C													
ARACHNIDA													
Aranea	–	–	–	–	–	–	–	–	–	–	–	–	–
Acari	0.49	0.58	0.34	0.71	0.85	0.93	0.95	1.2	1.1	0.98	1.27	0.95	10.39
MYRIAPODA													
Chilopoda	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplopoda	0.02	–	–	–	–	0.02	0.09	0.17	–	0.02	0.09	0.07	0.51
HEXAPODA													
Coleoptera	0.07	–	–	0.07	0.12	0.02	0.09	0.12	–	0.04	–	–	0.56
Collembola	0.39	0.31	0.24	0.73	0.73	0.85	0.9	0.85	0.9	0.88	1.12	0.93	8.89
Dermaptera	–	0.02	–	–	0.04	0.04	0.04	0.04	–	–	–	0.04	0.26
Diplura	–	0.02	–	–	0.02	–	–	0.07	0.04	–	0.09	0.09	0.36
Diptera	–	–	–	–	–	–	–	–	–	–	–	–	–
Hymenoptera	0.02	0.02	0.07	–	0.31	0.04	–	–	0.02	0.02	0.02	–	0.56
CRUSTACEA													
Isopoda	–	–	–	–	–	0.02	0.02	–	0.02	0.07	0.09	0.02	0.26
Total	1.02	0.98	0.66	1.51	2.1	1.96	2.13	2.47	2.1	2.03	2.72	2.13	21.86

Table 3 : (Cont'd.).

Arthropod group	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
(iv) AT SITE D													
ARACHNIDA													
Aranea	0.02	0.02	-	-	0.04	-	-	0.02	-	-	-	0.02	0.14
Acari	0.58	0.68	0.26	0.8	0.83	0.9	0.95	1.1	1	1.05	1.44	1.07	10.73
MYRIAPODA													
Chilopoda	-	-	-	-	-	-	-	-	-	-	-	-	-
Diplopoda	-	-	-	-	0.09	-	-	0.09	-	-	-	0.02	0.22
HEXAPODA													
Coleoptera	-	-	-	-	0.02	0.02	0.17	0.24	-	-	0.02	0.02	0.51
Collembola	0.36	0.39	0.29	0.68	0.8	0.75	0.83	0.98	0.73	0.78	1.05	0.9	8.6
Dermaptera	-	-	-	-	-	-	-	-	-	-	-	-	-
Diplura	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera	-	0.04	-	-	0.02	-	-	-	0.09	-	0.09	-	0.26
Hymenoptera	-	-	0.02	-	0.12	-	-	-	-	-	0.17	0.07	0.39
CRUSTACEA													
Isopoda	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.98	1.15	0.58	1.49	1.96	1.69	1.96	2.45	1.83	1.83	2.79	2.1	20.86

Fluctuation of edaphic factors :

Soil factors in the study sites exhibited fairly wide range of variation during different months of the year (Fig. 2). The lowest soil temperature was 1°C during January at Sandakphu and highest was 27°C during May and September at Sukna. The relative humidity (%) of these study sites varies from 58% to 89%. The maximum relative humidity was recorded during the month of July at Sandakphu and minimum in the month of January at Sukna. The moisture content of soil being maximum (56.51%) in July at Sandakphu and minimum (10.62%) in February at Sukna. The electrical conductivity (EC) of soil varied from 0.22 in November at Sukna to 0.96 in November at Kurseong. The soil pH varied from 5.97 in January at Kurseong to 4.18 in April at Sandakphu. The content of soil organic carbon (%) varied from 2.69 to 5.01. The content of soil organic carbon (%) was maximum in December at Kurseong and was minimum in July at Sandakphu.

DISCUSSION

The soil arthropods collected in this study shows that the Arachnida population (48.23%) was maximum followed by Hexapoda (47.96%) and lowest population was found in case of Crustacea (1.27%). All the four classes of soil arthropod fauna showed their gradual decrease of number with the increase of altitude except class Arachnida which exhibit their minimum populations in the site C (Table 4). The soil insects are highly abundant at lower altitudinal site than the sites at higher altitude (Fig. 3).

It is also observed that sites A, B, C and D of Darjeeling Himalaya represented respectively by 30.3%, 26.96%, 21.86% and 20.86% individuals of the total soil microarthropods community (Fig. 4) and gradually their abundance (%) decreases with the increase of altitude. The minimum and maximum abundance (%) of soil arthropods varied from one altitudinal site to another altitudinal site as well as varied with the months. In the site A and B minimum population were observed in the month of May when moisture content and organic matter were also low and similar results were also obtained by Hazra and Choudhuri (1983), Mitra *et al.*, (1977) in plains of West Bengal, India. The population maxima were obtained from these two sites in the month of December when the soil parameters were found to be optimum condition. In the month of December population maxima was also obtained by Hazra and Sanyal (1996) in an alluvial island in West Bengal, India. The population minima in the site C and D were in the month of July. These two sites are on high hill slopes and due to high precipitation rate resulting to drainage of soil nutrients. As a result values of edaphic factors like organic carbon were also at lower level during this period. The population maxima in the Site C and D were in the month of March when temperature was not so cold and other edaphic factors were also present in optimum level. These results coincide with the finding of Mukherjee and Banerjee (1993), Ghosh and Roy (2004).

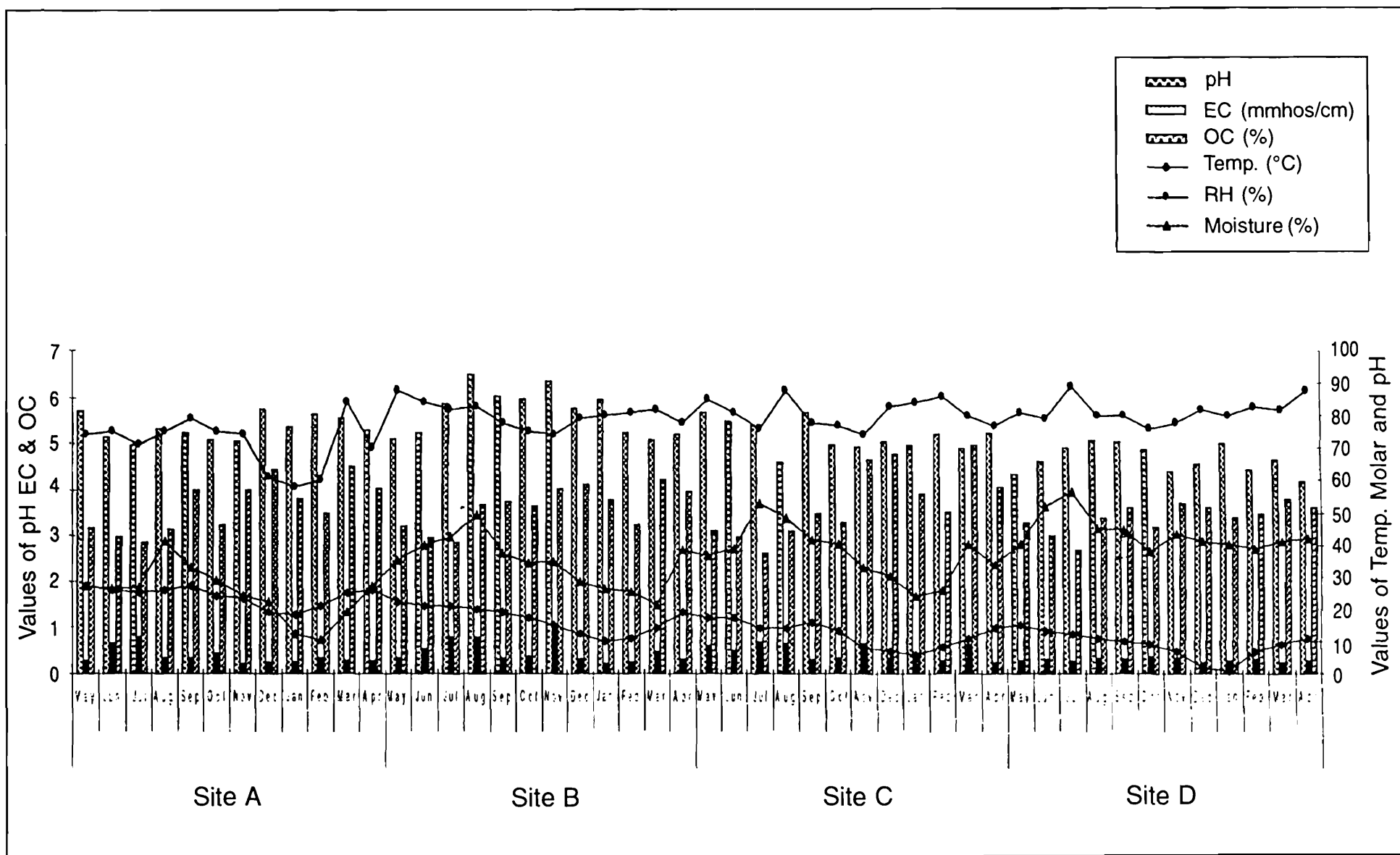


Fig. 2 : Monthly fluctuation of edaphic factors at four different altitudinal sites of Darjeeling Himalaya, India.

Table 4 : Class wise abundance (%) of soil arthropods in four altitudinal sites of Darjeeling Himalaya, India.

Classes	Sites [altitude]			
	A [161 m]	B [1478 m]	C [2573 m]	D [3636 m]
Arachnida	13.87	13.09	10.39	10.88
Hexapoda	14.97	12.55	10.66	9.78
Myriapoda	0.8	0.95	0.51	0.22
Crustacea	0.63	0.36	0.26	0

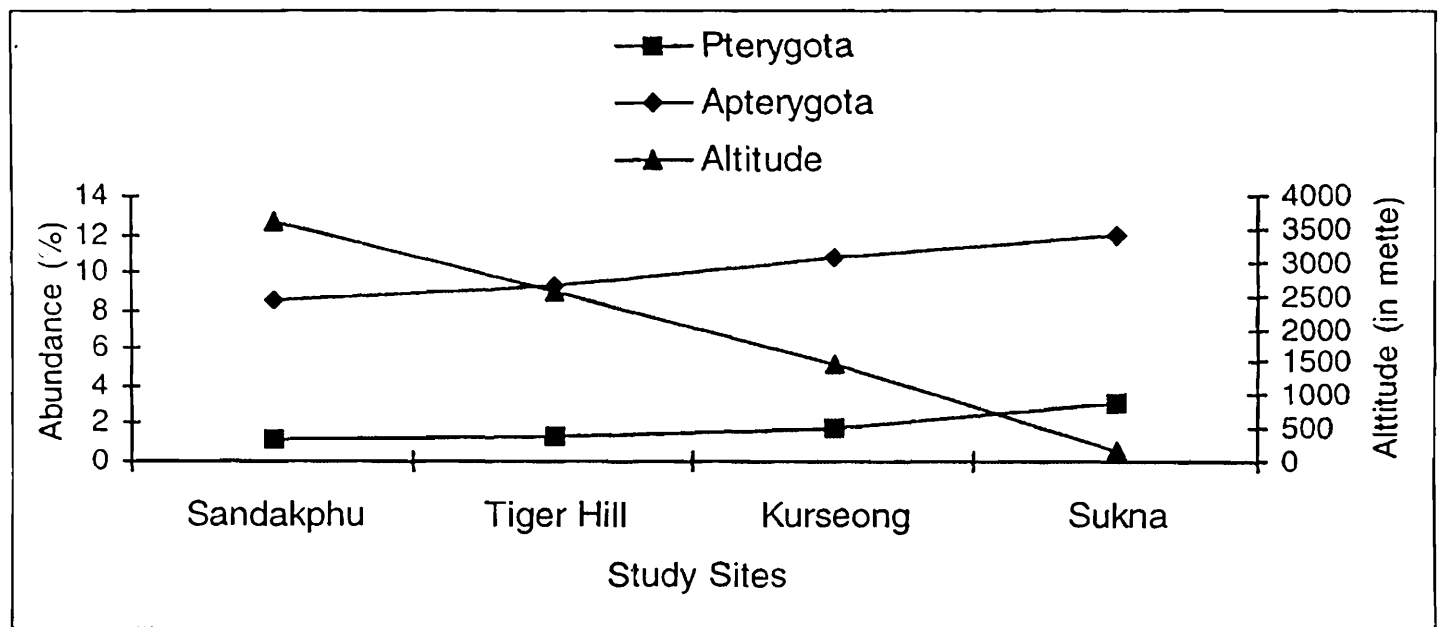


Fig. 3 : Showing the abundance (%) of the subclass Pterygota & Apterygota in relation to altitude of four altitudinal sites of Darjeeling Himalayas, India

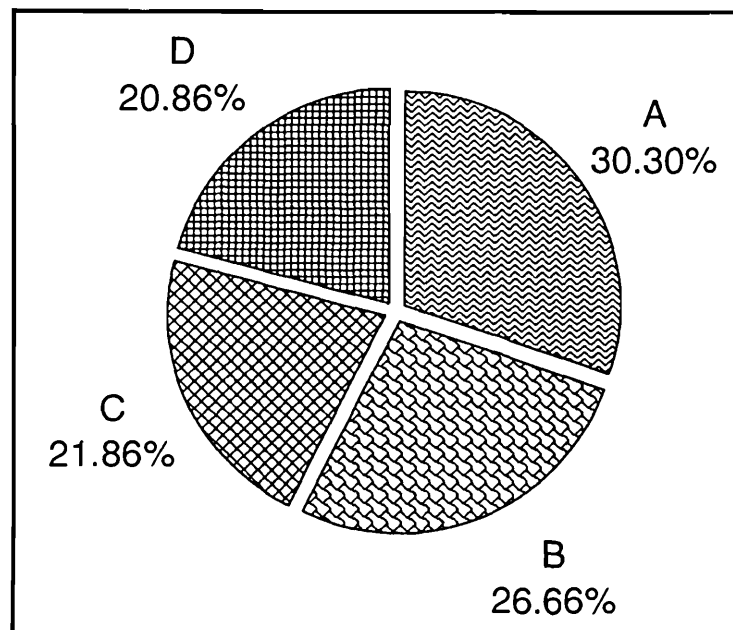


Fig. 4 : Distribution of soil arthropod community in different altitudinal sites of Darjeeling Himalayas, India.

It is evident from the Table 5 that group diversity increases with the decrease of altitude when group diversity index as determined by Shannon's method is applied. This is substantiated by the occurrence of different number of groups (orders) in these sites and the group diversity index increases with the addition of groups and with increasing evenness. Only 7 orders of soil arthropods were found in Sandakhphu [$H'(G)_y = 1.0124$] and 8 orders of soil arthropods found in Tiger hill site [$H'(G)_y = 1.1734$] and 9 orders of soil arthropods found in Kurseong [$H'(G)_y = 1.2926$] and 10 orders of soil arthropods found in Sukna site which showed higher diversity index value [$H'(G)_y = 1.421$] (Table 4). β -diversity between the sites suggested that site A and B had maximum similarity of the soil arthropod fauna and minimum similarity between site C and D (Table 6). This might be due to changes in micro climatic conditions in different altitudes of Darjeeling Himalaya.

Table 5 : Group diversity index of soil arthropods, measured by $H'(G)_y$, the Shannon index, increases with the addition of groups and with increasing evenness, measured as $H'(G)_y/H_{max}$ in four altitudinal sites of Darjeeling Himalaya, India.

Sites	$H'(G)_y$	H_{max}	E
A	1.421	2.30259	1.6204
B	1.2926	2.1972	0.5882
C	1.1734	2.07944	0.5642
D	1.0124	1.945356	0.5204

Table 6 : Sorenson's coefficient of similarity of soil arthropods diversity between different altitudinal sites of Darjeeling Himalaya, India.

Sites	B	C	D
A	94.73	88.88	70.58
B		82.35	75
C			66.66

Different soil factors like temperature, relative humidity (RH), pH, moisture, organic carbon (OC) and electrical conductivity (EC) in the study sites exhibited fairly wide range of variation during different months of the study period (Fig. 4). Throughout the period of study the average temperature of soil in these four sites exhibited a decline with increase of altitude (Table 7). In this study the population density of soil arthropods in higher altitudinal sites attained their peak during March when the temperature was moderate. The soil temperature showed a negative significant correlation with the soil arthropod population (Table 7). This result also coincided with the earlier result of Hazra and Choudhuri (1983), Ghosh and Roy (2004).

The mean moisture content of soil in each site showed wide range of variation and exhibited a higher value with altitude (Table 7). In plain areas moisture played a positive correlation with the soil arthropod population as reported by earlier workers like Hazra and Choudhuri (1983) and Mitra (1993). But in this present investigation of the study a negative correlation between the soil

Table 7 : Showing the mean and correlation of soil factors with the soil arthropods in four study sites of Darjeeling Himalaya, India.

Sites	Parameters	Mean	<i>r'</i> value of microarthropods	Remarks
A	Temperature (°C)	23.91	-0.645583971	*
	Moisture (%)	24.88	-0.583717762	*
	RH (%)	71.33	-0.369615209	ns
	pH	5.33	0.240817238	ns
	EC (mmhos/cm)	0.375	-0.176646705	ns
	OC (%)	3.63	0.57947287	**
B	Temperature (°C)	16.75	-0.649963102	*
	Moisture (%)	34.41	-0.576778652	*
	RH (%)	80	-0.617493204	*
	pH	5.68	0.0395285	ns
	EC (mmhos/cm)	0.478	-0.031929639	ns
	OC (%)	3.55	0.737868705	**
C	Temperature (°C)	12.08	-0.620260423	*
	Moisture (%)	36.76	-0.56273687	*
	RH (%)	80.75	-0.063855101	ns
	pH	5.17	-0.443703159	ns
	EC (mmhos/cm)	0.474	-0.449621281	ns
	OC (%)	3.67	0.736948296	**
D	Temperature (°C)	8.91	-0.577009981	*
	Moisture (%)	43.70	-0.623833061	*
	RH (%)	81.58	-0.147758561	ns
	pH	4.67	-0.15677827	ns
	EC (mmhos/cm)	0.31	-0.303788862	ns
	OC (%)	3.39	0.886686806	***

* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; ns = not significant

arthropod population and moisture contents was noticed in the study sites (Table 7). Such a negative correlation was earlier witnessed by Dhillon and Gibson (1962), Hazra (1978), Mukherjee and Banerjee (1993), Ghosh and Roy (2004). As altitude increases, the requirement of moisture from the soil of these arthropods is reduced due to cold climatic condition.

In this study, the soil EC did not exhibit wide range of variation with the change of season and possibly did not have a significant impact on population fluctuation.

The soil pH has been found to be strongly associated with soil arthropod distribution (Van Straalen and Verhoef, 1997 and Loranger *et al.*, 2001). In the present study, as expected from the nature of the parent rock (mainly granite or gneiss), the soil pH of all the samples was very low. In general acidity of the soil led to differentiation of humus type and thus the occurrence of Collembola and other soil arthropods has often been related to humus form (Schaefer and Schaueremann, 1990). The occurrence of soil arthropods in slightly acidic soil as observed in this study confirmed to the earlier reports made in relation to mites (Chaudhuri and Pande, 1979).

Though the average RH (%) of each study site increased with the increase of altitude, but except in site B, the RH did not show any significant correlation with soil arthropods in these altitudinal sites (Table 7).

The organic carbon (%) exhibits a strong positive correlation with the soil arthropod population (Table 7). The soil organic matter not only served as a source of food for soil arthropods but also influenced the amount of living space required by them. The increase in soil arthropod population with the increase in organic matter of soil as encountered here as reported by Haarlov (1960), Christiansen *et al.*, (1961), Hazra (1978), Hazra and Choudhuri (1983), Mukherjee and Banerjee (1993), Ghosh and Roy (2004).

It can be concluded from the present investigation that low altitude, optimum quantity of rain fall, relatively higher soil temperature and less acidic soils perhaps the important reasons for supporting a diverse group of soil fauna in Sukna [$H'(G)_y = 1.421$] than in high altitudinal sites like Kurseong [$H'(G)_y = 1.2926$] Tiger Hill [$H'(G)_y = 1.1734$] and Sandakhphu [$H'(G)_y = 1.0124$]. However, the definite role of altitude on the population structure of soil fauna in the Darjeeling Himalayas can only be made when each species will be studied in laboratory condition which is under progress.

SUMMARY

The soil arthropod fauna in four different altitudinal sites, A (161m), B (1478 m), C (2573 m) and D (3636 m) in the Darjeeling Himalaya, West Bengal, India have been studied. The aim of the present study was to investigate the distribution, dominance and diversity of soil arthropod communities in these altitudinal sites; to observe the altitudinal variation in faunal composition

and obtain a record of their seasonal abundance; to ascertain the impact of altitude and some important edaphic factors on the soil arthropod communities; and also to compare similarity and equitability of different groups of soil arthropods in different altitudinal sites. A total of 4079 examples of soil arthropod fauna belonging to 4 classes and 11 orders have been recorded. From a total of 1957 soil insects, over 84% belonged to the subclass Apterygota and remainder to the subclass Pterygota. The majority of apterygotes are Collembola and most of the pterygotes are endopterygotes. Among 1938 examples of arachnids, over 98% belonged to the order Acari. The abundance of soil arthropods belonging to order Acari (47.04%) followed by Collembola (38.68%) are found to be maximum in all the sites. The order Diptera has minimum dominance (0.26%). The site A shows maximum richness in faunal diversity in comparison to other three sites. The soil arthropod population shows irregular trends of fluctuation in different altitudinal sites during one year study, being maximum in December (in site A and B) and March (in site C and D) and minimum in May (in site A and B) and July (in site C and D). Of the six edaphic factors studied only organic carbon shows positive correlation, while soil temperature and moisture exhibit negative correlation with soil arthropod population in all the sites. Group diversity index analyzed indicate a more diverse soil arthropod community in site A and group diversity increases with the decrease of altitude. α -diversity between the sites indicate that site A and B had maximum similarity of the soil arthropod fauna and minimum similarity between site C and D. The over all observation reveals that the order wise faunal abundance, diversity and distribution of soil arthropods decrease with the increase of altitude.

ACKNOWLEDGEMENTS

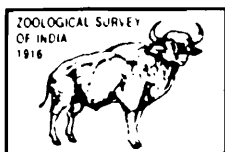
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EFFECTS OF AGRICULTURAL PRACTICES ON SOIL ARTHROPOD POPULATION IN WEST BENGAL

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INTRODUCTION

Agriculture is the practice of cultivating the soil to produce crops. Though at first this practice was simple, but more recently, synthesized fertilizers and pesticides are being added to this, as a result, with high production of crops, natural soil condition and natural microorganism populations are being affected. Among all the soil micro-arthropods, mites are predominant and playing important role in increasing soil fertility through organic decomposition. But in agricultural fields, due to application of different fertilizers and also by crop rotation, tillage, irrigation, etc. the natural mite population as well as the other soil microarthropods and their ecology are affected. Bhattacharyya, Joy and Joy (1981), Majumder and Deb (1991a, 1991b), Sanyal (1991), Sanyal and Sarkar (1993), Sengupta and Sanyal (1991) studied the effect of agricultural practices on mite population in laterite and alluvial soils in West Bengal.

MATERIAL AND METHODS

The soil and litter samples were taken at fifteen days interval over a period of eight months (January-August, 2006) except the fields-C and D where samples were collected during March-August, '06 and May-August, '06 respectively, by means of stainless steel corers, each measuring 5 cm in diameter. A total number of 170 samples were drawn (at the rate of five samples from each field in one collection). The collected soil samples were extracted in a Tullgren funnel extractor as modified by Macfadyen (1953). The adult insects and spiders were also collected by hand picking method. Soil temperature and moisture content were measured by soil thermometer and infra-red moisture meter respectively.

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SITE DESCRIPTION

Five fields were selected for the study, of these four fields were agricultural and one non-agricultural (control). All the fields were located at Gobardanga, North 24-Parganas, West Bengal.

1. Agricultural fields :

Four selected agricultural fields were denoted as Field-A, Field-B, Field-C and Field-D, each having the area of approximately one acre.

Field-A : This field was a paddy field when the study began and after harvesting the crop, the same field was again prepared for paddy cultivation.

Field-B : When the study started, this field was with chrysanthemum flower and after that, marigold cultivation was started.

Field-C : This field was with sunflower when the study began and after that jute cultivation started in the same field.

Field-D : This field was prepared for Banana cultivation.

All these fields were parts of a large agricultural field and as a result no natural vegetation could grow in the study fields. The other agricultural fields in the surroundings were china-rose (*Hibiscus rosa-sinensis*) field, garden balsam (*Impatiens balsamina*) field, common arum (*Colocasia antiquorum*) field, etc. and some grasses as *Cynodon dactylon*, *Brachiaria* sp. were also found during the sampling period. All of these agricultural fields were treated with different fertilizers like N-P-K, Urea, Suphala, Agromin, oil-cake, etc. in different concentrations, depending upon the type of crops cultivated in the fields. Tillage and irrigation were also done at a regular interval. Some pesticides as Endosulfan, Cypermethrin, Phosphamidon, etc. were also applied to the fields during cultivation.

2. Non-agricultural field :

This field was very near to the agricultural field-A. It was a fallow land having no crop through out the study. The soil was loamy in texture and the field was covered with grasses like *Cynodon dactylon* and *Brachiaria* sp. Some other seasonal plants like *Eclipta prostrata*, *Amaranthus spinosus*, *Cardiospermum halicacabum*, etc. were also found to grow in the field.

RESULTS

FAUNAL COMPOSITION

Altogether 7,412 arthropods belonging to seven different groups viz., Acarina, Collembola, Hymenoptera, Coleoptera, Hemiptera, Diptera and Spider were collected. As the population of Isoptera, Pseudoscorpion, Diplopoda and Chilopoda were very low and irregularly distributed,

these groups are not considered for calculation. A comparison between arthropods of non-agricultural and agricultural fields showed that non-agricultural field was rich in faunal groups while in agricultural fields, the population fluctuation of arthropod depended on nature of cultivation. In all the fields, Acarina was most dominant group. It formed 73.01%, 67.54%, 61.43%, 66.15% and 67.97% of the total population obtained from non-agricultural field, field-A, field-B, field-C and field-D respectively. In non-agricultural field, the second, third and fourth dominant groups were Collembola (1496.3/m²), Coleoptera (282.75/m²) and Hymenoptera (1496.3/m²) respectively.

Table 1 : Arthropod population and mean values of soil factors in non-agricultural field (January-August, 2006).

Arthropods/m ² & soil factors	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Acarina	6158.3	4021.7	4901.5	5781.2	5027.2	10054.4	7352.2	11185.5
Collembola	2262.2	879.7	911.1	1822.3	848.3	1728.1	2010.8	1508.1
Hymenoptera	125.6	–	314.2	345.6	565.5	31.4	157.1	408.4
Coleoptera	377	502.7	62.8	125.6	157.1	31.4	502.7	502.7
Hemiptera	–	188.5	–	125.6	314.2	–	219.9	–
Diptera	–	–	31.4	125.6	92.2	188.5	125.5	31.4
Spider	–	–	125.6	62.8	188.5	94.2	31.4	125.6
Temperature (°C)	25.9	26.1	29.2	31.3	31.8	29	28.3	27.7
Moisture (%)	25.1	26.3	26	23.8	23.2	27.6	32.5	31.7

Table 2 : Arthropod population and mean values of soil factors in Field-A (January-August, 2006).

Arthropods/m ² & soil factors	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Acarina	3644.7	6032.6	5341.4	4084.6	8609	6472.5	4021.7	7855
Collembola	2513.6	4210.2	3393.3	1633.8	2073.7	1351	1728	1319.6
Hymenoptera	754	251.3	62.8	62.8	439.8	565.5	596.9	816.9
Coleoptera	–	188.5	31.4	31.4	251.3	62.8	157.1	314.2
Hemiptera	–	31.4	–	–	–	–	157.1	314.2
Diptera	188.5	–	–	–	–	–	–	157.1
Spider	–	215.3	94.2	31.4	62.8	–	94.2	219.9
Temperature (°C)	26.2	26.4	28.5	30.1	32.2	28.3	28.1	27.2
Moisture (%)	26.5	27.1	26.4	25.1	24.8	28.3	33.2	33.1

Table 3 : Arthropod population and mean values of soil factors in Field-B (January-August, 2006).

Arthropods/m² & soil factors	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Acarina	4713	1256.8	4398.8	5687	3267.6	4618.7	48.7.2	3770.4
Collembola	10054.4	3142	619.2	2010.8	754	2199.4	1633.8	1256.8
Hymenoptera	251.3		125.6	439.8	188.5	125.6	94.2	282.7
Coleoptera	314.2	125.6	282.7	628.4	219.9	596.9	345.6	125.6
Hemiptera	–	–	–	157.1	–	–	94.2	62.8
Diptera	–	–	62.8	157.1	157.1	–	62.8	x
Spider	–	188.5	219.9	62.8	125.6	–	62.8	31.4
Temperature (°C)	25.5	25.2	28.4	30.2	30.9	29.1	28.2	27.3
Moisture (%)	25.8	27.2	27.1	23.5	23.2	28.1	32.2	31.2

Table 4 : Arthropod population and mean values of soil factors in Field-C (March-August, 2006).

Arthropods/m² & soil factors	Mar.	Apr.	May	Jun.	Jul.	Aug.
Acarina	12693.6	4430.2	2513.6	4084.6	4587.3	1728
Collembola	2513.6	1351	1445.3	2450.7	2387.9	1068.2
Hymenoptera	–	62.8	251.3	157	377	345.6
Coleoptera	125.6	–	62.8	188.5	314.2	596.9
Hemiptera	–	–	–	31.4	251.3	157.1
Diptera	–	157.1	188.5	–	62.8	–
Spider	157.1	125.6	–	31.4	251.3	157.1
Temperature (°C)	27.9	30.2	30.2	28.1	26.3	25.2
Moisture (%)	26.2	24.5	24.5	26.8	31.2	32.8

Table 5 : Arthropod population and mean values of soil factors in Field-D (May-August, 2006).

Anthropods/m² & soil factors	May	Jun.	Jul.	Aug.
Acarina	3016.3	3361.9	3079.1	4587.3
Collembola	691.2	1445.3	1382.4	502.7
Hymenoptera	62.8	219.9	125.6	314.2
Coleoptera	–	157	188.5	282.7
Hemiptera	–	–	157	125.6
Diptera	–	–	314.2	–
Spider	–	62.8	31.4	219.9
Temperature (°C)	31.2	28.4	27.2	26.2
Moisture (%)	23.1	28.5	33.1	32.8

Similarly in field-A, Collembola (2277.9/m²), Hymenoptera (443.75/m²) and Coleoptera (129.58/m²); in field-B, Collembola (2717.8/m²), Coleoptera (329.86/m²) and Hymenoptera (188.46/m²); in field-C, Collembola (1869.45 m²), Coleoptera (214.6/m²) and Hymenoptera (198.95 m²) and in field-D, Collembola (1005.4/m²), Hymenoptera (180.62/m²) and Coleoptera (157.05/m²) occupied first, second and third position in order of dominance (Tables 1-5).

EDAPHIC FACTORS

The physical factors of the soil considered in this study showed fluctuations in all the fields. In the non-agricultural field, the maximum (31.8°C) and minimum (25.9°C) temperature were recorded in May and January respectively. Maximum moisture (31.7%) was recorded in August where as minimum (23.2%) in May.

In field-A, the temperature showed a range of 26.2°C to 32.2°C (January and May) and the moisture varied between 24.8% to 33.2% (May and August). In field-B, the temperature fluctuated from 25.2°C to 30.2°C (April to May and August). In field-C, temperature varied between 25.2°C (August) to 30.2°C (April and May) and moisture showed range of 24.5% (April to May) to 32.8% (August). In field-D, temperature fluctuated in between 26.2°C (August) to 31.2°C (May) and moisture varied from 23.1% (May) to 33.1% (July) (Tables 1-5).

POPULATION FLUCTUATION

The total number of arthropods collected showed population maxima in March and monsoon months, *i.e.*, July-August in all fields. The arthropods were minimum in number in February in non-agricultural field where as in agricultural fields it varied in different fields depending upon agriculture practices in the respective field.

The population of different groups showed an irregular trend of fluctuation during the sampling period but there was a tendency to increase their number in January-July in all the cultivated fields.

The collembola population was recorded maximum in March in both non-agricultural and agricultural fields (Figs. 1-7).

DISCUSSION

The non-agricultural field as well as most of the agricultural fields showed a higher population during monsoon months when soil moisture was high. The record of low population of mite in agricultural fields, might be due to influence of tillage, irrigation, application of different fertilizers and pesticides. These observations are supported by the earlier works of Sanyal (1991), Sanyal and Sarkar (1993) and Sengupta and Sanyal (1991). The study recorded that when there was standing crop in the field, the number of mites and other soil microarthropods were increased. The acarina population decreased each time after tillage. When there were no crops in the agricultural

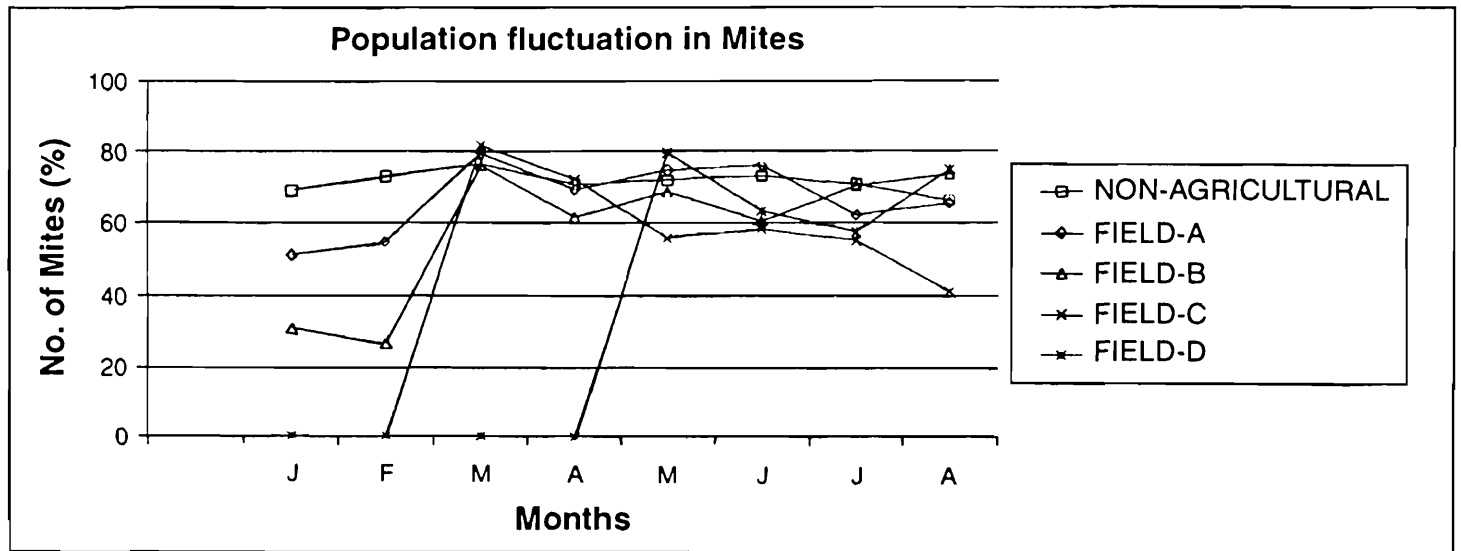


Fig. 1

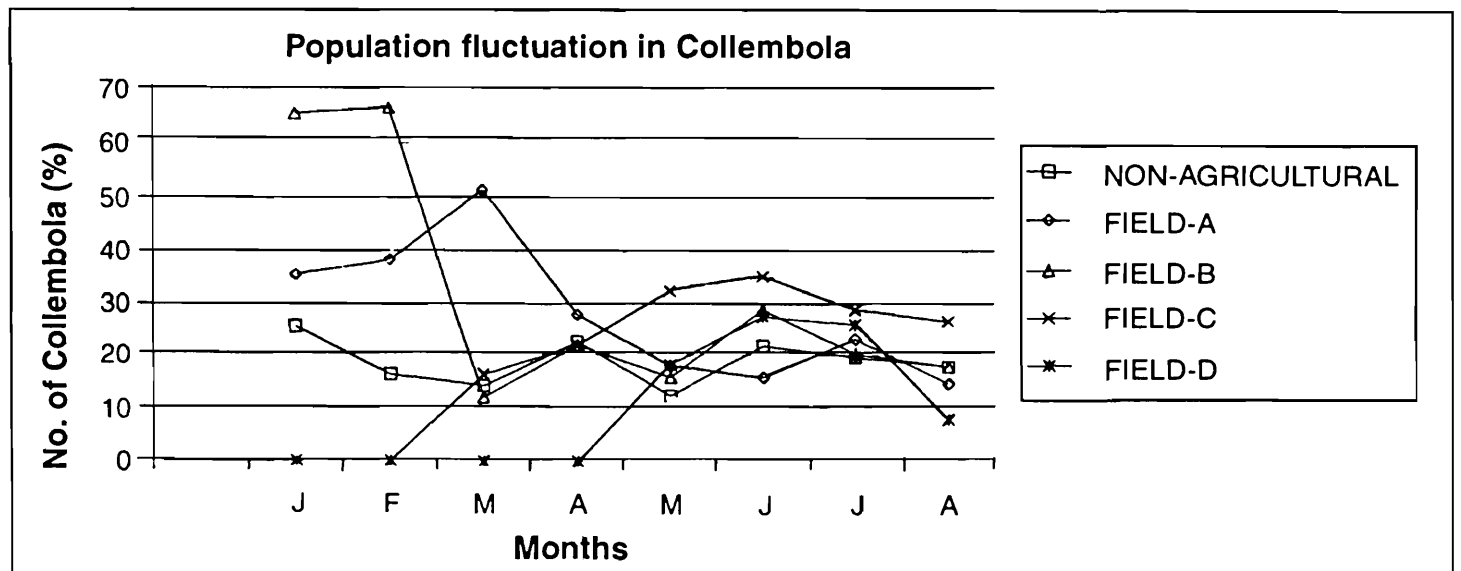


Fig. 2

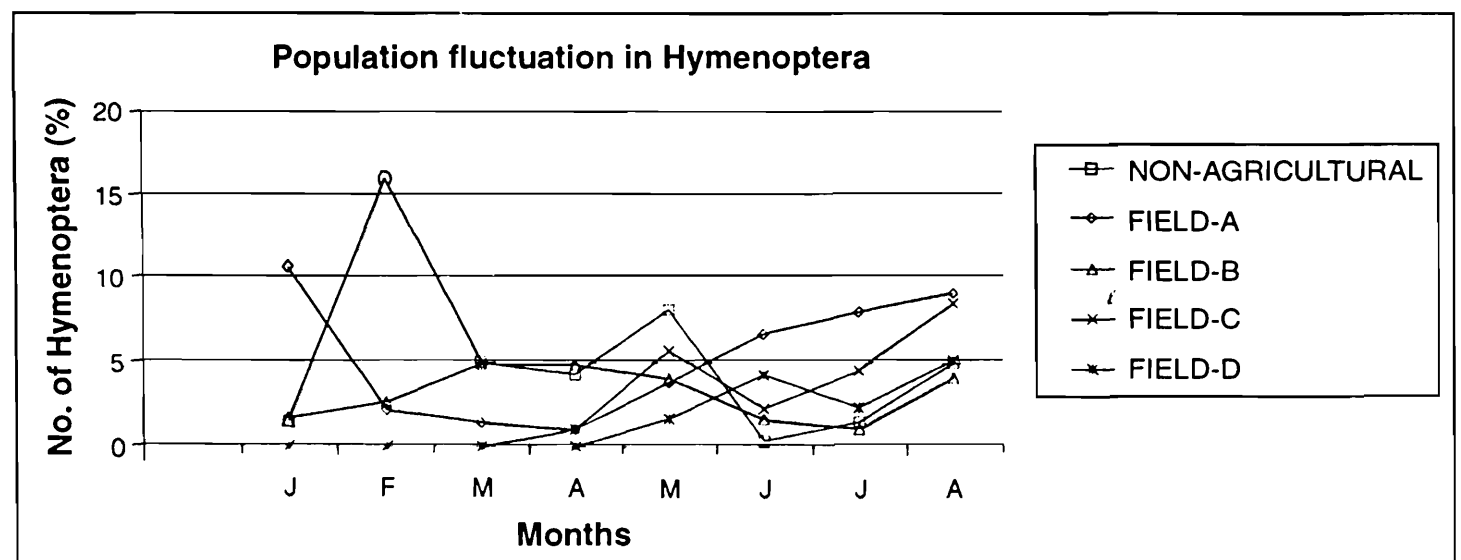


Fig. 3

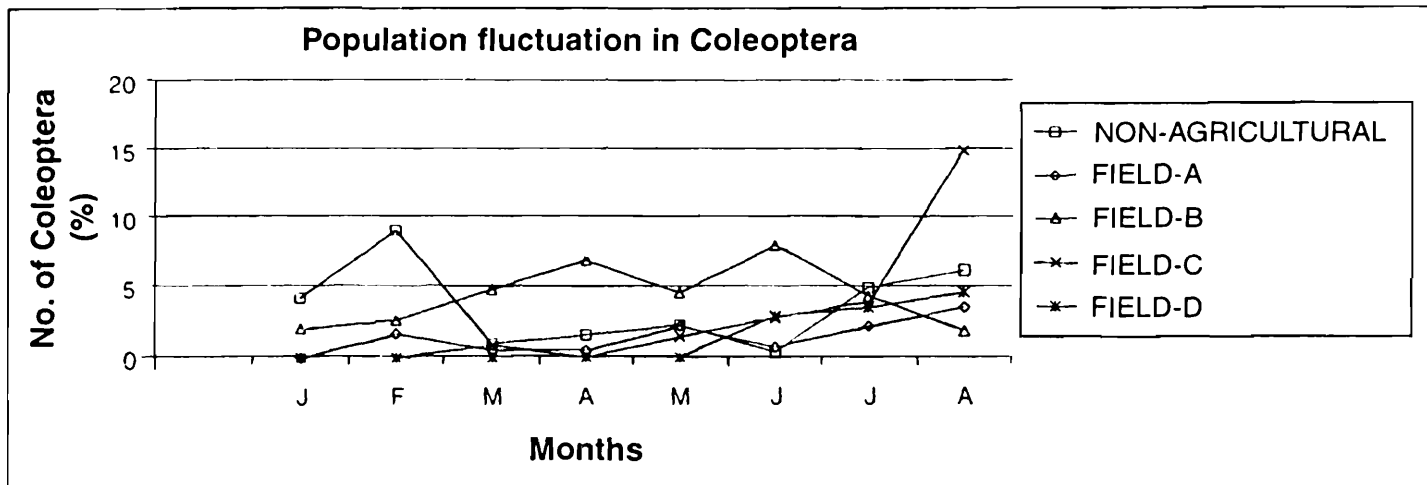


Fig. 4

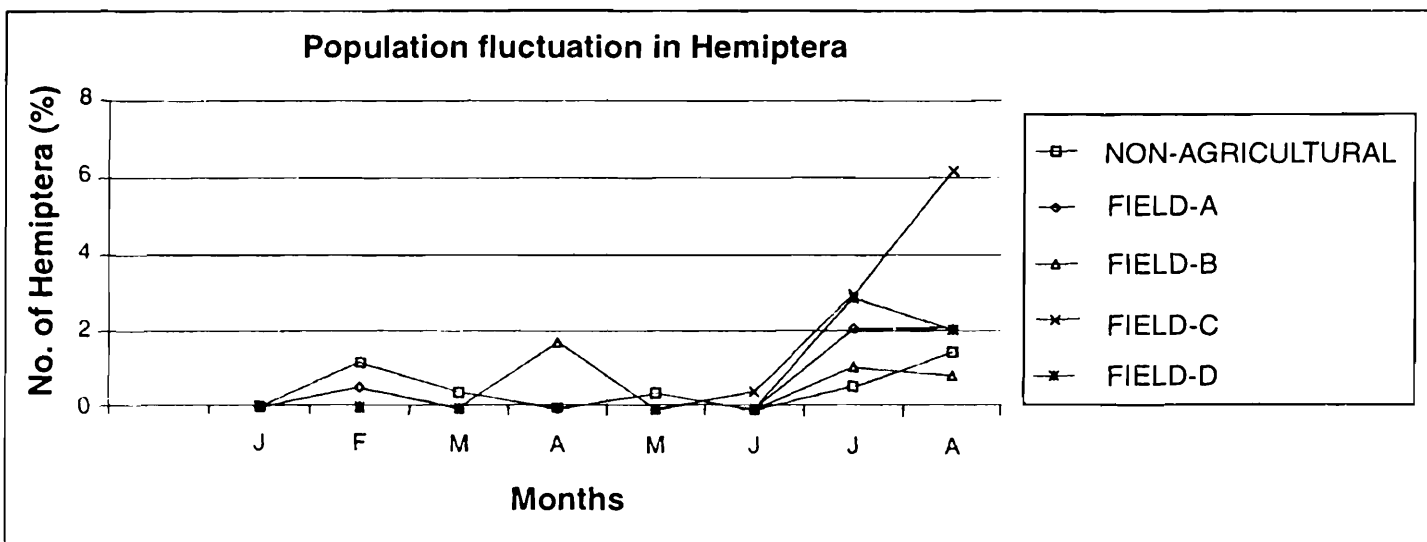


Fig. 5

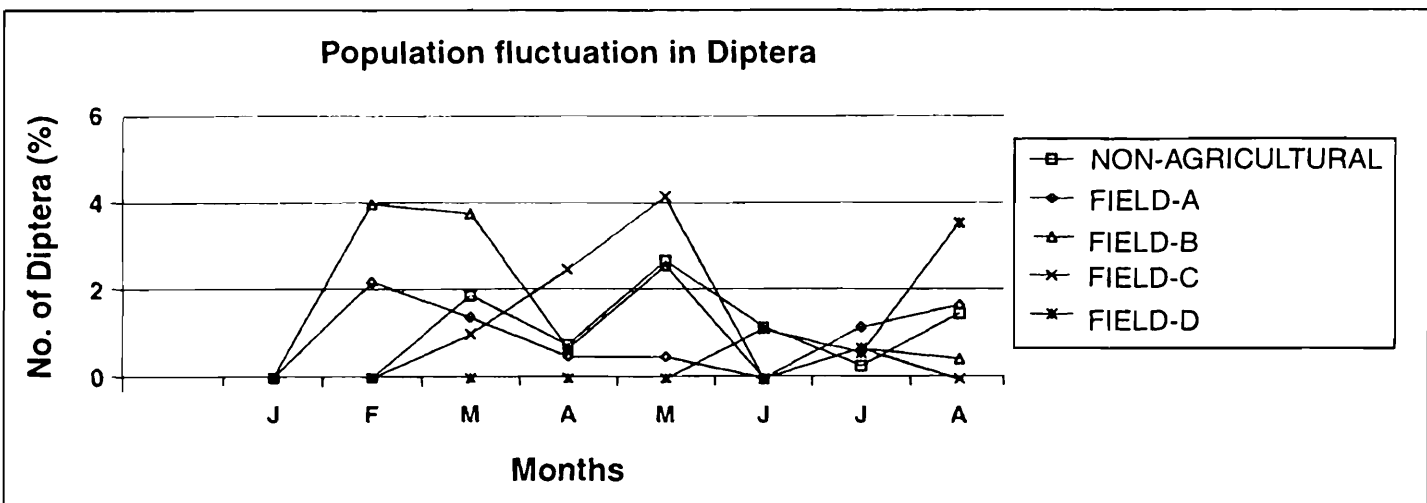


Fig. 6

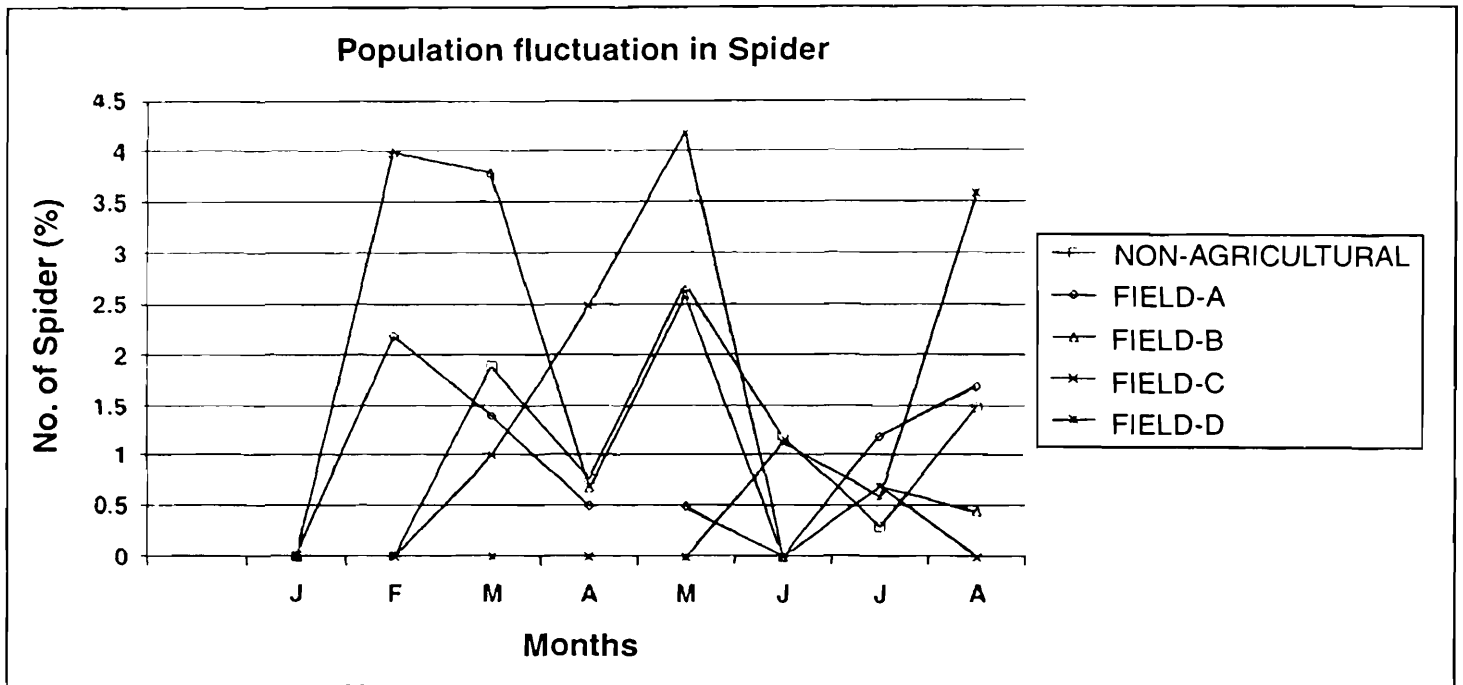


Fig. 7

fields for a long time, the number of soil microarthropods also increased. Majumder and Deb (1991a, 1991b) also reported that microarthropod population was poor in cultivated fields and suggested a crop-dependent association.

SUMMARY

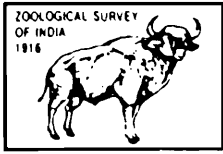
The seasonal abundance of soil inhabiting arthropod fauna and their interrelationship with the edaphic factors like temperature and moisture in agricultural and non-agricultural fields in West Bengal were studied. The soil arthropods were extracted with the help of modified Tullgren funnel apparatus. Altogether 7,412 arthropods belonging to 7 groups were extracted from 170 soil samples collected at fifteen days interval during the period from January, 2006 to August, 2006 except the fields-C and D where samples were collected during March – August, '06 and May – August, '06 respectively. Acarina was the most dominant (67.25% of the total population) group which was followed by Collembola and Hymenoptera. The fauna of non-agricultural site was quantitatively rich as compared to the agricultural fields because of application of different fertilizers, pesticides and also crop rotations. The arthropod population showed seasonal variation with peak in June-July in all the sites.

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A CHECKLIST OF AQUATIC AND SEMIAQUATIC HEMIPTERA (INSECTA) OF MADHYA PRADESH

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INTRODUCTION

The aquatic and semi-aquatic groups of insects are highly specialized and constitute a significant level of diversity (Pennak, 1978; Ghosh, 1996). Among them, the aquatic and semi-aquatic heteropterans form food in different trophic levels of freshwater ecosystem. These bugs are overall indicators of long term environmental conditions and constitute integral components of almost all freshwater communities (Hynes, 1984; Patrick & Palavage, 1994; Ramakrishna, 2000). Because of their poor dispersal capabilities, this group of bugs serves as zoogeographical indicators for diverse habitats (Jordon, 1951; Hungerford & Matsuda, 1958). Further, some members belonging to the families of infraorder Nepomorpha are useful in the biological control of mosquito larvae (Jenkins, 1964). Besides, a few species of corixids are known as indicators of water quality. Moreover, studies also indicate that the quality of aquatic environment is partially dependent on the abundance of aquatic bug population (Murdoch, *et al.*, 1984; Thirumalai & Raghunathan, 1988). Thus, the inventerisation of aquatic insects becomes imperative to understand the functional aspects of community structure in any aquatic ecosystem and provides information of energy flow (Ananthakrishnan, 1989).

The aquatic and semi-aquatic fauna of India is represented by 79 genera and 284 species accommodated in 15 major families as against 302 genera and 3946 species in 19 recognized families globally (Thirumalai, 1999 & 2002, Thirumalai, 2007 and Thirumalai & Krishnan, press). The aquatic and semi-aquatic bugs of Madhya Pradesh belonging to the infraorders Gerromorpha and Nepomorpha received only rather cursory attention, limited to taxonomic preliminaries including recording of species from different parts of the state. However, the work of Agarker *et al.*, (1994) and Thirumalai (2002) throw some light on the fauna from the state. The present checklist includes the study of aquatic and semi-aquatic heteropterans collection present in Zoological Survey of India, Jabalpur

**Zoological Survey of India, Central Regional Station, Jabalpur - 482 002*

which comprises of 57 species belonging to 27 genera accommodated in 13 families, revealing the rich diversity of aquatic and semi-aquatic bugs occurring in this table land of Central India. This study also records the occurrence of 3 families, Aphelocheiridae, Naucoridae, Ochteridae and 33 species first time from the state. Under each species citation of the original description and other accompanying work necessary to understand the taxon or its occurrence in India is also provided.

Table 1 : Families, habitats, species of Gerromorpha & Nepomorpha associated with water.

Family	Habitat	World	India	Madhya Pradesh
	Infraorder GERROMORPHA			
Gerridae	→ (water striders)-surface of fresh & brackish waters (sea)	696	79	11
Hebridae	→ (velvet water bugs)-marshes & wet riparian mosses Infraorder Nepomorpha	192	15	1
Hydrometridae	→ (water measurers)-surface of calm waters	125	3	1
Mesoveliidae	→ (water treaders)-vegetated banks of ponds & lakes	46	3	1
Veliidae	→ (riffle bugs)-surface of ponds & streams, also brackish	876	31	3
	Infraorder NEPOMORPHA			
Aphelocheiridae	→ (bottom bugs) lentic & lotic	63	5	1
Belostomatidae	→ (giant water bugs)-ponds, on vegetation	143	6	4
Corixidae	→ (water boatmen)-fresh & brackish lentic waters	552	48	10
Gelastocoridae	→ (toad bugs)-shorelines, in mud & plant debris	103	4	No report
Helotrephidae	→ (beetle back-swimmers) ponds & lakes, on vegetation	171	13	No report
Naucoridae	→ (creeping water bugs)-lentic & lotic, stones & vegetation	325	17	2
Nepidae	→ (water scorpions)-ponds, on vegetation	230	24	9
Notonectidae	→ (back-swimmers)-ponds and lakes	347	31	11
Ochteridae	→ (shore bugs)-stream margins, pond vegetation	36	1	1
Pleidae	→ (pygmy back-swimmers)-ponds & lakes, on vegetation	36	4	2

AQUATIC AND SEMI-AQUATIC HETEROPTERA OF MADHYA PRADESH

Order HEMIPTERA

Suborder HETEROPTERA

Infraorder GERROMORPHA POPOV, 1971

Superfamily MESOVELIOIDEA Douglas & Scott, 1867

Family MESOVELIIDAE Douglas & Scott, 1867

Subfamily MESOVELIINAE Douglas & Scott, 1867

Genus *Mesovelia* Mulsant & Rey, 18521. *Mesovelia vittigera* Horvath, 18951895. *Mesovelia vittigera* Horvath *Revue. ent.*, **14** : 160.1994. *Mesovelia vittigera* Horvath : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 28.1903. *Mesovelia mulsanti* White : Distant, *Fauna British India*, **2** : 169.1901. *Mesovelia orientalis* Kirkaldy, *Annali Mus. civ. Stor. Nat. Giacomo Doria*, **20** : 808.2002. *Mesovelia vittigera* Horvath : Thirumalai, *Rec. zool. Surv. India*, **100** : 73.

Superfamily HYDROMETROIDEA Billberg, 1820

Family HYDROMETRIDAE Billberg, 1820

Subfamily HYDROMETRINAE Esaki, 1927

Genus *Hydrometra* Latreille, 17962. *Hydrometra greeni* Kirkaldy, 18981898. *Hydrometra greeni* Kirkaldy, *Entomologist*, **31** : 2.1994. *Hydrometra greeni* Kirkaldy : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 29.1995. *Hydrometra greeni* Kirkaldy : Polhemus & Polhemus, *Bishop Mus. Occ. Pap.*, **43** : 22.2002. *Hydrometra greeni* Kirkaldy : Thirumalai, *Rec. zool. Surv. India*, **100** : 79.1903. *Hydrometra vittata* (Stål) : Distant, *Fauna British India*, **2** : 170.

Superfamily GERROIDEA Reuter, 1910

Family VELIIDAE Amyot & Serville, 1843

Subfamily MICROVELIINAE

Genus *Microvelia* Westwood, 1834Subgenus *Microvelia* Westwood, 18343. *Microvelia (Microvelia) annandalei* Distant, 19091909. *Microvelia annandalei* Distant., *Ann. Mag. nat. Hist.*, **3**(8) : 501.1989. *Microvelia annandalei* Distant : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **118** : 52.2002. *Microvelia annandalei* Distant : Thirumalai, *Rec. zool. Surv. India*, **100** : 72.

Subgenus *Picaultia* Andersen & Weir, 20034. *Microvelia (Picaultia) douglasi* Scott, 1874

1874. *Microvelia douglasi* Scott, *Ann. Mag. nat. Hist.*, **14** : 448.
 1903. *Microvelia repentiana* Distant, *Fauna Brit. India*, **3** : 174.
 1909. *M. kumaonensis* Distant, *Ann. Mag. nat. Hist.*, **3(8)** : 500.
 1995. *Microvelia (Microvelia) douglasi* Scott : Andersen, *Cat. Het. Palaearctic Region*, **1** : 87.
 2002. *Microvelia (Microvelia) douglasi* Scott : Thirumalai, *Rec. zool. Surv. India*, **100** : 73.
 2003. *Microvelia (Picaultia) douglasi* Scott : Andersen and Weir. *Invertebrate Systematic*, **17** : 338.
 2006. *Microvelia (Picaultia) douglasi* Scott : Thirumalai & Suresh Kumar, *Zool. Surv. India Fauna of Conservation Area Series*, **27** : 79.

Subfamily RHAGOVELIINAE China & Usinger, 1949

Genus *Rhagovelia* Mayr, 1865Subgenus *Rhagovelia* Mayr, 18655. *Rhagovelia (Rhagovelia) ceylanica* Lundblad, 1936

1936. *Rhagovelia ceylanica* Lundblad, *Ark. Zool.*, **28(21)** : 32.
 1910. *Rhagovelia nigricans* (Burmeister) : Distant, *Fauna British India*, **5** : 132.
 1989. *R. (Rhagovelia) ceylanica* Lundblad : Thirumalai., *Misc. Occ. Pap. Rec. zool. Surv. India*, **118** : 51.
 1994. *R. (Rhagovelia) ceylanica* Lundblad : Thirumalai, *Rec. zool. Surv. India*, **94** : 386.
 2002. *R. (Rhagovelia) ceylanica* Lundblad : Thirumalai, *Rec. zool. Surv. India*, **100** : 75.

Family GERRIDAE

Subfamily GERRINAE

Genus *Aquarius* Schellenberg, 18006. *Aquarius adelaidis* (Dohrn, 1860)

1860. *Aquarius adelaidis* Dohrn., *Stettin. ent. Ztg.*, **21** : 408.
 1896. *Gerris spinolae* Leth. & Ser., *Cat. gen. Hemiptera*, **3** : 63.
 1903. *Gerris spinolae* Leth. & Ser. : Distant., *Fauna British India*, **2** : 180.
 1990. *Aquarius adelaidis* (Dohrn) : Andersen., *Steenstrupia*, **16(4)** : 61.
 1994. *Gerris spinolae* Leth. & Ser. : Agarker *et al.*, *Bionature*, **14** : 78.
 2002. *Aquarius adelaidis* (Dohrn) : Thirumalai., *Rec. zool. Surv. India*, **100(1-2)** : 60.

Genus *Neogerris* Matsumura, 19137. *Neogerris parvula* (Stål, 1859)

1859. *Gerris parvula* Stål, *Zoology*, **4** : 265.
 1934. *Limnogonus parvulus* (Stål) : Lundblad, *Arch. Hydrobiol. Suppl.*, **12** : 384.

1959. *L. (Limnagonellus) parvulus* (Stål) : Hungerford & Matsuda, *J. Kans. Ent. Soc.*, **32**(1) : 41.
 1961. *L. (Neogerris) parvulus* (Stål) : Hungerford & Matsuda., *Insecta matsum.*, **24** : 114.
 1975. *Neogerris parvula* (Stål) : Andersen, 1975. *Ent. Scand. Suppl.*, **7** : 86.
 2002. *Neogerris parvula* (Stål) : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 63.
 1899. *Gerris tristan* Kirkaldy, *Revue. Ent.*, **18** : 88.

Genus *Limnagonus* Stål, 1868

Subgenus *Limnagonus* Stål, 1868

8. *Limnagonus (Limnagonus) nitidus* (Mayr, 1865)

1865. *Hydrometra nitida* Mayr, *Verh. zool.-bot. Ges. Wien*, **15** : 443.
 1903. *Gerris nitida* (Mayr) : Distant, *Fauna British India*, **2** : 178.
 1908. *Limnagonus nitidus* (Mayr) : Kirkaldy, *Wissenschaft Ergebn. der Schwed. Zool. Exped. nach dem Kilimandjaro*, **12** : 21.
 1975. *L. (Limnagonus) nitidus* (Mayr) : Andersen, *Ent. Scand. Suppl.*, **7** : 62.
 2002. *L. (Limnagonus) nitidus* (Mayr) : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 62.

9. *Limnagonus (Limnagonus) fossarum fossarum* (Fabricius, 1775)

1775. *Cimex fossarum* Fabricius, *Syst. Ent.*, 727.
 1903. *Gerris fossarum* (Fabricius) : Distant, *Fauna British India*, **2** : 178.
 1868. *Limnagonus fossarum* Stål, *K. Svenska Vetensk. Akad.*, **7** : 133.
 1975. *L. (L) fossarum* (Fabricius) : Andersen, *Ent. Scand. Suppl.*, **7** : 30;
 2002. *L. (L) fossarum* (Fabricius) : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 62.

Genus *Limnometra* Mayr, 1865

10. *Limnometra fluviorum* (Fabricius, 1798)

1798. *Cimex fluviorum* Fabricius, *Ent. Syst. Suppl.*, 543.
 1903. *Gerris fluviorum* (Fabricius) : Distant, *Fauna British India*, **2** : 177.
 1958. *Limnometra fluviorum* (Fabricius) : Hungerford & Matsuda, *Kans. Univ. Sci. Bull.*, **39** : 401.
 1960. *Tenagogonus (Limnometra) fluviorum* (Fab.) : Matsuda, *Kans. Univ. Sci. Bull.*, **41** : 206.
 2002. *Limnometra fluviorum* (Fabricius) : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 63.
 2006. *Limnometra fluviorum* (Fabricius) : Thirumalai & Suresh Kumar, *Zool. Surv. India Fauna of Conservation Area Series*, **27** : 24.
 1903. *Gerris armata* Spinola : Distant, *Fauna British India*, **2** : 180.

Subfamily EOTRECHINAE Matsuda, 1960

Genus *Amemboa* Esaki, 1925

Subgenus *Amemboa* Esaki, 1925

11. *Amemboa (Amemboa) kumari* (Distant, 1910)

1910. *Onychotrechus kumari* Distant, *Ann. Mag. nat. Hist.*, **5** : 145.
 1984. *Amemboa (Amemboa) kumari* (Distant) : Polhemus & Andersen, *Steenstrupia*, **10**(3) : 85.
 2002. *Amemboa (Amemboa) kumari* (Distant) : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 58.
 1950. *Amemboa pervati* Pradhan, *Rec. Indian Mus.*, **48**(3 & 4) : 12.

Subfamily CYLINDROSTETHINAE

Genus *Cylindrostethus* Mayr, 1865

12. *Cylindrostethus productus* (Spinola, 1840)

1840. *Gerris productus* Spinola, Esaki. *Sur less insectes hemipteres rhynchotes on heteropteres*, 64.
 1903. *Cylindrostethus productus* (Spinola) : Distant, *Fauna British India*, **2** : 184.
 1994. *Cylindrostethus productus* (Spinola) : Polhemus., *Bishop Mus. Occ. Pap.*, **38** : 10.
 2002. *Cylindrostethus productus* (Spinola) : Thirumalai., *Rec. zool. Surv. India*, **100**(1-2) : 58.
 2006. *Cylindrostethus productus* (Spinola) : Thirumalai & Suresh Kumar, *Zool. Surv. India Fauna of Conservation Area Series*, **27** : 73.
 1910. *Janias elegantulus* Distant., *Ann. Mag. nat. Hist.*, **5**(8) : 145.

Subfamily PTILOMERINAE

Genus *Ptilomera* Amyot & Serville, 1843

Subgenus *Ptilomera* Amyot & Serville, 1843

13. *Ptilomera (Ptilomera) agroides* Schmidt, 1926

1926. *Ptilomera agroides* Schmidt, *Ent. Mitt.*, **15**(1) : 63.
 1903. *Ptilomera laticaudata* (Hardwicke) : Distant, *Fauna Brit. India*, **2** : 185 (Fig : 133).
 1960. *Ptilomera (Ptilomera) agroides* Schmidt : Matsuda, *Kans. Univ. Sci. Bull.*, **41**(2) : 269.
 2002. *Ptilomera (Ptilomera) agroides* Schmidt : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 69.
 2006. *Ptilomera (Ptilomera) agroides* Schmidt : Thirumalai & Suresh Kumar, *Zool. Surv. India, Fauna of Conservation Area Series*, **27** : 77.
 1926. *Ptilomera lachne* Schmidt, *Ent. Mitt.*, **15**(1) : 64.

Genus *Stridulobates* Zettel & Thirumalai, 2001

14. *Stridulobates anderseni* Zettel & Thirumalai, 2001

2001. *Stridulobates anderseni* Zettel & Thirumalai, *Insect Syst. Evol.* : **31** : 434.
 2004. *Stridulobates anderseni* Zettel & Thirumalai : *Rec. zool. Surv. India*, **102**(1-2) : 62.
 2004. *Stridulobates anderseni* Zettel & Thirumalai : Thirumalai *et al.*, *Zool. Surv. India. Fauna of Conservation Area Series*, **20**, *Fauna of Pench National Park* : 248.

Subfamily HALOBATINAE

Tribe METROCORINI Matsuda, 1960

Genus *Metrocoris* Mayr, 186515. *Metrocoris communis* (Distant, 1910)

1910. *Euodus communis* Distant, *Ann. Mag. nat. Hist.*, **5**(8) : 151.
 1929. *Metrocoris communis* (Distant) : Esaki, *Ann. Mag. nat. Hist. Soc.*, **4**(10) : 419.
 1965. *Metrocoris communis* (Distant) : Den Boer, *Zool. Verh. Leiden.*, **74** : 13.
 1993. *Metrocoris communis* (Distant) : Chen & Nieser., *Steenstrupia*, **19**(2) : 49.
 2002. *Metrocoris communis* (Distant) : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 65.
 2006. *Metrocoris communis* (Distant) : Thirumalai & Suresh Kumar, *Zool. Surv. India Fauna of Conservation Area Series*, **27** : 77.

16. *Metrocoris communoides* Chen & Nieser, 1993

1993. *Metrocoris communoides* Chen & Nieser, *Steenstrupia*, **19**(2) : 51.
 2002. *Metrocoris communoides* Chen & Nieser : Thirumalai, *Rec. zool. Surv. India*, **100**(1-2) : 66.

Family HEBRIDAE

Subfamily HEBRINAE

Genus *Hebrus* Curtis, 1833Subgenus *Hebrus* Curtis, 183317. **Hebrus (Hebrus) orientalis* Distant, 1903

1903. *Hebrus orientalis* Distant : *Fauna British India*, **2** : 167.
 1994. *Hebrus orientalis* Distant : Agarker *et al.*, *Bionature*, **14** : 78.

*Agarkar *et al.*, (1994) identification of this species is doubtful. This species is known from Myanmar.

Infraorder NEPOMORPHA

Superfamily NEPOIDEA Latreille, 1802

Family BELOSTOMATIDAE Leach, 1815

Subfamily BELOSTOMATINAE Leach, 1815

Genus *Diplonychus* Laporte, 183318. *Diplonychus annulatus* (Fabricius, 1781)

1781. *Nepa annulata* Fabricius, *Carol. Ernest. Bokhni. Hamburgi et Kiloni*, 333.
 1832. *Belostoma marginata* Gray, *Griffith's Animal King., Insecta.*, **2** : 248.
 1833. *Sphaerodema rotundata* Laporte, *Systematique Hemipteres, zoologie, Paris* : 18.
 1863. *Sphaerodema annulatum* (Fabricius) : Dufour, *Ann. Soc. Entomol. France*, (4)**3** : 397.

1906. *Sphaerodema annulatum* (Fabricius) : Distant, *Fauna British India*, **3** : 35.
 1994. *Sphaerodema annulatum* (Fabricius) : Agarker *et al.*, *Bionature*, **14** : 77.
 1995. *Diplonychus annulatus* (Fabr.) : Polhemus *et al.*, *Proc. Entomol. Soc. Washington*, **97** : 651.
 2002. *Diplonychus annulatus* (Fabr.) : Thirumalai, Metha & Sharma, *Res. Bull. Panjab Univ.*, **52** : 157.
 1985. *Abedus sangameshwari* Rupavathi, *Ph.D Dissertation, Nagarjuna University, Andhra Pradesh*, 169.

19. *Diplonychus molestus* (Dufour, 1863)

1863. *Appasus molestum* Dufour, *Ann. Soc. Ent. France*, (4)**3** : 395.
 1871. *Diplonychus molestum* (Dufour) : Mayr, *Verh. zool.-bot. Ges. Wien*, **21** : 437.
 1906. *Sphaerodema molestum* (Dufour) : Distant, *Fauna British India Rhyn.*, **3** : 36.
 1947. *Sphaerodema molestum* (Dufour) : Hafiz and Pradhan, *Rec. Indian Mus.*, **45** : 374.
 2000. *Diplonychus molestus* (Dufour) : Ramakrishna, *Rec. Zool. Surv. India*, **98** : 183.
 2002. *Diplonychus molestus* (Dufour) : Thirumalai, Metha & Sharma, *Res. Bull. Panjab Univ.*, **52** : 157.
 2004. *Diplonychus molestus* (Dufour) : Bal & Basu, *Zool. Surv. India, State Fauna Series*, **10** : 302.
 1871. *Diplonychus subrhombus* Mayr, *Verh. zool.-bot. Ges. Wien*, **21** : 437.

20. *Diplonychus rusticus* (Fabricius, 1781)

1781. *Nepa rustica* Fabricius, *Species insectorum*, **2** : 333.
 1868. *Diplonychus rusticus* (Fab.) : Mayr *Zoolog. TeilWien*, 188.
 1871. *Diplonychus rusticum* (Fab.) : Mayr, *Verh. zool.-bot. Ges. Wien*, **21** : 437.
 1906. *Sphaerodema rusticum* (Fab.) : Distant, *Fauna British India*, **3** : 36.
 1915. *Sphaerodema rustica* (Fab.) : Bergroth, *J. Bombay nat. Hist.*, **24** : 179.
 1934. *Diplonychus rusticum* (Fab.) : Lundblad, *Arch. Hydrobiol. Suppl.*, **12** : 55.
 1961. *Diplonychus rusticus* (Fab.) : Lauck & Menke., *Ann. Entomol. Soc. Amer.*, **54** : 649.
 1994. *Diplonychus rusticus* (Fab.) : Thirumalai, *Misc. Occ. Pap. Rec. Zool. Surv. India*, **165** : 25.
 1995. *Diplonychus rusticus* (Fab.) : Polhemus *et al.*, *Proc. Entomol. Soc. Wash.*, **97** : 651.
 2005. *Diplonychus rusticus* (Fab.) : Thirumalai & Suresh Kumar, *Rec. zool. Surv. India*, **105** : 13.
 1776. *Nepa plana* Sulzer, *abgek. Gesch. Insect*, 92.
 1863. *Appasus marginicollis* Dufour, *Ann. Soc. Ent. France*, (4)**3** : 393.
 1980. *Diplonychus indicus* Venkatesan & Rao, *J. Bombay. Nat. Hist. Soc.*, **77** : 299.

Subfamily LETHOCERINAE Lauck & Menke, 1961

Genus *Lethocerus* Mayr, 1853

Subgenus *Lethocerus* Mayr, 1853

21. *Lethocerus indicus* (Lepeletier & Serville, 1825)

1825. *Belostoma indica* Lepeletier & Serville, *Encycl. Meth.*, **X** : 272.
 1871. *Belostoma indicum* Lepeletier & Serville : Mayr, *Verh. zool.-bot. Ges. Wien*, **21** : 426.

1906. *Belostoma indicum* (Lepeletier & Serville) : Distant, *Fauna British India*, **3** : 38.
 1911. *Belostoma indica* Lepeletier & Serville : D'Abreu, *J. Bombay nat. Hist.*, **20** : 883.
 1934. *Lethocerus indicus* (Lep. & Serv.) : Lundblad, *Arch. Hydrobiol. Suppl.*, **12** : 52.
 1939. *Lethocerus indicus* (Lep. & Serv.) : Hafiz & Ribeiro, *Rec. Indian Mus.*, **41**(4) : 432.
 2004. *Lethocerus indicus* (Lep. & Serv.) : Thirumalai, *Rec. zool. Surv. India*, **102**(1-2) : 67.
 1901. *Amorgius indicus* Kirkaldy, *Entomologist*, **34** : 51.

Family NEPIDAE Latreille, 1802

Subfamily NEPINAЕ Latreille, 1802

Tribe NEPINI Latreille, 1802

Genus *Laccotrephes* Stål, 1866

22. *Laccotrephes griseus* (Güerin-Méneville, 1844)

1844. *Nepa griseus* Güerin-Méneville, *Iconoogr. Regne. Anim. Ins.*, 352.
 1910. *Laccotrephes griseus* (Güerin-Méneville) : Distant, *Fauna British India*, **5** : 314.
 1994. *Laccotrephes griseus* (Güerin-Méneville) : Thirumalai, *Misc. Occ. Pap. Rec. Zool. Surv. India*, **165** : 21.
 2001. *Laccotrephes griseus* (Güerin-Méneville) : Thirumalai, ZSI, *Fauna of Conservation Area*, **11** : 118.
 2004. *Laccotrephes griseus* (Güerin-Méneville) : Thirumalai, *Rec. zool. Surv. India*, **102** : 66.
 2006. *Laccotrephes griseus* (Güerin-Méneville) : Thirumalai & Suresh Kumar, *Rec. zool. Surv. India*, **105** : 11.

23. *Laccotrephes ruber* (Linnaeus, 1764)

1764. *Nepa ruber* Linnaeus, *Mus. Lud. Ulr.*, 165.
 1906. *Laccotrephes ruber* (Linn.) : Distant, *Fauna Brit. India*, **3** : 18.
 1981. *Laccotrephes robustus* Stål : Selvanayagam & Rao, *J. Bombay, Nat. Hist.*, **78** : 621.
 1994. *Laccotrephes ruber* (Linn.) : Thirumalai, *Misc. Occ. Pap. Rec. Zool. Surv. India*, **165** : 22.
 2004. *Laccotrephes ruber* (Linn.) : Bal & Basu, *Zool. Surv. India, State Fauna*, **10** : 298.
 2006. *Laccotrephes ruber* (Linn.) : Thirumalai & Suresh Kumar, *Rec. zool. Surv. India*, **105** : 11.

Subfamily RANATRINAE Douglas & Scott, 1865

Tribe RANATRINI Douglas & Scott, 1865

Genus *Cercotmetus* Amyot & Serville

24. *Cercotmetus brevipes* Montandon, 1909

1909. *Cercotmetus brevipes* Montandon, *Annl. Hist. Nat. Mus. nat. Hung.*, **7** : 65.
 1934. *Cercotmetus brevipes* Montandon : Lundblad, *Arch. Hydrobiol. Suppl.*, **12** : 48.
 1973. *Cercotmetus brevipes* Montandon : Lansbury, *Tijdschrift Voor Entomol.*, **116** : 92.
 1995. *Cercotmetus brevipes* Montandon : Polhemus *et al.*, *Cat. Het. Palaearctic region*, **1** : 17.

25. *Cercotmetus fumosus* Distant, 1904

1904. *Cercotmetus fumosus* Distant, *Entomologist*, **37** : 278.
 1906. *Cercotmetus fumosus* Distant : *Fauna Brit. India*, **3** : 23.
 1947. *Cercotmetus fumosus* Distant : Hafiz & Pradhan, *Rec. Indian Mus.*, **45** : 361.
 1973. *Cercotmetus fumosus* Distant : Lansbury, *Tijdschrift Voor Entomol.*, **116** : 100.
 2001. *Cercotmetus fumosus* Distant : Thirumalai, ZSI, *Fauna of Conservation Area*, **11** : 118.

Genus *Ranatra* Fabricius, 1790

26. *Ranatra digitata* Hafiz & Pradhan, 1947

1947. *Ranatra digitata* Hafiz & Pradhan, *Rec. Indian Mus.*, **45** : 361.
 1972. *Ranatra digitata* Hafiz & Pradhan : Lansbury, *Trans. R. ent. Soc. Lond.*, **124** : 337.

27. *Ranatra elongata* Fabricius, 1790

1790. *Ranatra elongata* Fabricius, *Skrif. Nat. Selesk.*, **1** : 228.
 1906. *Ranatra elongata* Fabricius : Distant, *Fauna Brit. India*, **3** : 18.
 1947. *Ranatra elongata* Fabricius : Hafiz & Pradhan, *Rec. Indian Mus.*, **45** : 368.
 1972. *Ranatra elongata* Fabricius : Lansbury, *Trans. R. Ent. Soc. Lond.*, **124** : 306.
 1994. *Ranatra elongata* Fabricius : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 22.
 2004. *Ranatra elongata* Fabricius : Thirumalai, *Rec. zool. Surv. India*, **102**(1-2) : 66.

28. *Ranatra filiformis* Fabricius, 1790

1790. *Ranatra filiformis* Fabricius, *Skrit. Nat. Selsk.*, **1** : 228.
 1906. *Ranatra filiformis* Fabricius : Distant, *Fauna British India*, **3** : 21.
 1972. *Ranatra filiformis* Fabricius : Lansbury, *Trans. R. Ent. Soc. Lond.*, **124** : 321.
 1994. *Ranatra filiformis* Fabricius : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 22.
 2001. *Ranatra filiformis* Fabricius : Thirumalai, ZSI, *Fauna of Conservation Area*, **11** : 118.
 1860. *Ranatra sordidula* Dohrn, *Stett. ent. Zeit.*, **21** : 409.

29. *Ranatra titilaensis* Hafiz & Pradhan, 1947

1947. *Ranatra titilaensis* Hafiz & Pradhan, *Rec. Indian Mus.*, (**45**) : 369.
 1972. *Ranatra titilaensis* Hafiz & Pradhan : Lansbury, *Trans. R. Ent. Soc. Lond.*, **124** : 338.

30. *Ranatra varipes atrophha* Montandon, 1903

1903. *Ranatra atrophha* Montandon, *Bull. Soc. Sci. Bucarest*, **12** : 105.
 1907. *Ranatra varipes atrophha* Montandon, *Ann. Soc. Ent. France*, **76** : 57.
 1972. *Ranatra varipes* var *atrophha* Mayr : Lansbury, *Trans. R. Ent. Soc. Lond.*, **124** : 317.
 1998. *Ranatra varipes atrophha* Montandon : Nieser & Polhemus, *Amemboa*, **2** : 22.
 2005. *Ranatra varipes atrophha* Montandon : Thirumalai & Suresh Kumar, *Rec. zool. Surv. India*, **105** : 12.

Superfamily OCHTEROIDEA Kirkaldy, 1906

Family OCHTERIDAE Kirkaldy, 1906

Genus *Ochterus* Latreille, 1807

Subgenus *Ochterus* Latreille, 1807

31. *Ochterus marginatus marginatus* (Latreille, 1804)

1804. *Acanthia marginata* Latreille, *Hist. Nat. Crust. Ins. Paris*, **12** : 242.
 1807. *Pelogonus marginatus* Latreille, *Gen. Crust. Ins. Paris*, **3** : 143.
 1910. *Pelogonus marginatus* (Latreille) : Distant, *Fauna British India*, **5** : 310.
 1934. *Ochterus marginatus marginatus* (Latreille) : Jaczewski, *Ann. Mag. nat. Hist.*, **13** : 602.
 1971. *Ochterus marginatus* (Latreille) : Kormilev, *Pac. Ins.*, **13** : 433.
 1989. *Ochterus marginatus marginatus* (Latreille) : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **118** : 9.
 2001. *Ochterus marginatus marginatus* (Latreille) : Thirumalai, *Fauna Conservation Area Series*, **11** : 113.
 2004. *Ochterus marginatus* (Latreille) : Bal & Basu, *State Fauna Series*, **10** : 295.
 1874. *Pelogonus flavomarginatus* Scott, *Ann. Mag. nat. Hist.*, **14** : 446.
 1915. *Pelogonus formosanus* Matsumura, *Ent. Mag. Kyoto*, **1** : 103.

Superfamily CORIXOIDEA Leach, 1815

Family CORIXIDAE Leach, 1815

Subfamily CORIXINAE Leach, 1815

Genus *Sigara* Fabricius, 1775

Subgenus *Tropocorixa* Hutchinson, 1940

32. *Sigara (Tropocorixa) distorta* (Distant, 1910)

1910. *Corixa distorta* Distant, *Fauna British India*, **5** : 343.
 1933. *Sigara distorta* (Distant) : Hutchinson, *Rec. Indian Mus.*, **35** : 403.
 1940. *Corixa (Tropocorixa) distorta* Distant : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 440.
 1947. *Corixa (Tropocorixa) distorta* Distant : Hafiz & Pradhan, *Rec. Indian Mus.*, **45** : 356.
 1994. *Corixa distorta* Distant : Agarker *et al.*, *Bionature*, **14** : 78.
 1995. *Sigara (Tropocorixa) distorta* (Distant) : Polhemus *et al.*, *Cat. Het. Palaerctic Region*, **1** : 54.
 2004. *Corixa (Tropocorixa) distorta* Distant : Bal & Basu, *Zool. Surv. India, State Fauna Series*, **10** : 297.
 1910. *Corixa affinis* Distant, *Fauna British India*, **5** : 341.
 1910. *Corixa verecunda* Distant, *Fauna British India*, **5** : 344.

33. *Sigara (Tropocorixa) graveleyi* (Hutchinson, 1940)

1940. *Corixa (Tropocorixa) graveleyi* Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 453.
 1989. *Corixa (Tropocorixa) graveleyi* Hutchinson : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **118** : 12.

2001. *Sigara (Tropocorixa) graveleyi* Hutchinson : Thirumalai, *Fauna Conservation area*, **11** : 113.
 2005. *Sigara (Tropocorixa) graveleyi* Hutchinson : Thirumalai & Sharma, *Zool. Surv. India, Conservation area Series*, **24** : 351.
 1910. *Corixa lima* Distant, *Fauna British India*, **5** : 342.

Subfamily MICRONECTINAE Jaczewski, 1924

Genus *Micronecta* Kirkaldy, 1897

Subgenus *Basilonecta* Hutchinson, 1940

34. *Micronecta (Basilonecta) scutellaris scutellaris* (Stål, 1858)

1858. *Sigra scutellaris* Stål, *Vetens akad. Forh.*, **15** : 319.
 1940. *Micronecta (Basilonecta) scutellaris scutellaris* (Stål) : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 365.
 1940. *Micronecta scutellaris pseudostriata* Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 371.
 1947. *Micronecta (Basilonecta) scutellaris scutellaris* (Stål) : Hafiz and Pradhan, *Rec. Indian. Mus.*, **45** : 354.
 1994. *Micronecta (Basilonecta) scutellaris scutellaris* (Stål) : Thirumalai, *Misc. Occ. Pap. Rec. Zool. Surv. India*, **165** : 9.
 1997. *Micronecta scutellaris* (Stål) : Sarala & Venkatesan, *Hexapoda*, **9** : 41.
 2004. *Micronecta (Basilonecta) scutellaris scutellaris* (Stål) : Thirumalai, *Rec. Zool. Surv. India*, **102** : 68.
 2005. *Micronecta (Basilonecta) scutellaris scutellaris* (Stål) : Thirumalai & Sharma, *Zool. Surv. India, Fauna of Melghat Tiger Reserve Conservation area Series*, **24** : 352.
 1908. *Micronecta malabarica* Kirkaldy, *Canad. Ent.*, **40** : 209.
 1910. *Micronecta dione* Distant, *Fauna Brit. India*, **5** : 348.
 1910. *Micronecta proba* Distant, *Fauna Brit. India*, **5** : 348.

Subgenus *Dichaetonecta* Hutchinson, 1940

35. *Micronecta (Dichaetonecta) albifrons* (Motschoulsky, 1863)

1863. *Corixa albifrons* Motschoulsky, *Bull. Soc. Nat. Moscou*, **36** : 94.
 1897. *Sigara albifrons* (Motschoulsky) : Kirkaldy, *Entomologist*, **30** : 240.
 1940. *Micronecta (Dichaetonecta) albifrons* (Motschoulsky) : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 379.
 1940. *Micronecta (Dichaetonecta) albifrons albifrons* (Motschoulsky) : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 380.
 1940. *Micronecta (Dichaetonecta) albifrons albifrons* trans ad *striatella* Lundblad : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 381.
 1940. *M. albifrons striatella* Lundblad : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 382.
 1960. *Micronecta albifrons* (Motschoulsky) : Chen, *J. Kans. ent. Soc.*, **33** : 116.29.
 1999. *Micronecta (Dichaetonecta) albifrons* (Motschoulsky) : Thirumalai, *Zoos Print J.*, **1-10** : 132.

1999. *Micronecta albifrons* (Motschoulsky) : Nieser, *Amemboa*, **3** : 11.

1910. *Micronecta lucina* Distant, *Fauna Brit. India*, **5** : 345.

1960. *Micronecta fascioclavus* Chen, *J. Kans. ent. Soc.*, **33** : 108.

36. *Micronecta (Dichaetonecta) prashadana* Hutchinson, 1940

1940. *Micronecta (Dichaetonecta) prashadana* Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 387.

1950. *Micronecta (Dichaetonecta) prashadana* Hutchinson : Pradhan, *Rec. Indian Mus.*, **48** : 102.

1972. *Micronecta prashadana* Hutchinson : Wróblewski, *Bull. Entomol. Pologne.*, **42** : 16.

1989. *Micronecta (Dichaetonecta) prashadana* Hutchinson : Thirumalai, *Misc. Occ. Pap. Rec. Zool. Surv. India*, **118** : 15.

2001. *Micronecta (Dichaetonecta) prashadana* Hutchinson : Thirumalai, *Fauna conservation area*, **11** : 114.

2004. *Micronecta (Dichaetonecta) prashadana* Hutchinson : Thirumalai, *Rec. Zool. Surv. India*, **102** : 69.

Subgenus *Indonectella* Hutchinson, 1940

37. *Micronecta (Indonectella) grisea* (Fieber, 1844)

1844. *Sigara grisea* Fieber, *Entomol. Mono. Leipzig*, **14**.

1968. *Micronecta (Indonectella) grisea* (Fieber) : Wróblewski, *Bull. Entomol. Pologne.*, **38** : 773.

1972. *Micronecta grisea* (Fieber) : Wróblewski, *Bull. Entomol. Pologne.*, **42** : 23. *India*, **118** : 13.

1995. *Micronecta (Indonectella) grisea* (Fieber) : Polhemus *et al.*, *Cat. Het. Palaerctic region*, **1** : 30.

2002. *Micronecta grisea* (Fieber) : Nieser, *Raffles Bull. Zoology*, **50** : 267.

2004. *Micronecta (Indonectella) grisea* (Fieber) : Thirumalai, *Rec. zool. Surv. India*, **102** : 69.

1910. *Micronecta thyesta* Distant, *Fauna Brit. India*, **5** : 349.

1940. *Micronecta (Indonectella) thyesta* Distant : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 363.

1960. *Micronecta (Indonectella) thyesta* Distant : Chen, *J. Kans. ent. Soc.*, **33** : 117.

1968. *Micronecta (Indonectella) thyesta* Distant : Wróblewski, *Bull. Entomol. Pologne.*, **38** : 772.

1994. *Micronecta (Indonectella) thyesta* Distant : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 8.

2001. *Micronecta (Indonectella) thyesta* Distant : Thirumalai, *ZSI. Fauna Conservation area*, **11** : 115.

Subgenus *Pardanecta* Wroblewski, 1962

38. *Micronecta (Pardanecta) punctata* Horvath, 1904

1904. *Micronecta haliploides* Horvath, *Ann. Hist. Nat. Mus. Hung.*, **2** : 594.

1934. *Micronecta haliploides* Horvath : Lundblad, *Arch. Hydrobiol. Suppl.*, **12** : 104.

1940. *Micronecta (Dichaetonecta) haliploides* Horvath : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 377.

1960. *Micronecta punctata* Fieber : Chen, *J. Kans. ent. Soc.*, **33** : 117.

1977. *Micronecta haliploides* Horvath : Julka, *Oriental Insects*, **11** : 141.

1999. *Micronecta (Pardanecta) haliploides* Horvath : Nieser, *Amemboa*, **3** : 9.

2002. *Micronecta haliploides* Horvath : Nieser, *Raffles Bull. Zoology*, **50** : 267.
2002. *Micronecta (Pardanecta) punctata* Fieber : Thirumalai, *Vistas Entomological Research New Millenium*, **25**.
2004. *Micronecta (Dichaetonecta) haliploides* Horvath : Bal & Basu, *Zool. Surv. India, State Fauna Series*, **10** : 296.
1905. *Micronecta inflatula* Breddin, *Soc. Ent. Zurich*, **20** : 57.
1905. *Micronecta pardalina* Breddin, *Soc. Ent. Zurich*, **20** : 57.
1910. *Micronecta merope* Distant, *Fauna Brit. India*, **5** : 351.

Note : Fieber, 1844 described *Micronecta punctata* in *Sigara* Illiger, 1807 described what is now *Corixa punctata* in *Sigara* so the epitheton *punctata* is not available for *M. punctata* and the next available name should be used *i.e.* *M. haliploides* Horvath, 1904 (Nieser, Personal communication, 2006).

Subgenus *Micronecta* Kirkaldy, 1897

39. *Micronecta (Micronecta) anatolica anatolica* Lindberg, 1922

1922. *Micronecta anatolica* Lindberg, *Not. Ent. Helsingfors*, **2** : 116; *Sci.*, **33** : 359.
1962. *Micronecta anatolica* Lindberg : Wróblewski, *Bull. Acad. Polon. Sci., CI II*, **10** : 33.
1968. *Micronecta anatolica* Lindberg : Wróblewski, *Bull. Entomol. Pologne*, **38** : 754.
1999. *Micronecta anatolica* Lindberg : Nieser, *Amemboa*, **3** : 11.
2002. *Micronecta anatolica* Lindberg : Thirumalai, *Vistas Entomological Research New Millenium*, **25**.
1940. *Micronecta (Micronecta) wui kashmirica* Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 356.
1940. *Micronecta (Micronecta) wui wui trans. ad. kashmirica* Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 358.
1940. *Micronecta (Micronecta)*. cf. *wui. kashmirica* and *poweri* Hutchinson, *Trans. Connecticut Acad. Art.*
1988. *Micronecta wui* Lundblad : Bisht, *Recent Adv. Fish Ecol. Limnology & Conservation*, **124**.

Subgenus *Sigmonecta* Wroblewski, 1962

40. *Micronecta (Sigmonecta) quadririgata* Breddin, 1905

1905. *Micronecta quadririgata* Breddin., *Soc. Ent. Zurich*, **20** : 57.
1940. *Micronecta (Basileonecta) quadririgata* Breddin : Hutchinson, *Trans. Connecticut Acad. Art. Sci.*, **33** : 376.
1947. *Micronecta (Basilonecta) quadririgata* Breddin : Hafiz and Pradhan, *Rec. Indian. Mus.*, **45** : 355.
1962. *Micronecta (Sigmonecta) quadririgata* Breddin : Wróblewski, *Bull. Acad. Pol. Sc. II. Warszawa*, **10** : 176.
1972. *Micronecta (Sigmonecta) quadririgata* Breddin : Wróblewski, *Bull. Entomol. Pologne*, **42** : 29.
1983. *Micronecta quadririgata* Breddin : Rupavathi & Radhakrishna, *J. Aqua. Biol.*, **1** : 66.
1994. *Micronecta (Sigmonecta) quadririgata* Breddin : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 8.

2000. *Micronecta (Sigmonecta) quadristrigata* Breddin : Ramakrishna, *Rec. Zool. Surv. India*, **98** : 183.
 2002. *Micronecta (Sigmonecta) quadristrigata* Breddin : Nieser, *Raffles Bull. Zoology*, **50** : 269.
 2004. *Micronecta (Sigmonecta) quadristrigata* Breddin : Thirumalai, *Rec. zool. Surv. India*, **102** : 70.
 2006. *Micronecta (Sigmonecta) quadristrigata* Breddin : Thirumalai & Sureshkumar, *ZSI. Fauna of Biligiri Rangaswamy Temple Wildlife Sanctuary, Conservation Area Series*, **27** : 71.
 1910. *Micronecta minthe* Distant, *Fauna Brit. India*, **5** : 347.

Position of the subgenus of the following species is not clear

41. *Micronecta tarsalis* Chen, 1960

1960. *Micronecta tarsalis* Chen, *J. Kans. ent. Soc.*, **33** : 114.
 1968. *Micronecta tarsalis* Chen : Wróblewski, *Bull. Entomol. Pologne*, **38** : 761.
 1972. *Micronecta tarsalis* Chen : Wróblewski, *Bull. Entomol. Pologne*, **42** : 40.
 2002. *Micronecta tarsalis* Chen : Nieser, *Raffles Bull. Zoology*, **50** : 270.
 2007. *Micronecta tarsalis* Chen : Thirumalai, *Rec. zool. Surv. India, Misc. Occ. Pap.*, **273** : 31.

Superfamily NAUCOROIDEA Leach, 1815

Family APHELOCHEIRIDAE Fieber, 1851

Genus *Aphelocheirus* Westwood, 1833

Subgenus *Aphelocheirus* Westwood, 1833

42. *Aphelocheirus (Aphelocheirus)* sp. could turn out new to science

Family NAUCORIDAE Leach, 1815

Subfamily LACCOCORINAE Stål, 1876

Genus *Heleocoris* Stål, 1876

Subgenus *Heleocoris* Stål, 1876

43. *Heleocoris (Heleocoris) bengalensis bengalensis* Montandon, 1910

1910. *Heleocoris bengalensis* Montandon, *Bull. Soc. Sci. Bucarest*, **19** : 653.
 1910. *Heleocoris bengalensis* Montandon : Distant, *Fauna British India*, **5** : 323.
 1950. *Heleocoris bengalensis* Montandon : Pradhan, *Rec. Indian Mus.*, **48** : 102.
 1971. *Heleocoris bengalensis bengalensis* Montandon : La Rivers, *Biol. Soc. Nev. Mem.*, **2** : 78.

44. *Heleocoris (Heleocoris) elongatus* Montandon, 1897

1897. *Heleocoris elongatus* Montandon, *Ann. Soc. Ent. Belg.*, **41** : 59.
 1906. *Heleocoris elongatus* Montandon : Distant, *Fauna British India*, **3** : 31.
 1910. *Heleocoris elongatus* Montandon : Distant, *Fauna British India*, **5** : 324.
 1919. *Heleocoris elongatus* Montandon : Paiva, *Rec. Indian Mus.*, **16** : 154.
 1971. *Heleocoris elongatus* Montandon : La Rivers, *Biol. Soc. Nev. Mem.*, **2** : 78.

Superfamily NOTONECTOIDEA Latreille, 1802

Family NOTONECTIDAE Latreille, 1802

Subfamily ANISOPINAE Hutchinson, 1929

Tribe ANISOPINI Hutchinson, 1929

Genus *Anisops* Spinola, 1837

45. *Anisops barbatus* Brooks, 1951

1951. *Anisops barbata* Brooks, Kan. Univ. Sci. Bull., **34** : 387.
 1994. *Anisops barbata* Brooks : Thirumalai, Misc. Occ. Pap. Rec. zool. Surv. India, **165** : 13.
 1995. *Anisops barbatus* Brooks : Polhemus *et al.*, Cat. Heteroptera Palaearctic region, **1** : 64.
 2004. *Anisops barbatus* Brooks : Thirumalai, Rec. zool. Surv. India, **102**(1-2) : 65.
 2004. *Anisops barbatus* Brooks : Nieser, Raff. Bull. Zoology, **52** : 84.

46. *Anisops bouvieri* Kirkaldy, 1904

1904. *Anisops bouvieri* Kirkaldy, Wiener Ent. Zeit., **23** : 116.
 1951. *Anisops bouvieri* Kirkaldy : Brooks, Kans univ. Sci. Bull., **34** : 430.
 2004. *Anisops bouvieri* Kirkaldy : Thirumalai, Rec. zool. Surv. India, **102**(1-2) : 65.
 2004. *Anisops bouvieri* Kirkaldy : Nieser, Raff. Bull. Zoology, **52** : 85.

47. *Anisops breddini* Kirkaldy, 1901

1901. *Anisops breddini* Kirkaldy, Entomologist, London, **34** : 5.
 1951. *Anisops breddeni* Kirkaldy : Brooks, Kans univ. Sci. Bull., **34** : 439.
 1991. *Anisops breddini* Kirkaldy : Polhemus., J. Kans. Entomol. Soc., **64** : 442.
 1997. *Anisops breddini* Kirkaldy : Bal & Basu, Zool. Surv. India, State Fauna Series, **6** : 273.
 2004. *Anisops breddini* Kirkaldy : Nieser, Raff. Bull. Zoology, **52** : 85.
 1951. *Anisops kempi* Brooks, Kans. Univ. Sci. Bull., **34** : 441.
 1964. *Anisops kempi* Brooks : Lansbury., Ann. zool. Warszawa, **22** : 215.

48. *Anisops cavifrons* Brooks, 1951

1951. *Anisops cavifrons* Brooks, Kans. Univ. Sci. Bull., **34** : 418;
 1994. *Anisops cavifrons* Brooks : Thirumalai, Misc. Occ. Pap. Rec. Zool. Surv. India, **165** : 16.
 2004. *Anisops cavifrons* Brooks : Thirumalai, Rec. zool. Surv. India, **102**(1-2) : 65.

49. *Anisops exiguus* Horvath, 1919

1919. *Anisops exigua* Horvath, Abhandl. Senckenberg. Naturf. Gesell., **35** : 314.
 1951. *Anisops exigera* Horvath : Brooks, Univ. Kans. Sci. Bull., **34** : 447.
 1991. *Anisops exigua* Horvath : Polhemus, J. Kans. Ento. Soc., **64** : 442.

1994. *Anisops exigera* Horvath : Thirumalai, *Misc. Occ. Pap. Rec. zool. Surv. India*, **165** : 16.
 1995. *Anisops exiguus* Horvath : Polhemus *et al.*, *Cat. Het. Palaearctic region*, **1** : 65.
 2002. *Anisops exiguus* Horvath : Thirumalai, Metha & Sharma, *Res. Bull. Panjab Univ.*, **52** : 156.
 2004. *Anisops exiguus* Horvath : Nieser, *Raff. Bull. Zoology*, **52** : 86.

50. *Anisops naustus* Fieber, 1851

1851. *Anisops nausta* Fieber, *Abhandl. Konigl. bohm. Ges. Wiss.*, **7** : 484-485.
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 1951. *Anisops nausta* Fieber : Brooks, *Kans. Univ. Sci. Bull.*, **34** : 416.
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53. *Anisops sardeus sardeus* Herrich-Shaffer, 1850

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Subfamily NOTONECTINAE Latreille, 1802

Tribe NOTONECTINI Latreille, 1802

Genus *Enithares* Spinola, 183754. *Enithares ciliata* (Fabricius, 1798)

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Superfamily PLEOIDEA Fieber, 1851

Family PLEIDAE Fieber, 1851

Genus *Paraplea* Esaki & China, 192856. *Paraplea frontalis* (Fieber, 1844)

1844. *Plea frontalis* Fieber, *Entomologische Monographien, Leipzig* : 18.
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- 1844b. *Ploa frontalis* Fieber, *Entomologische Monographien, Leipzig* : 19.
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DISCUSSION

Information on families, habitats, species of Gerromorpha and Nepomorpha known from world, India and Madhya Pradesh are provided in the table 1. As checklists of provincial area is of immense value in diversity studies (Daniels, 1997), this account provides a baseline data to the functional aspects of freshwater communities and to dispel taxonomic uncertainties existing at various levels.

The present study also records three families of nepomorphan bugs, Aphelocheiridae, Naucoridae and Ochteridae first time from the state. It is interesting to note that the family Aphelocheiridae, so far known from Southern Western Ghats and Eastern Himalaya, is recorded from the state and the species could turn out new to science (Zettel, 2007 personal communication). The occurrence of *Stridulobates andersoni* hitherto, known from Southern Western Ghats and Satpura range in Western India is a note worthy finding from this table land of Central India. The presence of *Ptilomera (Ptilomera) agroides*, a common torrential 'water strider' of Western Ghats, exhibits an extended distribution to this Gondwana land. These findings support the Satpura hypothesis of Hora (1949), put forward to explain disjunct distribution in wet-zone species. Hora (1949) postulated that the wet-zone species colonized southern India by way of once continuous corridor of tropical evergreen forests from Eastern Himalaya across Vindhya-Satpura ranges to the Western Ghats of South India (Karanth, 2003).

The present checklist documents 33 species of aquatic & semi aquatic bugs for the first time from the state viz. (*Amemboa (Amemboa) kumari*, *Hydrometra greeni*, *Limnogonus (Limnogonus) nitidus*, *Limnometra fluviorum*, *Mesovelgia vittigera*, *Metrocoris communis*, *Metrocoris communoides*, *Microvelia (Microvelia) annandalei*, *Microvelia (Picaultia) douglasi*, *Neogerris parvula*, *Ptilomera (Ptilomera) agroides*, *Rhagovelia (Rhagovelia) ceylanica*, *Stridulobates anderseni*, *Anisops cavifrons*, *Anisops nigrolineatus*, *Anisops niveus*, *Aphelocheirus (Aphelocheirus) sp.* {could turn out new to science} *Cercotmetus brevipes*, *Cercotmetus fumosus*, *Enithares ciliata*, *Enithares fusca*, *Heleocoris (Heleocoris) bengalensis bengalensis*, *Heleocoris (Heleocoris) elongatus*, *Micronecta (Dichaetonecta) albifrons*, *Micronecta (Dichaetonecta) prashadana*, *Micronecta (Indonectella)*

grisea, *Micronecta* (*Micronecta*) *anatolica anatolica*, *Micronecta tarsalis*, *Ochterus marginatus marginatus*, *Ranatra digitata*, *Ranatra titilaensis*, *Sigara* (*Tropocorixa*) *graveleyi*, *Paraplea frontalis*). The study forms the authentic report of all the known five families of Gerromorpha from the state. Out of 3000 species of Indian freshwater insects (Alfred and Nandi, 2001), the aquatic and semi-aquatic bugs constitute 9.5%. The present checklist of 57 species belonging to 13 families from Madhya Pradesh constitutes 20.1% of Indian occurrence reiterates the necessity to explore the group intensively.

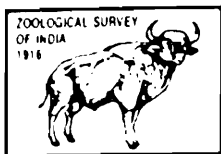
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SOIL MICRO-ARTHROPODS POPULATION IN ALLUVIAL AND COASTAL SOIL IN MIDNAPORE DISTRICT WITH SPECIAL REFERENCE TO RELATIVE ABUNDANCE

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INTRODUCTION

The earliest attempt to study the soil fauna was made by Diem (1930) in the alpine soil. There after a series of workers have published on taxonomy, ecology of collembola, Acarina (mites) of different ecosystem in India and abroad viz. Brown (1912-13) Imms (1912), Mitra *et al.* (1977), Hazra and Choudhuri (1981, 83). Although, considerable works have so far been made on soil fauna of West Bengal in general (1-8) but very little is known as to the relative abundance of soil arthropods in relation to different types of soil. Soil salinity has becoming a worldwide problem causing significant losses of arable land. Investigations of the effect of salinity have mainly been concentrated on the physical and chemical changes brought about by excess salts in the soil (1, 2). However the effects of salinity on micro arthropods components of the soil have not been examined in details. Present investigation has been under taken to record the occurrence and proportionate distribution as adjudged from the analysis of relative abundance from different soil types experiencing different salinity condition.

KEY WORDS : *Micro arthropods, Salinity, Relative abundance.*

Characteristic of study area :

Nayachar Island lies on the river Hooghly opposite to the port of Haldia in Midnapore district. The island is spindle shaped with total area of about 29.38 sq km. The climate in this island is of subtropical type. For the plantation programme of the island mangrove plant selected were *Sonneratia* followed by *Avicenia marina*, *A officinalis*, *Nipa fruticans*, *Exocoecaria* sp.,

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Xyllocarps molluscensis and *X. granatum*. Second site was Dadanpatharabhar is the important fish landing processing center is situated around 8 km away from Kontai by the side of Sea. A patch of mangrove is still present here under stressed condition which is reflected by scanty growth. The soil is sandy loam. The climate in this area subtropical type. The third site Khejuri is a small coastal village with historical important is situated on the bank Haldi estuary. The soil is sandy loam and goods patches of mangroves have come up during last one-decade giving impression of healthy mangrove environment.

MATERIAL AND METHOD

Soil samples were collected at random at the rate 6 samples per plot at one-month interval during July, 2003 to June, 2004. The soil samples were taken from each sites for soil micro arthropods extraction and also for the estimation of soil parameters. Extraction of soil samples were carried out by 'Expedition type Tullgram Faunal Apparatus' modified by Macfadyen (1953). A 40-watt bulb was used for heat and light source. Soil factors were analysis by the laboratory stander method. Relative abundance was calculated with the help of formula Jose M. Paruelo *et al.* (1996).

RESULT AND DISCUSSION

Soil micro arthropods at Nayachar Island (Table-1) shows that the relative abundance was always high in July, January and March and comparatively low during September, November, and March. Relative abundance (With the help of Jose M Paruelo et al formula) of mites (Acarina) showed maximum results followed by Collembola, coleoptera, Centiped, Milliped, Hymenoptera (Table-1).

Dadanpatharabar (Table-2) registered high relative abundance of soil micro arthropods during March only and during other sampling periods comparatively less relatively abundance was notice. Relative abundance of Acarina (Mites) was found to maximum followed by Collembola, coleoptera, sand flea. Khejuri (Table-3) registered higher relative abundance of soil micro arthropods population of (Acarina) mites followed by Collembola and sand flea.

Soil parameter played an important role in determining the relative abundance of soil microarthropods. Temperature was comparatively similar in three sites. In case of pH study, the Nayachar has less pH than other two sites. Khejuri and Dadanpatharabar sites are highly saline than Nayachar Island. In Nayachar the soil moisture was high. Organic carbon comparatively high in Nayachar Island other than two other sites. During study period, Collembola and Acarina (Mite) relative abundance was high in all sites than other groups.

Results

Table 1 : (Nayachar Island) (%).

Groups/Order	July 03	Sep 03	Nov 03	Jan 04	March 04	May 04
Mites	59.7	69.76	52.94	56.6	48.24	44.68
Collembola	29.1	23.25	35.29	28.3	25.68	42.55
Hymenoptera	0	0	0	6.60	6.14	12.76
Orthoptera	0	4.65	1.96	0	2.63	0
Hemiptera	0.74	0	0	0	0.87	0
Isopoda	1.49	0	5.88	2.83	0	0
Sand Flea	0	0	0	0	0	0
Centiped	1.49	0	0	1.88	6.14	0
Milliped	2.98	0	3.92	0.94	0	0
Spider	0	0	0	0	2.63	0
Coleoptera	4.47	2.32	0	2.83	9.64	0
Total population	134	86	51	106	114	47

Table 2 : (Dadanpatharabhar) (%).

Groups/Order	July 03	Sep 03	Nov 03	Jan 04	March 04	May 04
Mites	63.15	66.66	64.7	35	32.07	33.33
Collembola	15.78	27.77	11.76	20	35.84	23.8
Hymenoptera	0	0	5.88	30	0	9.52
Orthoptera	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0
Isopoda	0	0	0	5	0	0
Sand Flea	0.52	0	17.64	10	0	33.33
Centiped	0	0	0	0	1.88	0
Milliped	0	0	0	0	0	0
Spider	0	0	0	0	0	0
Coleoptera	10.52	5.26	0	0	30.18	0
Total population	19	18	17	20	53	21

Table 3 : (Khejuri) (%).

Groups/Order	July 03	Sep 03	Nov 03	Jan 04	March 04	May 04
Mites	30.43	34.48	75	33.33	48.64	48
Collembola	26.08	34.48	25	25	43.24	32
Hymenoptera	34.78	0	0	16.66	8.10	16

Table 3 : (Cont'd.).

Groups/Order	July 03	Sep 03	Nov 03	Jan 04	March 04	May 04
Orthoptera	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0
Isopoda	0	0	0	0	0	4
SandFlea	0	3.44	0	16.66	0	0
Centiped	0	0	0	0	0	0
Milliped	0	0	0	0	0	0
Spider	0	0	0	0	0	0
Coleoptera	8.69	27.58	0	8.33	0	0
Total population	23	29	12	12	37	25

Soil factors of Nayachar Island

Month	Tem (°C)	ph	Salinity ds/m	Moisture %	Organic Carbon
July	32	6.7	1.13	15.2	0.9
Sep	29	6.66	1.11	9.39	0.82
Nov	24	6.5	1.6	8.87	0.62
Jan	18	5.9	1.9	9	0.6
Mar	30	6	2	5.99	0.55
May	31	6.33	2.1	7.23	0.58
Mean Value	27.33	6.34	1.64	9.28	0.67

Soil factors of Dadanpatharbar 2003

Month	Tem (°C)	ph	Salinity ds/m	Moisture %	Organic Carbon
July	32.33	6.66	5.9	8.59	0.12
Sep	28.6	6.68	5.66	4.33	0.2
Nov	25	7	6.7	3.2	0.11
Jan	19	7.2	7.9	2.1	0.19
Mar	30	6.65	8.99	1.91	0.11
May	31.5	7.22	10.1	1.81	0.15
Mean Value	27.73	6.9	7.54	3.65	0.14

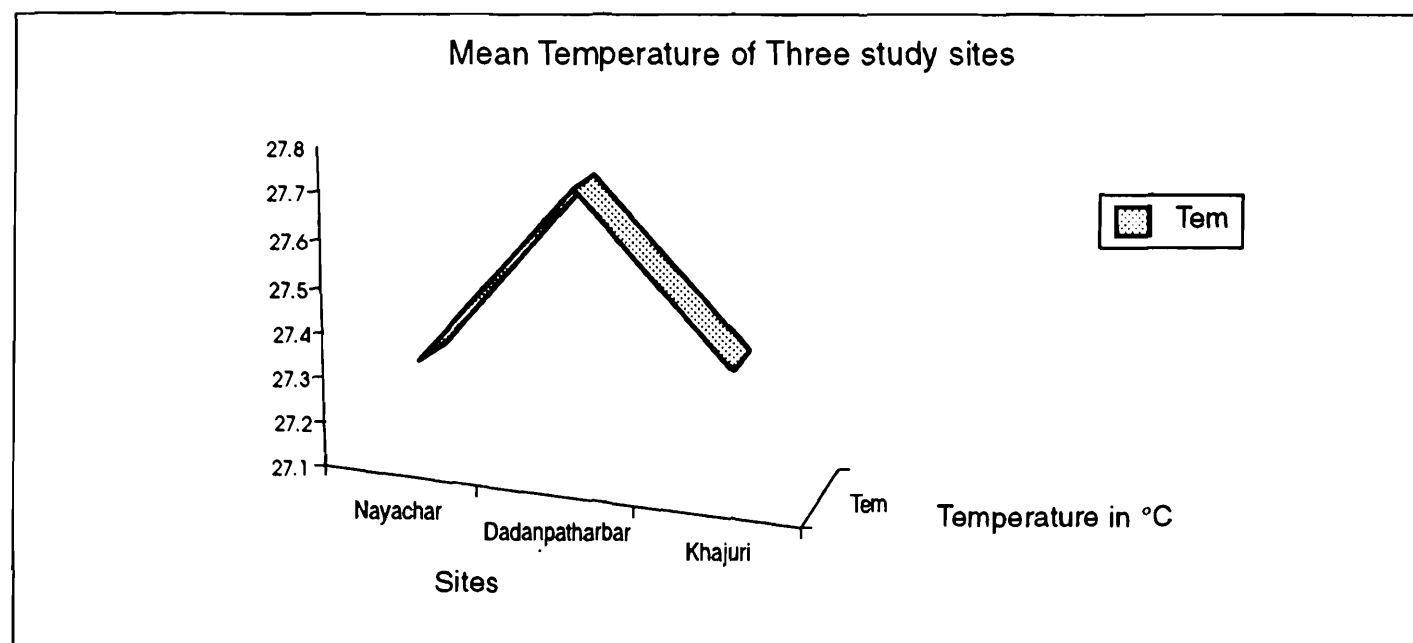
Soil factors of Khajuri 2003

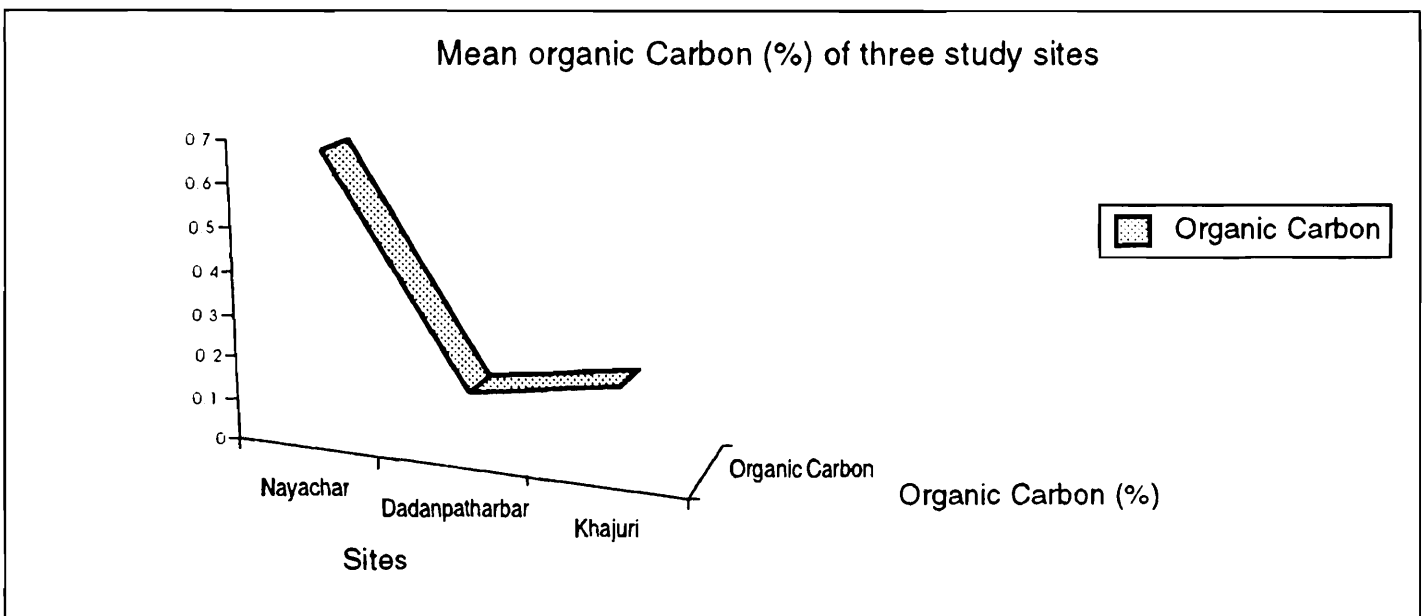
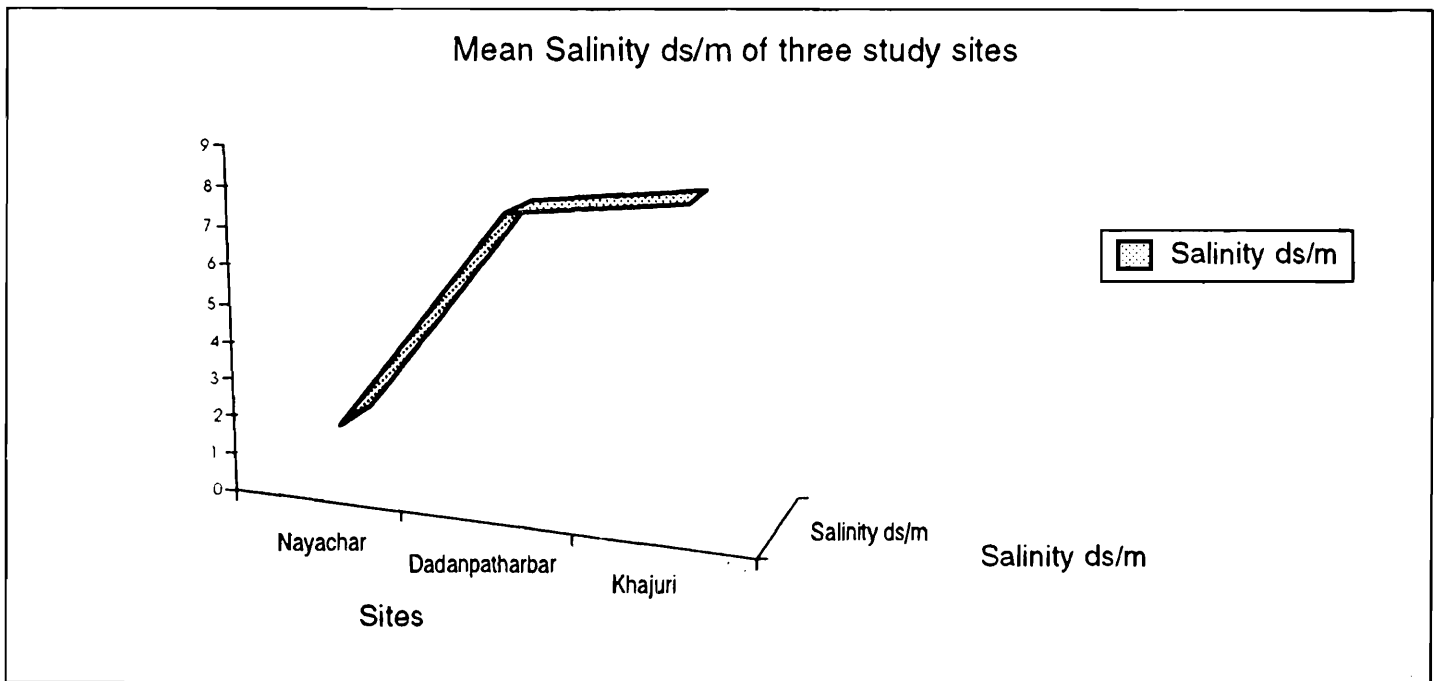
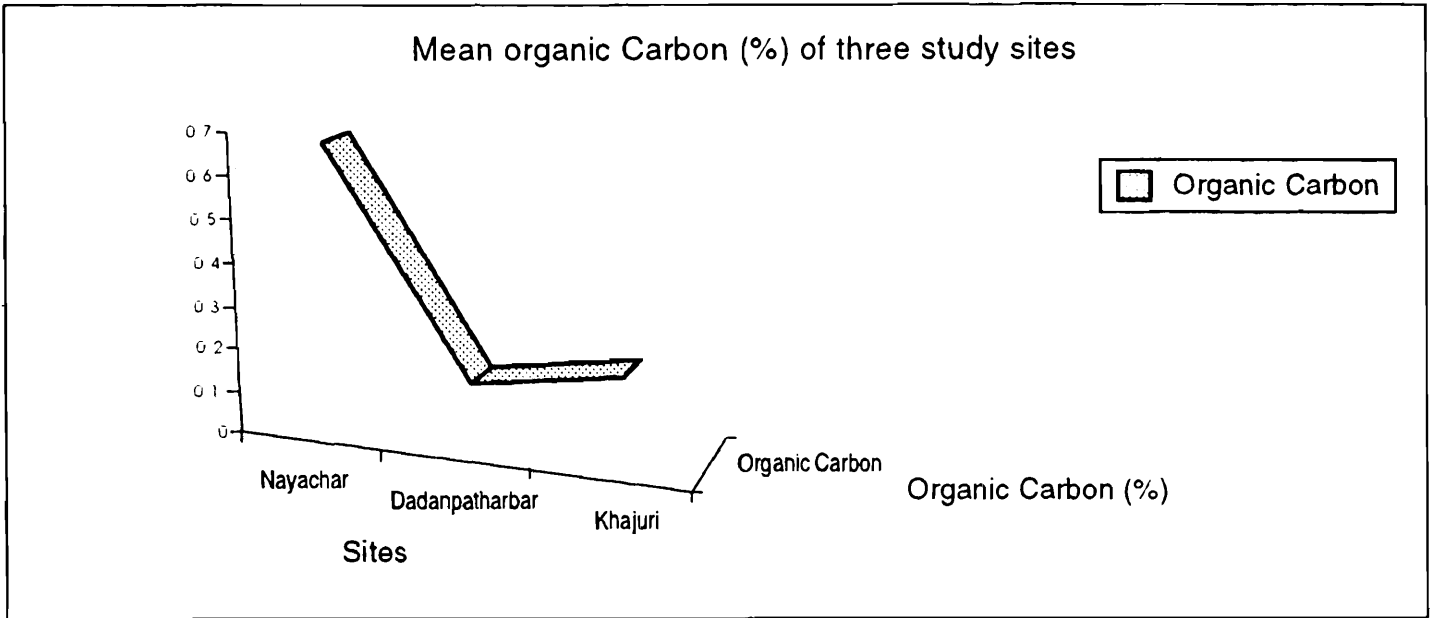
Month	Tem (°C)	ph	Salinity ds/m	Moisture %	Organic Carbon
July	31.9	7.1	6.2	11.1	0.21
Sep	28	6.7	6.7	6.5	0.22
Nov	25.5	7.2	7.2	5.33	0.19
Jan	17.9	7.89	7.89	4.6	0.11
Mar	31	8.88	8.88	3.2	0.13
May	30	11.29	11.29	3.8	0.32
Mean Value	27.38	8.02	8.09	5.75	0.196

So it can be concluded that the soil salinity and organic carbon was highly responsible for abundance of micro arthropods. This result coincides with the result of Jose M. Paruelo *et al.* (1996). Although the other soil parameters evaluate this study. Detail study is going on.

SUMMARY

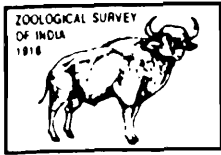
Population of various soil microarthropods were studied in soil of three separate sites viz. Nayachar Island, Khejuri and Dadanpatharbar of Midnapore coastal tract of West Bengal, India. The density of soil micro arthropods was tended to fluctuate vis-à-vis decrease and increase with the variability of ecological parameters in different sites. A total of 162-soil samples collected during July, 2003 to June, 2004 from above mentioned study sites. Relative abundance showed Collembola and Acarina (Mites) were the most dominant group among micro arthropods.





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MICROBIAL COMMUNITIES OF EARTHWORM (*PERIONYX EXCAVATUS* PERRIER) GUT, CAST AND ADJACENT SOIL IN TWO DIFFERENT FIELDS OF WEST BENGAL

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INTRODUCTION

The microbial activities in the earthworm gut content have been studied by numerous workers in India and abroad (Parle, 1963; Dash and Cragg, 1972; Dash *et al.*, 1979; Scheu, 1987; Edwards and Fletcher, 1988; Barois, 1992; Daniel and Anderson, 1992; Kristufek *et al.*, 1992; Edwards and Bohlen, 1996; Wolter and Scheu, 1999). Some researchers have studied the activities of fungi flora in different types of soil (Choudhary and Sachar, 1934; Ghatak and Roy, 1939; Gujarati, 1968; Hazra, 1984; Hazra and Choudhuri, 1990 and Bhattacharyya and Hazra, 1997).

However, in India so far no serious attempt have been made to study the microbial association of earthworm inhabiting in single crop mango vegetation and a cultivated field of mixed vegetables which changes with season. In view of this, the present study was conducted to estimate the quantitative and qualitative microbial association of earthworm (*Perionyx excavatus* Perrier) gut content, cast and adjacent soil.

MATERIALS AND METHODS

The collected earthworms were washed thoroughly with fresh tap water, followed by sterile double glass distilled water for several times. The anterior gut, mid gut and hind gut region (each 1 cm.) have been dissected out aseptically from fresh living earthworm. Dissected parts were then kept separately in 10 ml. sterile water and homogenized thoroughly aseptically in homogenizer.

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One ml. of this homogenate was plated in Nutrient agar (Beef extract 3.0 g, Peptone 5.0 g, NaCl 8.5 g, Agar 20.0 g, Distilled water 1000 ml., pH 7.4 ± 0.2), Potato Dextrose agar (Potato infusion 200.00 gm, Dextrose 20.00 gm, Agar 15.00 gm, Water 1000.00 ml., pH 5.1 ± 0.2), Actinomycetes isolation agar (Sodium Caseinate 2.00 gm, L-asparaginase 0.10 gm, Sodium Propeonate 4.00 gm, Dipotassium Phosphate 0.50 gm, MgSO₄ 0.10 gm, FeSO₄ 0.001 gm, Agar 15.00 gm, Water 1000.00 ml, pH 8.1 ± 0.2), Brain heart infusion agar (infusion from Beef Heart 250.00 gm, infusion from Calf Brain 200.00 gm, Proteose Peptone 10.00 gm, NaCl 5.00 gm, Disodium Phosphate 2.50 gm, Dextrose 2.00 gm, Agar 15.00 gm, Water 1000.00 ml, pH 7.4 ± 0.2) in triplicates.

Separate soil samples (0–25 cm deep profile) for the analysis of soil factor and for culture of microbial flora were drawn at the same time when collection of earthworm was made. Freshly produced casts were collected by using a sterilized forcep and spatula. One gm each of soil and cast were inoculated in the same media by conventional dilution plate method in triplicates, 30°C and 37°C temperatures were maintained for incubation of fungi and bacteria-actinomycetes respectively. Periodical observations have been made after incubation for a period over seven days. Identification of fungi has been made as per Alexopoulos *et al.*, (1996) and bacteria-actinomycetes genera have identified by series of biochemical tests as per Kanwar *et al.*, (1997) and Bergey's Manual of Determinative Bacteriology (Holt *et al.*, 2000).

Organic carbon content of the soil was determined by "Rapid Titration Method" (Walkley and Black, 1934). Soil thermometer was used to record the temperature of the soil. Soil humidity was estimated by dial hygrometer (Huger-85 mm.—Model-8265).

CHARACTERISTICS OF THE STUDY SITES

Site-I : The site is located at Dhapa, East Kolkata and main constituents elements are garbage material of Kolkata city. Major portion of the field is now converted for cultivation of mixed vegetable crops like cauliflower, cabbage, cucurbita, lettuce, raddish etc. Besides maize are also grown during monsoon. The defoliated vegetable leaves are principal litter elements in the site. The site is devoid of any tree species. The soil is alluvial in nature, sandy loam in texture, blackish brown in colour and mainly comprised of decomposed and semidecomposed litter.

Site-II : The site is nearly 40 km. north of Kolkata, in the district of North 24 Parganas, West Bengal. The site is mainly covered with mango trees (*Mangifera indica*). Scattered cowdung in the field were observed may be due to occasional visit of the domestic cattles for grazing. The soil in this site is alluvial in nature, brownish in colour and clay loam in texture.

OBSERVATIONS

Microbial communities :

The microorganism *viz.*, bacteria-actinomycetes and fungi obtained from the soil, earthworm gut contents and casts of both the sites belonged to twelve genera of bacteria-actinomycetes and twelve species under eight genera of fungi flora (Table 1). The bacteria-actinomycetes were most dominant group found in surrounding soil of both the sites followed by fungi flora. The bacteria-actinomycetes genera *viz.*, *Bacillus*, *Micrococcus*, *Pseudomonas* and *Streptomyces* were most dominant and occurred from adjacent soil and earthworm cast of both sites (Tables 1, 2, 2a) followed by *Arthrobacter* found in the soil of site-I, II and earthworm cast of site-II and third dominant genus *Azotobacter* found only from the soil of both the sites (Table 1). The most dominant and well distributed bacteria-actinomycetes genera occurred from the different regions of guts of the earthworm species obtained from both the sites were *Bacillus*, *Micrococcus*, *Pseudomonas* and *Streptomyces* (Table 3, 3a). The *Perionyx excavatus* Perrier which was occurred from the site I showed maximum genera of bacteria-actinomycetes (8 nos.) each from anterior gut and midgut region and 5 genera from hindgut (Table 3). The earthworm obtained from site-II also showed highest number of bacteria-actinomycetes genera (7 nos.) from anterior gut followed by midgut and hindgut (5 nos. from each) (Table 3a).

The quantitative analysis of composition of bacteria-actinomycetes showed maximum in site-I (54 nos. of CFU $\times 10^5$ gm) from adjacent soil and 72 nos. of CFU $\times 10^5$ gm from the earthworm cast and site-II shows minimum (Table 4). The quantitative study of bacteria-actinomycetes in earthworm gut regions shows their highest abundance (384 nos.) in hindgut of *P. excavatus* which was obtained from site-I followed by midgut (279 nos.) and minimum from anterior gut (152 nos.). The earthworm which was obtained from site-II also showed that maximum bacteria-actinomycetes are harbouring in hindgut (276 nos.) and minimum in anterior gut (57 nos.) (Table 4a).

The fungi species obtained from soils and earthworm casts of the sites were represented by 9 species and 8 species respectively from soils of site-I and site-II, the cast of earthworm showed 3 species of fungi each from site-I and from site-II (Tables 1, 2, 2a). The *Penicillium rubrum* was most dominant and widely distributed fungus flora obtained from soils of site-I, II and also from the cast of site-I and II followed by *Mucor luteus* represented in both the sites in soil and cast from site-I, the species *Rhizopus nigricans* also holds the same positions which was found in all the sites mentioned above except from the cast of site-I (Table 1, 2, 2a). It is evident from Table 3, 3a the maximum number of fungi species were also found in anterior gut (8 each in site-I and II) followed by midgut (6, 7 respectively in site-I and II) and minimum in hindgut (4, 5 respectively in site-I, II) of *P. excavatus* occurring in site-I and II (Tables 3, 3a).

The *Penicillium rubrum* also showed their maximum activities in the anterior gut, midgut and hindgut of the earthworm species in both the sites (Table 3, 3a).

The fungal population was abundant in adjacent soil of site-I (22 nos. of CFU \times 10³/gm) and minimum in site-II. The earthworm cast in site-I bounds maximum (31 nos. of CFU \times 10³/gm) fungi in comparison to the cast obtained from site-II. It is evident from Table 4 that the fungi population showed their maximum abundance in the earthworm cast than the culture made from surrounding soil in both site-I, II.

The analysis of different gut regions of the earthworm species showed higher population of fungi were in the anterior gut followed by midgut and lowest in the hindgut region in both the sites (Table 4a).

Soil factors :

In site-I the average organic carbon content, sub soil humidity were high (3.25% and 78% respectively) in comparison to the site-II. But the subsoil temperature (25.5°C) was more in site-II than site-I (21.9°C) (Table 5). The maximum and minimum of the above soil factors are shown in Table 5.

DISCUSSION

The results presented were based on a sample survey of two types of fields. The earthworm species, bacteria-actinomycetes and fungi belong to one genus, twelve genera and eight genera respectively. The number of genera of bacteria-actinomycetes and species of fungi differed in their abundance from one site to other (Table 1). Moreover, the number of bacteria-actinomycetes genera (11 genera) and fungi species (9 species) were maximum in site-I and the corresponding minimum number were 7 genera and 8 species in site-II. In adjacent soil five genera of bacteria-actinomycetes were restricted to site-I and one genus to site-II, while six genera of bacteria-actinomycetes were found to occur in both the habitats in the present study (Table 6). These genera, therefore, are "ubiquitous" as they were occurring in widely different habitats. In case of fungi four species were restricted to site-I and three species to site-II and five species of fungi viz., *Penicillium rubrum*, *Trichoderma viride*, *Mucor luteus*, *Cladosporium herbarum* and *Rhizopus nigricans* were found to occur in both the sites are also "ubiquitous" for their occurrence from distinctly different habitat (Table 6a). Similar results were obtained by Bodvarson (1961), Gujarati (1968), Hagvar (1982) and Hazra and Sanyal (1996) while studying with the fungi flora in cultivated fields and soil micro arthropod fauna respectively. Tables 6 to 9a clearly exhibit the "stenoecious" and "euryecious" bacteria-actinomycetes and fungi occurred from the cast and different regions of gut of the earthworm species *P. excavatus* of the studied sites-I and II.

The gradual increase of number of bacteria-actinomycetes (Table 4a) from the anterior gut to hind gut in this species of earthworm occurred from both the sites may be due to the epigeic nature

of *P. excavatus*, generally feeds on litter enriched with organic matter. When these passes through the gastrointestinal tract it accumulates in hind gut which provides an optimum microclimatic conditions for the profuse growth of the bacteria-actinomycetes population. It coincides with the findings of Karsten and Drabe (1995, '97) and Ihssen *et al.*, (2003). A distinct reduction of fungi population from the anterior gut to the hind gut has been observed (Table 4a) of this earthworm species, which indicates that the hyphae and spores of most of the fungi species serve as their food. Moreover, numerically lower population of fungi in the mid and hind gut suggests a gradient exists with regard to the digestion of fungi in different regions of this earthworm gut. Similar findings were also made by Dash *et al.*, (1979). Both the bacteria and fungi population in the cast of the studied earthworm were significantly higher in both the sites in comparison to microbial population of the adjacent soil (Table 4). This might be due to reason that the cast usually rich in ammonia and partially digested organic matter and some amount of egested intestinal mucus which provide good substrate for microbial growth (Edwards and Bohlen, 1996).

It has been observed that *Escherichia coli*, *Enterobacter* sp., *Flavobacterium* sp. present in adjacent soil, anterior gut, mid gut but were absent in the hind gut and casts of this earthworm species. This might be due to release of some inhibitory factors secreted from the hind gut of earthworm which perhaps prevents the growth of these organisms (Table 3). Similar result was also obtained in *Metaphire* sp. by Khambata and Bhatt (1957).

It is evident from the Table 3 that bacteria-actinomycetes and fungi *viz.*, *Cytophaga* sp. and *Cephalosporium asperum* were not found in the gut of earthworm, but their occurrence in the adjacent soil suggests that the studied earthworm species do not prefer these microorganisms as their food. The selective feeding of the earthworm was also suggested by Dash *et al.*, (1979) and Satchell (1983).

The average values of soil factors like organic carbon and relative humidity were maximum in the site-I in comparison to site-II. The microbial population also showed their maximum abundance in the site-I (Tables 4, 5). This result coincides with the findings of Gujarati (1968), Hazra (1984), Bhattacharyya and Hazra (1997). The subsoil temperature in this study might have exerted a cumulative effect with other factors (Hazra and Choudhuri, 1990) on soil microorganisms.

It might be concluded from the present study that (i) Mixed cultivated vegetations supports maximum abundance and diversity of microorganisms in the surrounding soil as well as the microorganisms occurred inside the gut contents of *P. excavatus*. (ii) The hindgut of *P. excavatus* bounds appreciably higher bacteria-actinomycetes population and anterior gut harboured maximum fungi flora. The present study showed that the earthworm *P. excavatus* has wide range of tolerance of habitat conditions and their capacity to utilize micrororganisms of surrounding soil as their source of food for survival. However, final conclusion can be made only after detailed study under laboratory condition.

Table 1 : Characteristics of sampling sites and microbial communities.

		Site-I (mixed vegetation)	Site-II (Mango orchard)
Dominant plant species		No single dominant plant	<i>Mangifera indica</i>
Other vegetations		<i>Lactuca sativa</i> Linn., <i>Zea mays</i> Linn., <i>Brassica oleracea</i> Linn., var. <i>capitata</i> , <i>Brassica oleracea</i> Linn., var. <i>botrytis</i> , <i>Cucurbita pepo</i> Linn., <i>Raphanus sativus</i> Linn., <i>Solanum nigrum</i> Linn., <i>Coccinia cordifolia</i> , <i>Marsilea minuta</i> , <i>Colocasia esculenta</i>	<i>Annona squamosa</i> Linn., <i>Cocos nucifera</i> Linn., <i>Musa paradisiaca</i> , <i>Cynodon dactylon</i> , <i>Chrysopogon aciculatus</i> Trin, <i>Solanum nigrum</i> Linn., <i>Centella asiatica</i> Urb., <i>Coccinia cordifolia</i> , <i>Eclipta rostrata</i> Linn., <i>Marsilea minuta</i> , <i>Colocasia esculenta</i>
Bacteria-actinomycetes and Fungi communities	Bacteria-actinomycetes	<ol style="list-style-type: none"> 1. <i>Bacillus</i> sp 2. <i>Micrococcus</i> sp 3. <i>Arthrobacter</i> sp 4. <i>Azotobacter</i> sp 5. <i>Pseudomonas</i> sp 6. <i>Escherichia coli</i> 7. <i>Enterobacter</i> sp 8. <i>Flavobacterium</i> sp 9. <i>Streptomyces</i> sp 10. <i>Promicromonospora</i> sp 11. <i>Cytophaga</i> sp 	<ol style="list-style-type: none"> 1. <i>Bacillus</i> sp 2. <i>Micrococcus</i> sp 3. <i>Nocardia</i> sp 4. <i>Arthrobacter</i> sp 5. <i>Azotobacter</i> sp 6. <i>Pseudomonas</i> sp 7. <i>Streptomyces</i> sp
	Fungi	<ol style="list-style-type: none"> 1. <i>Penicillium rubrum</i> 2. <i>Penicillium humicola</i> 3. <i>Aspergillus niger</i> 4. <i>Fusarium roseum</i> 5. <i>Trichoderma viride</i> 6. <i>Rhizopus nigricans</i> 7. <i>Cephalosporium asperum</i> 8. <i>Mucor luteus</i> 9. <i>Cladosporium herbarum</i> 	<ol style="list-style-type: none"> 1. <i>Penicillium rubrum</i> 2. <i>Aspergillus flavus</i> 3. <i>Fusarium nivale</i> 4. <i>Trichoderma viride</i> 5. <i>Rhizopus nigricans</i> 6. <i>Mucor hiemalis</i> 7. <i>Cladosporium herbarum</i> 8. <i>Mucor luteus</i>

Table 2 : List of Bacteria-actinomycetes and Fungi isolated from the casts of *P. excavatus* in site-I.

Bacteria-actinomycetes	Fungi
1. <i>Bacillus</i> sp	1. <i>Penicillium rubrum</i>
2. <i>Micrococcus</i> sp	2. <i>P. humicola</i>
3. <i>Pseudomonas</i> sp	3. <i>Mucor luteus</i>
4. <i>Streptomyces</i> sp	
5. <i>Promicromonospora</i> sp	

Table 2a : List of Bacteria-actinomycetes and Fungi isolated from the casts of *P. excavatus* in site-II.

Bacteria-actinomycetes	Fungi
1. <i>Bacillus</i> sp	1. <i>Penicillium rubrum</i>
2. <i>Micrococcus</i> sp	2. <i>Aspergillus flavus</i>
3. <i>Pseudomonas</i> sp	3. <i>Rhizopus nigricans</i>
4. <i>Streptomyces</i> sp	
5. <i>Arthrobacter</i> sp	

Table 3 : List of Bacteria-actinomycetes and Fungi obtained from different regions of gut of *P. excavatus* in site-I.

Bacteria-actinomycetes	Anterior gut	Mid gut	Hind gut
1. <i>Bacillus</i> sp	+	+	+
2. <i>Micrococcus</i> sp	+	+	+
3. <i>Arthrobacter</i> sp	-	-	-
4. <i>Azotobacter</i> sp	-	-	-
5. <i>Pseudomonas</i> sp	+	+	+
6. <i>Escherichia coli</i>	+	+	-
7. <i>Enterobacter</i> sp	+	+	-
8. <i>Flavobacterium</i> sp	+	+	-
9. <i>Streptomyces</i> sp	+	+	+
10. <i>Promicromonospora</i> sp	+	+	+
11. <i>Cytophaga</i> sp	-	-	-

Table 3 : (Cont'd.).

Fungi		Anterior gut	Mid gut	Hind gut
1.	<i>Penicillium rubrum</i>	+	+	+
2.	<i>Penicillium humicola</i>	+	+	+
3.	<i>Aspergillus niger</i>	+	+	+
4.	<i>Fusarium roseum</i>	+	-	-
5.	<i>Trichoderma viride</i>	+	+	-
6.	<i>Rhizopus nigricans</i>	+	-	-
7.	<i>Cephalosporium asperum</i>	-	-	-
8.	<i>Mucor luteus</i>	+	+	+
9.	<i>Cladosporium herbarum</i>	+	+	-

+ isolated; - not isolated

Table 3a : List of Bacteria-actinomycetes and Fungi obtained from different regions of gut of *P. excavatus* in site-II.

Bacteria-actinomycetes		Anterior gut	Mid gut	Hind gut
1.	<i>Bacillus</i> sp	+	+	+
2.	<i>Micrococcus</i> sp	+	+	+
3.	<i>Nocardia</i> sp	+	-	-
4.	<i>Arthrobacter</i> sp	+	+	+
5.	<i>Azotobacter</i> sp	+	-	-
6.	<i>Pseudomonas</i> sp	+	+	+
7.	<i>Streptomyces</i> sp	+	+	+
Fungi				
1.	<i>Penicillium rubrum</i>	+	+	+
2.	<i>Aspergillus flavus</i>	+	+	+
3.	<i>Fusarium nivale</i>	+	-	-
4.	<i>Trichoderma viride</i>	+	+	-
5.	<i>Rhizopus nigricans</i>	+	+	+
6.	<i>Mucor hiemalis</i>	+	+	-
7.	<i>Cladosporium herbarum</i>	+	+	+
8.	<i>Mucor luteus</i>	+	+	+

+ isolated; - not isolated

Table 4 : Showing number of microorganisms in surrounding soil and fresh casts in site-I and site-II.

Soil		
Microorganisms	Site-I	Site-II
Bacteria-actinomycetes (no. of CFU × 10 ⁵ /gm)	54	44
Fungi (no. of CFU × 10 ³ /gm)	22	13
Cast		
Microorganisms	Site-I	Site-II
Bacteria-actinomycetes (no. of CFU × 10 ⁵ /gm)	72	68
Fungi (no. of CFU × 10 ³ /gm)	31	19

Table 4a : Showing number of microorganisms in different regions of gut of *P. excavatus* from site-I and site-II.

Microorganisms	Site-I			Site-II		
	A. gut	M. gut	H. gut	A. gut	M. gut	H. gut
Bacteria-actinomycetes (no. of CFU × 10 ¹ /cm)	152	279	384	57	79	276
Fungi (no. of CFU × 10 ¹ /cm)	12	10	4	16	9	2

Table 5 : Showing average soil temperatures, humidity and organic carbon at site-I and site-II. (from June, '01 to Aug, '03)

	Subsoil Temperature (°C)	Subsoil Humidity (%)	Organic carbon (%)
Site-I	21.90°C	78%	3.25%
Maximum	May (30°C)	Aug (98.5%)	Aug (4.23%)
Minimum	Jan (17°C)	Jan (80%)	Apr (2.21%)
Site-II	25.5°C	73%	1.64%
Maximum	May (31.5°C)	Aug (96%)	Dec (2.21%)
Minimum	Jan (17.5°C)	Apr (72%)	Mar (0.9%)

Table 6 : "Euryecious" and "Stenoecious" genera of Bacteria-actinomycetes in adjacent soils of studied sites.

Genera restricted to Site-I	Genera restricted to Site-II	Genera present in both Sites
1. <i>Escherichia coli</i>	1. <i>Nocardia</i> sp	1. <i>Bacillus</i> sp
2. <i>Enterobacter</i> sp		2. <i>Micrococcus</i> sp
3. <i>Flavobacterium</i> sp		3. <i>Arthrobacter</i> sp
4. <i>Promicromonospora</i> sp		4. <i>Azotobacter</i> sp
5. <i>Cytophaga</i> sp		5. <i>Pseudomonas</i> sp
		6. <i>Streptomyces</i> sp

Table 6a : "Euryecious" and "Stenoecious" species of fungi in adjacent soils of studied sites.

Species restricted to Site-I	Species restricted to Site-II	Species present in both Sites
1. <i>Penicillium humicola</i>	1. <i>Aspergillus flavus</i>	1. <i>Penicillium rubrum</i>
2. <i>Aspergillus niger</i>	2. <i>Fusarium nivale</i>	2. <i>Trichoderma viride</i>
3. <i>Fusarium roseum</i>	3. <i>Mucor hiemalis</i>	3. <i>Rhizopus nigricans</i>
4. <i>Cephalosporium asperum</i>		4. <i>Mucor luteus</i>
		5. <i>Cladosporium herbarum</i>

Table 7 : "Euryecious" and "Stenoecious" genera of bacteria-actinomycetes isolated from the cast of *P. excavatus* in studied sites.

Genera restricted to Site-I	Genera restricted to Site-II	Genera present in both Sites
1. <i>Promicromonospora</i> sp	1. <i>Arthrobacter</i> sp	1. <i>Bacillus</i> sp
		2. <i>Micrococcus</i> sp
		3. <i>Pseudomonas</i> sp
		4. <i>Streptomyces</i> sp

Table 7a : "Euryecious" and "Stenoecious" species of fungi isolated from the cast of *P. excavatus* in studied sites.

Species restricted to Site-I	Species restricted to Site-II	Species present in both Sites
1. <i>Penicillium humicola</i>	1. <i>Aspergillus flavus</i>	1. <i>Penicillium rubrum</i>
2. <i>Mucor luteus</i>	2. <i>Rhizopus nigricans</i>	

Table 8 : "Euryecious" and "Stenoecious" genera of bacteria-actinomycetes found in different gut regions of *P. excavatus* in site-I.

Genera restricted to Anterior Gut	Genera restricted to Mid Gut	Genera restricted to Hind Gut	Genera present in All Guts
Nil	Nil	Nil	1. <i>Bacillus</i> sp
			2. <i>Micrococcus</i> sp
			3. <i>Pseudomonas</i> sp
			4. <i>Streptomyces</i> sp
			5. <i>Promicromonospora</i> sp

Table 8a : “Euryecious” and “Stenoecious” species of fungi found in different gut regions of *P. excavatus* in site-I.

Species restricted to Anterior Gut	Species restricted to Mid Gut	Species restricted to Hind Gut	Species present in All Guts
1. <i>Rhizopus nigricans</i>	Nil	Nil	1. <i>Penicillium rubrum</i>
2. <i>Fusarium roseum</i>			2. <i>Penicillium humicola</i>
			3. <i>Aspergillus niger</i>
			4. <i>Mucor luteus</i>

Table 9 : “Euryecious” and “Stenoecious” genera of bacteria-actinomycetes found in different gut regions of *P. excavatus* in site-II.

Genera restricted to Anterior Gut	Genera restricted to Mid Gut	Genera restricted to Hind Gut	Genera present in All Guts
1. <i>Nocardia</i> sp	Nil	Nil	1. <i>Bacillus</i> sp
2. <i>Azotobacter</i> sp			2. <i>Micrococcus</i> sp
			3. <i>Pseudomonas</i> sp
			4. <i>Streptomyces</i> sp
			5. <i>Arthrobacter</i> sp

Table 9a : “Euryecious” and “Stenoecious” species of fungi found in different gut regions of *P. excavatus* in site-II.

Species restricted to Anterior Gut	Species restricted to Mid Gut	Species restricted to Hind Gut	Species present in All Guts
1. <i>Fusarium nivale</i>	Nil	Nil	1. <i>Penicillium rubrum</i>
			2. <i>Aspergillus flavus</i>
			3. <i>Rhizopus nigricans</i>
			4. <i>Cladosporium herbarum</i>
			5. <i>Mucor luteus</i>

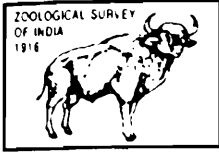
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ZOOGEOGRAPHY OF *NASIKABATRACHUS SAHYADRENSIS* BIJU-BOSSUYT (AMPHIBIA : ANURA : NASIKABATRACHIDAE) IN THE WESTERN GHATS, INDIA

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INTRODUCTION

For over 250 million years, amphibians have been inhabiting habitats in tropical moist environments, where the bulk of them live. Climatic conditions similar to those of today in the rain forests and cloud forests of the tropics presumably prevailed during the upper Carboniferous when amphibians were already numerous.

A taxonomic scrutiny reveals that India has about 253 species of known native frogs, and researchers estimate that many more are yet to be discovered. Despite observed declines in the amphibian populations, scientists succeed in discovering and describing the amphibian taxa new to science. No other discovery of a biological species in the recent past has become as remarkable as that of *Nasikabatrachus sahyadrensis* (Fig. 1) described new to science, from India, by Biju & Bossuyt (2003). By virtue of its evolutionary antiquity, assessed as a contemporary of the Dinosaurs of Jurassic period, it was veritably 'the coelacanth of frogs' and therefore 'once in a century find' (Hedges, 2003). The molecular-clock dating studies related to phylogenetic DNA analysis of the new frog, recognized under a new family, indicated its relationship to the Sooglossidae, a family endemic to Seychelles, suggesting its evolutionary origin 130 m yrs. ago, even before the break up of the ancient Gondwanan landmass.

Dutta *et al.*, (2004), based on the specimens collected from a few localities in the Anamalais-Cardamom hill ranges of southern Western Ghats in Tamil Nadu and Kerala, described a fossorial frog taxon, without assigning to it a scientific name. They considered the frog taxon similar to *N. sahyadrensis*, under the family Nasikabatrachidae. About the distribution of *N. sahyadrensis* in

the Western Ghats, they presumed the home range of the species to lie between 8° and 11° N latitudes, *i.e.*, the sector of southern Western Ghats just south of the Palakkad Gap.

Our faunal exploratory efforts in the Western Ghats areas north of Palakkad Gap resulted in the collection of two fossorial frog specimens from a plantation-site (Kundode Estate, latitude 11°06'4" N, longitude 76°64' E, elevation approximately 500 m), adjoining the premises of a disturbed secondary forest, at Karuvarakundu, Malappuram District, Kerala. Both the adult specimens (ZSI/WGFRS-V/A : 575 and 576, Snout-vent length 57.2 and 87.5 mm, 03.viii.2004 and 06.vii.2005, Coll. K. Sajith and M.J. Palot, respectively) were examined and they proved to be *N. sahyadrensis* Biju & Bossuyt, 2003. The salient characteristics of the specimens agreed not only with the described features of *N. sahyadrensis* Biju & Bossuyt, but also with those of the fossorial frog taxon of Dutta *et al.*, (2004), thereby indicating that specimens illustrated by Dutta *et al.*, are of the species *N. sahyadrensis* itself. Further, our field and lab observations on the bionomics of this species have revealed that this fossorial frog is an underground forager adapted to live on the subterranean termites and ants.

The current collection of this species from an area north of Palakkad Gap, for the first time, indicates the extension of range of distribution of *N. sahyadrensis* to the areas beyond the Palakkad Gap (11° N latitude) in the Western Ghats. It is evident from available data of collections that both the natural and disturbed secondary forests constitute the home habitat of this species. We collected our sample specimens from a degraded forest (plantation) in the peripheral habitat environs of the Silent Valley rainforests of the 'Nilgiris'. It is inferred that this fossorial taxon is very likely to inhabit both the prime and degraded/altered forest habitats in the Nilgiris, north of Palakkad Gap also as it has been observed to occur in the allied habitats in the Anamalais and Cardamom hills, south of Palakkad Gap. The range of distribution of this species, evidently, extends to further north of the presumed range of 8–11° N latitudes by Dutta *et al.*, (2004).

Given the availability of potential home habitat, close to the Nilgiris, this fossorial frog is also likely to occur in the forested habitat environs of Kodagu (Coorg) and adjoining areas in Karnataka, in close proximity to the Nilgiri hills. Therefore, it is presumed that the actual range of distribution of *N. sahyadrensis* is the stretch of the southern Western Ghats between 8–13° N latitudes, as this part of southern sector is biogeographically delineated from the Deccan Trap areas of the northern Western Ghats. A close look at the biogeography and the geomorphological evolution of this region, *i.e.*, the Peninsula of India of which the Western Ghats forms a part, would clarify the position.

Radiometric dating estimates have revealed the great antiquity of about 2500–2800 million years for some gneisses and schist in the dominating hill ranges (in Kerala and Southern Karnataka) of the Southern Western Ghats (Crawford, 1969). The basal complex of the Indian Peninsular block, according to Krishnan (1974), has probably been, geomorphologically, a distinct, relatively

little disturbed landmass of Archaean system since very ancient times, at least, from the Pre-Cambrian Era, and at a much later period, an integral part of the Gondwanan Landmass itself. Mani (1974a) is of the view that the true, original Indian flora and fauna, which essentially comprised tropical humid-forest forms, have originated from the ancient stock of the older Gondwanaland floras and faunas, evolved and differentiated throughout the Paleozoic, Mesozoic and Tertiary, even up to the Pleistocene times on the Indian Peninsular block of markedly advanced maturity.

They were widely distributed, ecologically and geographically differentiated and saturated to their maximum level to become evolutionarily stagnated or senile forms. The Gondwana faunal derivatives, therefore, represent the oldest component elements of the character fauna of the Peninsula. They include the Peninsular autochthonous endemics, and also other autochthonous forms having their closest allies in Madagascar (Lemurian faunas), or in South Africa (Ethiopian faunas) (Mani, 1974b). Savage (1973) has stated, in the case of Amphibia, that the historical biogeography of anurans is associated with Gondwanaland, based on the assumption that an ancestral stock of anurans was in Gondwanaland prior to its break up and separation in to continental landmasses.

Madagascar-Seychelles-Indian continent obviously had its share of diversity of life forms at the time of its rift from the rest of Gondwanaland about 140 million years ago (Bossuyt and Milinkovitch, 2001), presumably a biotic ferry transporting several groups of biota of Gondwanan origin, including anurans, and deporting various groups in isolation on fragments left along the path. Madagascar split away in the mid-cretaceous (88 million years ago). India-Seychelles sub-continent broke apart at the Cretaceous-Tertiary transition period (K-T boundary), in the early Paleocene 66–65 million years ago, with the massive flood basalt volcanism (Norton & Sclater, 1979; Mahoney, 1988). The catastrophic lava-deposits (Deccan Traps), which lasted for about 1.0–0.5 million years (Duncan & Pyle, 1988), covering the Western and Central Indian Peninsular plate, exterminated large chunks of the original, older character flora and fauna of the area, altering the effective size of the biogeographical area, shifting and reducing the range of numerous species.

The southern sector of the Western Ghats, which escaped from the massive volcanism and lava-flows, suffered only block fracturing and horst formation in the Archaean rock system, retaining the older, original character fauna of the region (*i.e.*, Peninsular autochthonous Gondwana elements) nearly intact, almost in isolation. The Deccan Trap Area, thus, served as a biogeographical barrier, isolating the original and older character fauna, confining it to the southern Western Ghats.

The drifting Indian plate finally collided with Eurasian continental mass, and the consequent series of intense orogenic movements resulted in the uplift of the Great Himalayan ranges towards the end of the Cretaceous, Tertiary and Pleistocene times (50–30 million years ago). Himalayan

uplift modified the climate and determined the flora and fauna, ultimately altering the biogeographical patterns/composition of India. New biogeographical routes through land connections, especially, the Assam Gateway, became the major thresholds for the influx and intermixing of younger Asiatic fauna with Indian fauna.

The rate and intensity of the older and senile Indian fauna recolonizing the virgin land and soils of the Deccan Trap region, during the intermittent quiescent periods of lava flows, and then making its efflux out of India, was rather much less than that of the profound influx of the Asiatic fauna (mainly from southeast Asia), which partly displaced the Peninsular autochthonous fauna, making them retreat to the extreme south of the Peninsula, even restricting them to isolated pockets/enclaves.

The Deccan Trap of Western Ghats extends from Lava Traps in the north to the trench of river. Moyar in the South that cuts off Nilgiris from Mysore Plateau. Lava traps of the Ghats from river. Tapti to Goa is dominated by mountain chains with deep ravines and canyons on the western side and flat-topped hills intersected by valleys and table lands, mostly denuded, with terrace topography, cut by river valleys. In the southern edge below 16° N latitude, at the level of Goa, the Deccan Lava is heavily eroded, exposing the older Archaeans, by a series of breaches in the mountain wall, by the rivers Kalinadi, Gangavali-Bedti, Tadri and Sharavati in Karnataka.

The high rising hill-ranges (the Nilgiris, Anamalai-Cardamom Hills) of southern sector, mostly constituted by ancient rocks of Archaean system, and only partly modified by block-fracturing and horst uplifts (Pithawala, 1942), still have the comparatively older stock of the fauna and flora. The evergreen forests in the Western Ghats of Maharashtra (Deccan Trap Region), unlike the typical evergreen forests, are with trees characteristically dwarfish, with no tiers or canopies of tropical species, whereas the evergreen forests along the southern Western Ghats are, characteristically, tropical rain forests, reflecting different tiers, about three or four layers (Subramanyam & Nair, 1974).

In the background of biogeography of the Peninsula in relation to the geomorphologic events, particularly with reference to the formation of the Deccan Trap Area, the distribution of *N. sahyadrensis* is likely to be restricted to the stretch of southern Western Ghats in the range between 8–13° N latitudes, beyond which lies the Deccan Trap Area. As a rare possibility, its range of distribution, owing to reoccupation of the area, may go upto 16° N latitude, spanning the breach areas of lava ghats formed of the river basins. The breach areas with intermittent peaks and valleys receive heavy rainfall and therefore have lush growth of tropical forests, as also of rich soil that enables the reoccupation of the area by this fossorial frog.

The present-day fauna of India is only an impoverished relict of a formerly much larger and more widely distributed complex. Their present-day distribution reflects a heavy concentration of the character forms in the extreme southwest, especially in the southern part of the Western Ghats.

This sector still has some areas of refugial pockets or niches for some of the older character fauna, acting as ecological islands of favourable conditions amidst the disappearing habitats.

Given the phylogenetic antiquity of the species *N. sahyadrensis*, and the biogeography of the Western Ghats in relation to the geomorphologic evolution of the Indian sub-continent, *N. sahyadrensis* is to be deemed a Gondwanan relict of Peninsular autochthonous endemic species. The break of the Deccan Trap Region in the northern sector of the Western Ghats inevitably makes the distribution of this fossorial frog species confined to the range 8–13° N latitudes. Daniels (1992) has observed in an exploratory survey in the Western Ghats that nearly 95% of the amphibian fauna of the Western Ghats are known from the southern segment (8–13° NL), and that except for 3 species, all other species endemic to Western Ghats are confined to this part of the Western Ghats. The influence of the Deccan Traps in the dissemination of taxa is amply reflected here.

The notion that the amphibians and many other ancient fauna of India are mostly of humid forest forms having almost completely derived from Gondwanan derivatives has been emphasized by studies (Mahendra, 1939; Jayaram, 1974 & Mani, 1974b). Molecular phylogenetic analyses and dating estimates (Bossuyt and Milinkovitch, 2001) suggest that multiple lineages of frogs had diverged in Indian Peninsular landmass before KT boundary, and that India being the center of dispersal, different lineages radiated to Asia and other parts of the world, after an 'out of India' dispersal mode, contradicting the earlier belief of an 'out of Africa' trend (Savage, 1973). In that case, it is to be surmised that they have been an integral component of the original and older character fauna of the Peninsula of India, very much susceptible to the phases of both extinction/evolution in the evolutionary biogeography of this region even after the break up of the Gondwanan land mass and drift of the 'biotic ferry' block of the Peninsula in the ancient geological past.

If Sooglossidae is related to Nasikabatrachidae, as suggested by Biju and Bossuyt (2003), sooglossids can be considered as isolated relicts, a derivative of the ancient lineage that is represented in India by *N. sahyadrensis* (Nasikabatrachidae). There is no compelling reason to assume that nasikabatrachids, the relatives of sooglossids, and other groups like microhylids, ranids and rhacophorids were not there in Seychelles; but those groups must have obviously embraced the fate of many island biota—extinction.

Molecular-clock-based dating estimates indicate that the origins of all the major neobatrachian lineages might have taken place in the Middle/Late Jurassic and Early Cretaceous period (Biju and Bossuyt, 2003), at around a time when the Gondwana supercontinent broke up into the western and eastern Gondwanan landmasses. One remarkable result of the phylogenetic DNA studies and the dating estimates, associated with the discovery of *N. sahyadrensis* is that it has, in the absence of conclusive fossil records, revealed information on the divergent times of the origin of major neobatrachian lineages, throwing light on their antiquity and evolution.

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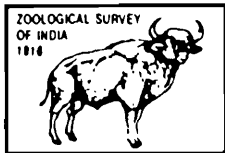
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PLATE I



Fig. 1. : *Nasikabatrachus sahyadrensis* Biju-Bossuyt.



Rec. zool. Surv. India : 107(Part-4) : 123-125, 2007

Short Communication

FIRST RECORD OF *CHERIANELLA NARAYANI* NARENDRAN (HYMENOPTERA : EUCHARITIDAE) FROM KERALA, INDIA

INTRODUCTION

The species *Cherianella narayani* Narendran is so far reported from Tamil Nadu (India) and Nilgala Uva Prov (Sri Lanka) (Narendran, 1994 and Heraty, 2002). Narendran (1994) originally described the species based on female and Heraty (2002) subsequently described the male of the species. Thus this communication is intended to report the extended distribution of this taxon in Kerala state.

***Cherianella narayani* Narendran**

(Fig. 1)

1994. *Cherianella narayani* Narendran, *Geobios new Reports*, **13** : 94-96. Type data : India : Tamil Nadu, Pambukurichi. Holotype Female (examined) (NZSI). by original designation.
2002. *Cherianella narayani* Narendran, Heraty; *Memoirs of the American Entomological Institute*, **68** : 116-117. Description of male, illustrated.

Material examined : 1 Male, INDIA : Kerala; Kannur Dt., Azhikode Chal (11°51' N 75°21' E), Divakaran, T., 16.ii.2003, Reg. No. 9995/H3, Deposited at Hymenoptera Section, Zoological Survey of India, Kolkata (NZSI).

Diagnosis : This species differs from all other African species of *Cherianella* Narendran by scutellar spine cylindrical and tapering to a blunt tip, spine much longer than gaster (Fig. 1) and dorsal thoracic setae lanceolate and thickened to base (Heraty, 2002).

Variation : This male specimen showing variations from the male specimen described by Heraty (2002) from Sri Lanka in the following characters : length 3.25 mm (in Sri Lankan specimen length 4.20 mm); head 2.06x as broad as high (in Sri Lankan specimen head 1.80x as broad as high); length of flagellum 2.56x height of head (in Sri Lankan specimen length of flagellum 2.40x height of head); first funicular segment 2.21x as long as broad, 1.26x as long as second funicular segment (in Sri Lankan specimen first funicular segment 2.90x as long as broad. 1.60x as long as

second funicular segment); scutellar process 6.60x as long as broad (in Sri Lanka specimen scutellar process 10.30x as long as broad); fore wing 2.73x as long as broad (in Sri Lankan specimen fore wing 2.50x as long as broad); petiole 2.63x as long as broad, 1.11x as long as hind coxa (in Sri Lankan specimen petiole 3.70x as long as broad and as long as hind coxa).

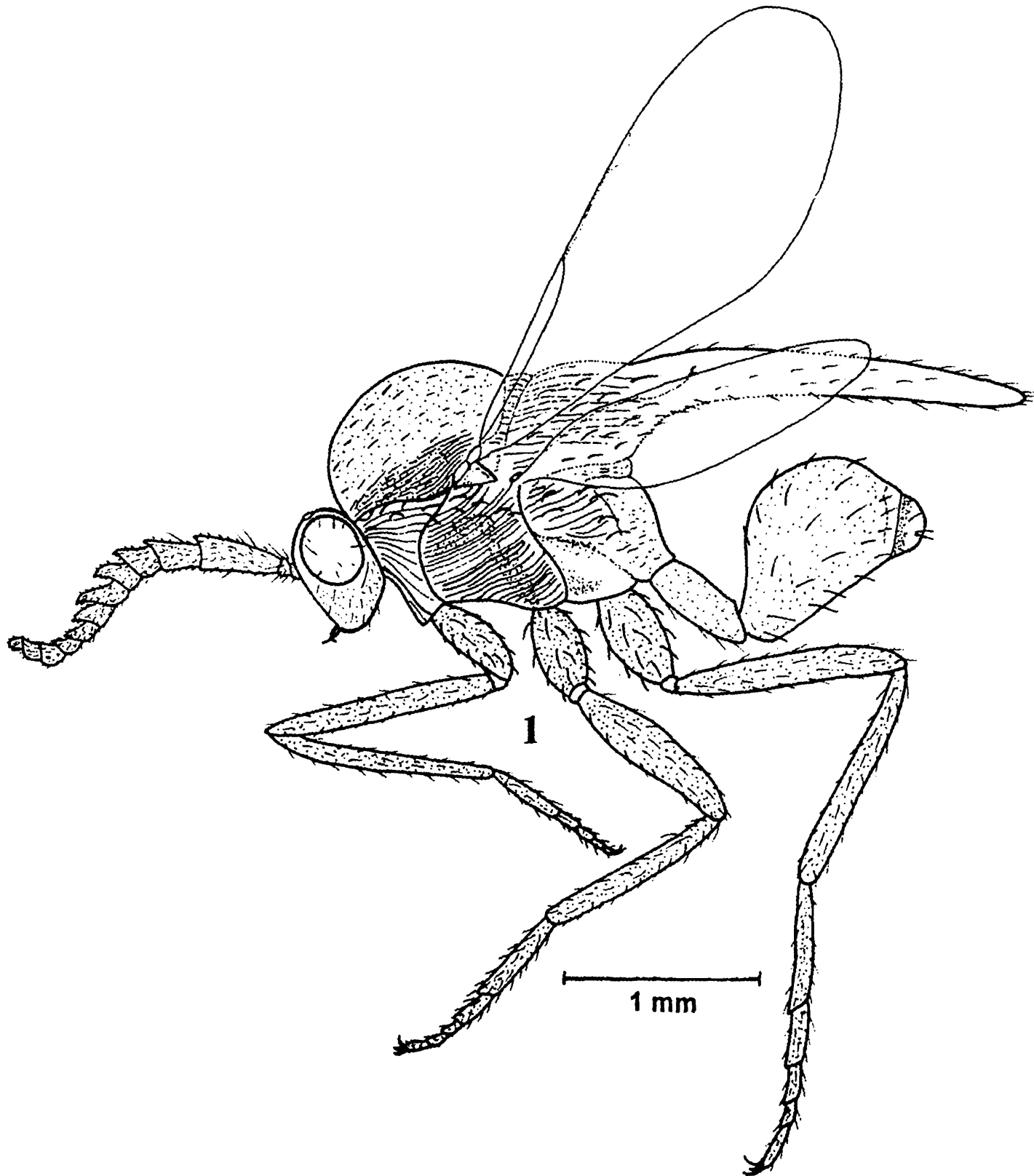


Fig. 1. : *Cherianella narayani* Narandran; Male : Body profile.

Host : Unknown.

Biology : Unknown.

Distribution : INDIA : Tamil Nadu (Pambukurichi), Kerala (Kannur); Sri Lanka : Nilgala Uva Prov.

Remarks : This is the first report of the genus and species from Kerala and also is the first report of male of the species from India.

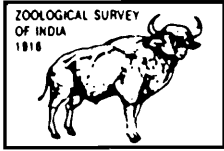
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Short Communication

FIRST RECORD OF *ORASEMA DELHIENSIS* NARENDRAN AND GIRISH KUMAR (HYMENOPTERA : EUCHARITIDAE) FROM UTTAR PRADESH, INDIA

INTRODUCTION

The species *Orasema delhiensis* Narendran and Girish Kumar is so far reported from New Delhi only (Narendran & Girish Kumar, 2005). Thus, this communication is intended to report the extended distribution of this taxon in the Uttar Pradesh state.

***Orasema delhiensis* Narendran and Girish Kumar**

2005. *Orasema delhiensis* Narendran and Girish Kumar. *Ecobios*, 3(1 & 2) : 10-14.

Type locality : New Delhi.

Material examined : 1 female, Meerut, Uttar Pradesh, India, 6.iv.2006, S.I. Kazmi & Party (Deposited at Hymenoptera Section, Zoological Survey of India, Kolkata. Reg. No. 9958/H3).

Diagnosis : This species differs from other species in the *assectator*-group of *Orasema* Cameron by length 2.75–3.16mm; head, mesosoma and petiole with metallic green reflections; gaster, all coxae and all femora except at apices with faint metallic reflections; lateral ocellar length 0.75–0.94x ocellocular length; temple relatively broad and reticulate; scutellum distinctly longer than broad and all coxae reticulate.

Variation : This female specimen showing variations from type specimen in the following characters : Length 2.75 mm (in type specimen length 3.16 mm); head, mesosoma and petiole with strong metallic green reflections (in type specimen head, mesosoma and petiole with slight metallic green reflections); gaster, all coxae and all femora except at apices with slight metallic green reflections (in type specimen metallic green reflections not so pronounced at gaster, all coxae and all femora); scape brownish yellow (in type specimen scape yellowish brown); ocelli reflecting blackish brown (in type specimen ocelli reflecting pale yellowish white); mandibles yellow with brownish tinge at margins (in type specimen mandibles yellowish brown); all apical tarsomeres

yellowish brown (in type specimen all apical tarsomeres brownish yellow); head 1.14x as broad as mesosoma (in type specimen head 1.25x as broad as mesosoma); lateral ocellar length 0.75x ocellular length (in type specimen lateral ocellar length 0.94x ocellular length); malar space 0.69x height of eye (in type specimen malar space equal to height of eye); upper mesepimeron finely reticulate with a smooth antero-ventral area (in type specimen upper mesepimeron more glabrate with reticulations); hind femur glabrate to aciculate medially (in type specimen hind femur more or less glabrate); forewing 2.33x as long as mesosoma (in type specimen forewing 2.22x as long as mesosoma); first gastral tergite 1.36x as long as hind femur (in type specimen first gastral tergite 1.26x as long as hind femur) and ovipositor not exerted (in type specimen ovipositor exerted).

Male : Unknown.

Host : Unknown.

Biology : Unknown.

Distribution : India : New Delhi (near Saptharjung airport), Uttar Pradesh (Meerut).

Remarks : This is the first report of the species from Uttar Pradesh state and the second report from India.

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