TAXONOMIC STUDIES ON SELECTED SPECIES OF COLLEMBOLA FROM NORTH-EAST INDIA

Bhattacharya

RANIT KUMAR BHATTACHARJEE

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SCHOOL OF LIFE SCIENCES

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PHONE : 27
GRAMS : N

North-Eastern Hill University

Mayurbhanj Complex, Nongthymmai, Shillong-793014

Prof. K. Chatterjee
Department of Zoology
Dean, School of Life Sciences

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This is to certify that the thesis entitled *"Taxonomic studies on selected species of Collembola from North-East India"*, submitted by Mr. Ranit Kumar Bhattacharjee for the Degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong (India), embodies the record of original investigations carried out under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of Ph.D. degree. This work has not been submitted for any Degree of any other University.

(K. Chatterjee)
Supervisor

Forwarded

Head
Department of Zoology
School of Life Sciences
North Eastern Hill University
Shillong

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Ranit Kumar Bhattacharjee

(Ranit Kumar Bhattacharjee)
Cyto-Genetics Laboratory
Zoology Department, NEHU

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FOREWORD

Collembola or Springtails are apterous, ametabolous insects primarily found in soils. It is interesting to note that the oldest known fossil record of insects is a Collembole Rhyniella praecursor that lived during mid Devonian period about 350 million years ago. These insects occur in diverse ecological habitatsviz. leaf litter , decaying vegetables, moss, bark of trees, mounds of ants and termites, and nest of rodents. They have even been reported from glaciers, snowclad mountains, caves and water surface. The adaptive plasticity of these insects have made them interesting material to the taxonomists for studying animal form and functions and on the other hand to the ecologists trying to study interactions and responses of animals to biotic and abiotic factors (Choudhuri, 1960,1963a,b; Roy, 1973,1974; Prabhoo, 1976). Physiologists attempted to relate insect hormones, pheromones (Verhoef,1984) and neuroendocrine system of Collembola to establish phylogeny (Tyszkiewiez, 1977). To an evolutionary biologist, Collembola, specially the cavernicolous forms have proved to be ideal material to study microgeographic evolution as the same species in different caves exhibits series of forms independent of each other from primitive to advanced type creating 'clines' within each cave system (Christiansen and Culver, 1968). Importance of Collembola to agricultural scientists is from the role they play in soil formation and litter decomposition or energy flow of soil

(Balaguer, 1982). Many forms e.g. Sminthurus viridis (Lucernae flea) have been found to be pests.

New species or new forms of Collembola are being described almost every day (over 6000 species now) from different parts of the world. However, many species described by earlier workers have later on turned out to be synonyms of some other species. Morphotaxonomists are thus handicapped and look for some perfectly nonadaptive criteria for species separation/identification. But as White (1973) has pointed out 'speciation is a slow and gradual process', and we must not forget that we are dealing with living entities, the basic requirement of which is of course plasticity - we wonder if perfect or stable characters do exist in a species. But surely everything is not closed and our problem of synonomy or homonomy can be resolved to some extent by interdisciplinary investigations like cytotaxonomy which collect chromosomal information within a given material and after due evaluation correlates these findings with morphotaxonomy. In course of time it has proved to be an additional tool in the repertory of taxonomists.

We have undertaken in our laboratory a survey of the Collembola fauna of North-East India specially the State of Meghalaya ("Abode of Clouds"), which with its rich evergreen forest and water resources, and a high relative humidity

is expected to harbour a rich and diverse fauna of springtails (Bhattacharjee, 1984,1985; Bhattacharjee and Chatterjee, 1989). In our pursuit we have made a combined approach of morpho- and cytotaxonomy and the results are described under two separate sections as follows:

Section A : Morphotaxonomic Study

This includes detailed notes on morphotaxonomic characters with illustrations, comparison of all related species, report of and key to new species and new records.

Section B : Cytotaxonomic Study

This section describes germ cell cytology of dominant species, karyotypes, meiotic behaviour and notes on sex chromosomes and accessory chromosomes. We have also attempted to suggest possible karyotype interrelationships among major families of Collembola. These findings have been correlated in a third section (Section C : Concluding Remarks) and a brief report has been made on the use of another additional tool viz. Scanning Electron Microscopy for elucidation of morphological characters.

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* Original not seen

[....] Translated version in English

1 INTRODUCTION

Taxonomy is the science of classification endeavouring to reflect possible phylogenetic relationship and affinities among different living beings. Taxonomists provide descriptions which enable biologists to identify readily the specimens they may collect and in doing so they mainly depend on morphological characters even though internal anatomy, behaviour, physiology or cytology of the organisms might provide additional information to their identity. Characters on which classification of a particular animal group is based need not be similar and often controversies arise among "taxonomists" regarding the relative importance of some taxonomic character. A difference between two populations may be an absolute one with little or no overlapping between the two groups or it may be only a matter of average values (Smith, 1962). Taxonomic characters should serve double purposes, viz. a) indicate intraspecific similarities, and b) interspecific dissimilarities. The extent to which these similarities/dissimilarities are found in a species are somewhat dependent on their habitat. However, the 'unit of taxonomic grouping', i.e. 'species' have two attributes: 1) some degree of structural differences and 2) reproductive isolation, the latter being primary according to Mayr (1969). Thus structural differences (similarities/dissimilarities) are to be judged through reproductive isolation which acts

as a check to controversial visible and morphological indistinctiveness between individuals. Simpson (1929) opines that distinctive characters for species separation need not be great but must be a 'constant one', eg. colour of apex of coiled shell whether pink or white in ornate snail Liguus or plumage colour of some birds. It is quite clear from the foregoing statements that there is always an element of individual subjective judgement to regard what are "distinctive characters" for a particular species (Moody, 1964). Stebbins (1970) mentions the necessity to hold a "test of sympatry" for readily separable species as "they do not exchange genes with each other or do so to a limited extent" due to reproductive isolation. Since speciation is a slow and gradual process, different populations of the same species might differ in adaptive and visible characteristic but intergrade in intermediate environment giving rise to "races" and "subspecies". In any taxonomic studies observation of such "races" or subspecies" is quite common.

Combining various points mentioned earlier it can be summarized that all "species" must stand the "test of sympatry" and possess distinctive, constant but non-adaptive structural differences among themselves.

"Collembola" or springtails belong to the primitive wingless insects or "Apterygota". Rhyniella praecursor, a Collembola, that lived during middle Devonian period about 350 m. years ago is the oldest known fossil record of any insect (Moore et. al. 1952).

The order "Collembola" Lubbock, 1862 (GK. Coll = glue, embola = peg or wedge) is sometimes regarded as an intermediate between Insecta and Myriapoda. These are wingless microarthropods (maximum size varies around 5 mm) possessing entognathous mouth parts, simple eyes or ocelli, 4 to 6 segmented antennae, 6 segmented abdomen (might be fused giving almost a globular shape as in suborder Symphypleona), with 3 pairs of appendages viz. a ventral tube or collophore (on segment I), retinaculum (on segment III) and a furcula or spring organ (may be vestigeal, on segment IV/V). Distribution of Collembola is world wide in all zoogeographical realms with a possible northern subtropical primary origin somewhere in South Europe or Asia (Salmon, 1949).

Collembola represent one of the most abundant soil microarthropods ranging 5,000 to 50,000 per sq. meter. They inhabit diverse biotopes like soil, leaf litters decaying vegetables, moss and bark. They have also been reported from the nests of rodents (Hrivnak, 1983), mounds of ants and termites, surface of fresh or salt water

(Prabhoo, 1970, Christiansen and Bellinger, 1988), glaciers of snowclad mountains (Baijal, 1955a,b, 1958) and caves in various parts of the world (Christiansen, 1982; Yosii, 1988).

The various parameters used in Collembolan taxonomy are size and shape of the body, coloration or color patterns on the body, food habit, mouth parts, relative proportion of body segments, antennae and parts of furcula, number of eyes or ocelli, structure of claw, presence or absence of spring organ and clothing of head, body and appendages in the form of scales, scaly setae and setae with their various modifications including bothriotrichia, lasiotrichia, micro and macrochaetae (flexed, clavate, plain, ciliated or serrated types). Macrochaetal pattern on head, body and appendages of Collembola are very unique and species-specific in nature and are being recently used extensively not only for species separation but for phylogenetic studies (Yosii, 1961, 1962; Szepteki, 1967, 1979, Snider, 1967, Cassagnau, 1974, and most recently Andre, 1988). However, "chaetotaxy" has to be verified in the light of the phenotypic plasticity including ecomorphosis, cyclomorphosis and epitoky (Cassagnau, 1971; Fjellberg, 1976, 1977).

The order Collembola Lubbock, 1862, originally included only two families Papiriidae and Anuridae.

Börner (1901) divided Collembola (order) into two suborders Arthropleona and Symphypleona and in 1913 further sub divided Arthropleona into two sections viz. (a) Poduromorpha and (b) Entomobryomorpha including in all 11 families under the order Collembola (Brues et. al., 1954). This classification was followed by many taxonomists including Gisin (1960) and Gama, (1961, 1964.) Salmon (1964) regrouped Arthropleona into 3 suborders viz. Arthropleona, Neoarthropleona and Metaxypleona mainly basing on shape of head, body segments and mouth parts. According to recent classification (Cassagnau, 1981 and Bellinger, 1985) the order Collembola consists of 3 suborders viz. (a) Arthropleona with 2 sections (i) Poduromorpha including 4 families, (ii) Entomobryomorpha with 8 families; (b) Symphypleona including 7 families; and (c) Neelipleona with a single family Neelidae (Table I). Thus, the total number of families is 20 (Cassagnau, 1981, Bellinger, 1985) including 752 genera (Ellis and Bellinger, 1973, 1984) and over 6000 species. From India about 431 species have been reported so far, of which only 41 species (including the present work) come from North-Eastern India (Table II).

Review of literature on Collembolan systematics indicate description of a number of new species, genera, subfamilies and families along with some revisional works

upgrading earlier taxonomic placement. Some of the leading "springtail" taxonomists of the world with significant contributions to their credit are Imms (India, Burma and Ceylon Collembola, 1912), Stach (Poland Collembola in relation to world fauna, Isotomidae 1947, Sminthuridae 1956, Collembola of Afghanistan 1960, 1963, China 1964 and North Vietnam 1965), Salmon (Revision of Onychiuridae 1959 and Index to Collembola 1964), Yosii (Critical Study of genera Hypogastrura (1960, 1962), Lobella, Lepidocyrtus and Callyntrura in Collembola of Thailand, 1961a, Isotoma and allies 1963, Afghanistan 1966d, Himalaya and Khumbu Himal 1966e and 1971 and Cavernicolous forms of Japan 1964, 1967), Christiansen (Cave Collembola 1960, 1982), Gisin (Collembola of Europe, 1960), Murphy (British Collembola 1960), Gama (Collembola of Portugal 1961, 1964, and monograph of Isotomodes 1963), Nosek (Collembola of Czechoslovakia 1962), Choudhuri (Revision of Bagnall's Onychiuridae 1963c), Massoud (family Neanuridae and Neelidae 1967), Martynova (Collembola of Middle Asia and U.S.S.R. 1968), Richards (World distribution, Classification and Evolution of Sminthuridae 1968), Mitra (Revision of genera Salina and Callyntrura 1973a, 1974), Marimutt (Revision and World distribution of sub-family Orchesellinae 1976-1988), Lee (Collembola of Korea 1977, 1983), Cassagnau (Neanurid Collembola, 1982).

Furthermore, comparatively recent works of Gama (Phylogeny and Evolution of Xenylla and Pseudosinella of the world 1984, 1986 and 1988), Bellinger (A new family Coenaletidae 1985), Yosii (Paronellids of South East Asia, 1985 and Cave Collembola of South and Central America, 1988) and Christiansen and Bellinger (Marine littoral Collembola of North and Central America, 1988) are of great significance to Collembolan morphotaxonomy.

Systematics of Indian Collembola dates back to Ritter, (1911). Imms (1912) recorded 27 new species and 4 new genera viz. Heteromuricus, Dicranocentroides, Idomurus and Pseudocyphoderus from oriental region. Carpenter (1917, 1924) reported new genus Cyphoderopsis and a new species from Rotung, Arunachal Pradesh and 4 new species from Garo Hills. Bonet (1930) reported 4 new species from Bandra, Bombay. Handschin (1929) and Denis (1936, 1947), reported altogether about 40 species from South India.

Collembola of North-West Himalaya specially the "Nival forms" have been extensively studied by Baijal and Singh (1954), Baijal (1955a,b, 1958 and 1966), Singh et al. (1956) and Mani and Singh (1961a,b). Baijal (1955a,b, 1958) described 16 new species and 2 new genera viz. Himalanura and Salmonia from Gramphu and Lahul Spiti, Great Himalaya. However, Yosii (1966e) considers the former as

a subgenus under genus Entomobrya. Baijal (1966) gave a list of 137 species and mentioned that 75% of these species are endemic to India. Singh (1967, 1968) listed 31 species belonging to 19 genera under 6 families.

Salmon (1956) described 2 new genera viz. Spinanurida and Uchidanurida from Sikkim. Salmon (1957a) studied Paronellid Collembola from Assam, Nagaland and Manipur and described 2 new species Handschinphysa serrata and Pseudo-paronellides bulbosa. From central Himalaya (=Tehri Gerwal, U.P.) Salmon (1957b) described a new species Pseudentomobrya lampreyi. In 1965 Salmon described a new genus and species of Prabhergia and recorded a new species of Paratullbergia from Kerala. In 1969 and 1970 Salmon described 5 new species (4 from Manipur and 1 from Assam) alongwith 2 new records from Manipur.

Yosii (1966d,e and 1971) mainly worked on the Collembola of India, Nepal Himalaya and Khumbu Himal. However, in 1966 Yosii described a number of new species and new records of Collembola from West Bengal (Botanical garden, Calcutta), Punjab, Sikkim and Assam. In Collembola of Himalaya (Yosii, 1966e), 11 new records from India are mentioned alongwith a new species of Lobella from Assam. Yosii (1966b) described 16 new species from Malabar Hills and Lonavella (Bombay) and Nasik.

Mitra (1966a,b, 1967, 1973a, 1974, 1976a,b) and Mitra and Choudhuri (1973) reported 12 new species and 3 new genus viz. Pseudosalina Mitra and Choudhuri and Yosiia Mitra and Delamarerus Mitra from various parts of Uttar Pradesh (mainly Dehradun, U.P.), West Bengal, Haryana and Orissa. The new species described by Mitra (l.cit.) and Mitra and Choudhuri (l.cit.) belong to the genera Xenylla, Salina, Pseudosalina, Callyntrura and Lepidocyrtus . Mitra (1976c) also studied Collembola of Arunachal Pradesh and described a new Seira sp. viz., Seira arunachala.

Prabhoo (1967, 1970, 1971a,b,c and 1974) and Prabhoo and Haq (1974) investigated Collembolan fauna of Kerala, South India and reported 30 new species, a new genus Indoscopus and 17 new records including the first record of a marine Collembola, Oudomansia subcoerulea Denis from India.

Cassagnau (1980, 1981, 1982) described 2 new genera viz. Paleonura and Parvitnura from Himalaya. Prabhoo and Muraleedharan (1980) added a new species Tomocerus mitrai to South Indian Collembolan fauna. Collembola of Kumaun Himalaya have been studied by Sharma et al. (1984). Paliwal et.al. (1985) reported 3 new species of Lepidocyrtinus from Agra. Baijal and Verma (1986) described a new Sminthurides : S. antennata also from Agra.

Turning towards the taxonomic studies of North-Eastern Collembolan fauna, it can be noted that out of 7 states forming this zone almost no work has been done on "Springtail" fauna of Tripura and Mizoram. However Collembola of other 5 states are studied to some extent (Table II). Carpenter (1917,1924) studied Collembola from some parts of Arunachal (=Rotung), border of Arunachal and Assam (=Sadiya) and Meghalaya, Garo Hills (=Siju cave, at various depths). He discovered a new genus Cyphoderopsis (Type C. kepmi) from Rotung in Arunachal Pradesh (Carpenter 1917), along with another new species Protanura spinifera from Sadiya, Assam (other 4 new species, 3 Paronella (=Callyntrura) and 1 Lepidocyrtus were from Burma. From different depth of Siju Cave Carpenter (1924) reported 4 new species viz. Lepidocyrtus nagnificus, Lepidocyrtus exploratorius, Paronella brunnea and Cyphoderopsis gracilis.

Salmon (1957a) studied Paronellinae Collembola from Manipur, Assam and Nagaland and described 2 new species viz. Handschinphysa serrata Salmon, 1957, from moss over stones at Kohima, Nagaland and Pseudoparonellides bulbosa Salmon 1957 from edge of a lake at Imphal, Manipur. He (Salmon, l. cit.) also reported Handschinphysa lineata (Parona, 1892) from Bisenpur, Manipur, Dicranocentroides fasciculatus (Imms, 1912) and Salina indica (Imms, 1912). However, Mitra (1973) considered this last species partly as

S. tricolour tricolour (Handschin, 1928). Salmon (l. cit.) also reported H. vestita (Handschin, 1925) from Kohima, Nagaland and H. longicornis (Oudemans, 1890) and Salina celebensis (Schaeffer, 1898) from Oating, Sibsagar, Assam.

Yosii (1966e) in his Collembola of Himalaya reported Cyphoderopsis ceylonica Yosii,1966 and a new species Lobella (s.str.) assamensis Yosii,1966 from Difu, Assam.

In 1969, Salmon reported 3 new species, i.e. Pronura indiana Salmon,1969 from Sibsagar, Assam, Setogaster manipuri Salmon,1969 from Moirang, Manipur and Rodanella plumosa Salmon,1969 from Imphal, Manipur. Salmon (1970) also described 2 new species from Manipur as Hypogastrura indovaria n.sp. and 2 new records Lepidocyrtus scaber Ritter,1910 and Brachystomella surendrai Goto,1961 from Imphal, Manipur.

Mitra (1973,1974,1976c) reported Salina indica (Imms 1912) and Salina tricolour tricolour (Handschin, 1928) from Manipur, S. striata (Handschin, 1928) from Shillong, S. montana (Imms, 1912) [Salmon (1957) synonymised this species with S. indica from Assam] and described a new species Salina choudhuri Mitra,1973 from Cave Mousmai, K & J Hills, Meghalaya. He also recorded Callyntrura vestita from Shillong Peak, Umdiengpun and a forest near cave Mousmai, K & J Hills,

Meghalaya (Mitra 1974). From Arunachal Pradesh Mitra (1976c) described a new species Seira arunachala along with record of Homidia cingula, Salina yosii and a Lepidocyrtus sp. all from Wakro, Lohit district of Arunachal Pradesh.

Cassagnau (1980) reported a new genus of Neanurid Collembola viz. Assamanura besucheti Gen.et. sp.n. from Nongpoh (Khasi Hills), Songsak and Rongrengiri (Garo Hills), Meghalaya. MariMutt and Bhattacharjee (1980) described 2 new species of Dicranocentrus viz. D. fraternus and D. singularis from Shillong, Meghalaya. Bhattacharjee (1984,1985) reported 4 new species from Shillong, Meghalaya viz. Hypogastrura prabhooii, Isotoma (s.str.) jayasrae Cyphoderus sarojini and Troglopedetes rasendrans. He (Bhattacharjee, 1984) also recorded Folsomia candida var distincta and Isotoma (Desoria) trispinata from Shillong, Meghalaya.

For the unique climatic conditions and other physical factors, North-Eastern India is expected to harbour a rich and diverse Collembolan fauna. With a view to study the springtail fauna of the North-Eastern states, we have undertaken a systematic survey of the Collembolan fauna of this region (Mari Mutt and Bhattacharjee 1980, Bhattacharjee

1984, 1985). Detailed results of our findings are embodied in the present work incorporating morphotaxonomic investigations on 12 species belonging to 5 families including some new species and new records with comparison and key to the new species (Table II).

Table I

Principal families of Collembola (Sensu lato)

		Families
Suborder - Arthropleona	Section - Poduromorpha	Poduridae
		Hypogastruridae
		Onychiuridae
		Neanuridae
	Section - Entomobryomorpha	Isotomidae
		Oncopoduridae
		Tomoceridae
		Entomobryidae
		Cyphoderidae
		Paronellidae
		Microfalculidae
		Coenaletidae
Suborder - Symphypleona		Sminthurididae
		Spinothecidae
		Arrohopalitidae
		Katiannidae
		Bourletiellidae
		Dicyrtomidae
		Sminthuridae
Suborder - Neelipleona		Neelidae

Table II

List of Collembola reported from N.E. India

Sl. No.	Family	Species and Authority	Localities	References
1	2	3	4	5
1.	Hypogasturidae	*Hypogastrura indovaria* Salmon, 1970	Bisenpur, Manipur	Salmon (1970)
		**H. prabhooi* Bhattacharjee 1985	Botanical Garden, Shillong	Bhattacharjee (1985)
2.	Neanuridae	*Lobella assamensis* Yosii, 1966	Difu, Assam	Yosii (1966e)
		Pronura indiana Salmon, 1969	Sibsagar, Assam	Salmon (1969)
		Protanura spinifera Carpenter, 1917	Sadiya, Assam	Carpenter (1917)
		Brachystomella surendrai Goto, 1961	Imphal, Manipur	Salmon (1970)
		Assamanura besucheti Cassagnau, 1980	Nongpoh (Khasi Hills) Songsak (Garo Hills) Rongrengiri (Garo Hills)	Cassagnau (1980)

Table II continued

Table II continued

1	2	3	4	5
3.	Isotomidae	*Rodanella plumosa* Salmon, 1969	Imphal, Manipur	Salmon (1969)
		**Isotoma jayasrae* Bhattacharjee, 1984	Botanical Garden, Shillong	Bhattacharjee (1984
		**I.(Desoria)trispinata* MacGillivary, 1896	Botanical Garden, Shillong	Bhattacharjee (1984
		**Folsomia candida distincta* Bagnall, 1939	Botanical Garden, Shillong Peak, Shillong	Bhattacharjee (1984
4.	Entomobryidae	*Lepidocyrtus magnificus* Carpenter.1924	Siju Cave, Garo Hills	Carpenter (1924)
		L.exploratorius Carpenter,1924	Siju Cave, Meghalaya,	Carpenter (1924)
		Lepidocyrtus sp.	Wakro, Lohit, Arunachal	Mitra (1976c)
		L. scaber Ritter,1910	Imphal, Manipur	Salmon (1970)
		Setogaster manipuri Salmon,1969	Moirang, Manipur	Salmon (1970)
		Homidia cingula (syn.*S. subscingula* Denis,1948	Wakro, Lohit Arunachal	Mitra (1976c)
		Seira arunachala Mitra,1976	Wakro, Lohit Arunachal	Mitra (1976c)
		**Dicranocentrus fraternus*	Crinoline falls, Shillong	
		**D. singularis*	Ka Mari Road, Shillong	
		**Sinella montana* Imms, 1912	Dohling House, Hopkinson Rd, Shillong	Present work
		**S. curviseta* Brook, 1882	Botanical Garden, Shillong.	Present work

Table II continued

Table II continued

1	2	3	4	5
5.	Paronellidae	*Paronella brunnea* Carpenter,1924	Siju Cave, Meghalaya	Carpenter (1924)
		Dicranocentroides fasciculatus Imms,1912	Bisenpur, Manipur	Salmon (1957)
		Pseudoparonellides bulbosa Salmon,1957	Edge of a lake, Imphal	Salmon (1957)
		Salina chouduri Mitra, 1973	Cave Mousmai, Meghalaya	Mitra (1973)
		S. indica Imms, 1912	Bisenpur, Manipur	Salmon (1957) Mitra (1973)
		S. celbenesis Schaeffer,1898	Oating, Sibsagar	Salmon (1957) as *S.tricolour* (see Mitra 1973)
		S. montana Imms,1912	Oating, Sibsagar	Salmon (1957) as *S.indica* (see Mitra 1973)
		**S. striata* Handschin, 1928	Bot.Garden,Shillong	Mitra (1973)
		S. tricolour tricolour Handschin, 1928	Bisenpur, Manipur	Salmon (1957) as *S.indica* (see Mitra 1973)
		S. yosii Salmon,1964	Wakro,Lohit, Arunachal	Mitra (1976c)
		Handschinphysa serrata Salmon, 1957	Bisenpur, Manipur	Salmon (1957)
		H. longicornis Oudemans, 1890	Bisenpur, Manipur and Sibsagar, Assam	Salmon (1957)
		Callyntrura (H) vestita Handschin, 1925	Bot.Garden, Shillong	Mitra (1974)

Table II continued

Table II continued

1	2	3	4	5
5.	Paronellidae (continued)	*Callyntrura(H) lineata (Parona 1892)	Forest near Cave Mousmai, K & J Hills Meghalaya	Mitra (1974)
			Bisenpur, Manipur	Salmon (1957)
		Cyphoderopsis kempi Carpenter 1917	Rotung, Arunachal Pradesh	Carpenter (1917)
		C. gracilis Carpenter 1924	Siju Cave, Garo Hills Meghalaya	Carpenter (1924)
		C. ceylonica Yosii 1966	Difu, Assam	Yosii (1966)
		**Troglopedetes rasendrans* Bhattacharjee 1985	Shillong Peak and Crinoline Falls area, Shillong, Meghalaya	Bhattacharjee (1985)
6.	Cyphoderidae	**Cyphoderus sarojini* Bhattacharjee 1985	Assam Rifles Road, Shillong, Meghalaya	Bhattacharjee (1985)

Note :

* Indicate Collembola detailed description of which are presented in this work

Additional data on localities of all described species are given under "Materials examined" in Observations.