STUDIES ON THE PRIMITIVE ORIBATID MITES OF NORTH KERALA

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CERTIFICATE

This is to certify that the thesis entitled "**STUDIES ON THE PRIMITIVE ORIBATID MITES OF NORTH KERALA**" has been carried out by **Mrs. SHIJI. M.T**, a candidate for Doctor of Philosophy in Zoology under my supervision and guidance, in the Acarology division of this Department and that no part of this work has been presented before for any other degree.

Place: C.U. Campus **Dr. N. RAMANI**

Date : .2009

DECLARATION

I do hereby declare that this thesis entitled **"STUDIES ON THE PRIMITIVE ORIBATID MITES OF NORTH KERALA"** is an authentic record of the work carried out by me under the supervision and guidance of **Dr. N. Ramani**, Reader, Division of Acarology, Department of Zoology, University of Calicut and that no part of this has been published previously or submitted for the award of any other Degree or Diploma.

C. U. Campus, **SHIJI. M.T**

Date: .2009

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SHIJI. M.T

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INTRODUCTION

Acarology, the scientific study of mites and ticks has borne and prospered through the advances in microscopy. Even more important to the birth of this new science was the industry and imagination of the Acarologists in the late 1800s. Now, Acarology has become one of the fastest growing disciplines of Zoology. An elaborate study of this branch of science has helped the scientific community to know more about the impact of mites and ticks on man and his environment.

The word 'mite' means a very small creature. Mites belong to the largest and most impressive image of animals, the Arthropods. Mites are species rich and biologically fascinating group of invertebrates. The extreme adaptability of these tiny creatures help them to thrive well in every sort of aquatic, terrestrial, arboreal and parasitic habitat. It is really surprising to note that these possess the supermost adaptability to survive in totally adverse ecological situations like benthic zones of oceans, hostile conditions of caves, freezing temperatures of arctics and warm water of thermal springs. 'Acari is marvellously heterogeneous, exhibiting all sorts of free living, parasitic and commensalistic nature. Hence they are capable of influencing plants and animals, both positively and negatively.

Mites are the major components of biological diversity. They are strong interactors and important indicators of disturbance in both aquatic and terrestrial ecosystems. In agricultural systems, plant parasitic mites are extremely damaging pests with rapid generation times, high fecundity and tendency to over exploit their hosts.

The original home of mites was the decaying vegetation and soil, where they dwindled in their most dazzling diversity. Mites are engineers of soil structure, indicators of the health of soil systems and major interactors with nematodes and microbes in decomposition. Mites tend to be concentrated in the surface litter layers and the area around roots in mineral soils. They contribute to the regulation of decomposition and nutrient cycling by comminuting organic matter, feeding on microbes and vectoring microbial propagules and preying up on decomposer worms and arthropods.

Oribatid mites are the most abundant of acarine taxa in soils rich in decaying organic matter and which represent one of the groups of soil arthropods involved in decomposer food web. These ground inhabitants are called "beetle mites" because of their heavily armoured body. More than 70% of oribatid mites are soil inhabitants while the remaining part of the community represents either pure arboreal forms or wandering forms which migrate from soil to plants and back to soil, depending on the availability of optimum conditions for life. They render significant contributions to the process of decomposition of organic matter, activation and dispersal of microbial colonies, indication of soil conditions and control of parasites, weeds etc. A good fraction of them serves important roles like transmission of pathogenic agents like cestodes, protozoans etc. Such vector mites play substantial role in the transmission of diseases like monieziasis in sheep and cattle.

Many species of oribatid mites are effectively useful for the control of population of different groups of pests like parasitic nematodes. Some mites act as potential biocontrol agents of root knot and fungus feeding nematodes also. *Orthogalumna terebrantis* and *Galumna curneata* are found regulating the growth and spread of *Eichhornia crassipes.*

Oribatid mites have extremely divergent nutritional habits which help them to be classified broadly as macrophytophages, microphytophages and panphytophages. Macrophytophages feed on leafy and woody materials of higher plants and dead root tissues. Accordingly, they are categorised into phyllophages, xylophages and rhizophages respectively. Microphytophages consume lower plant materials like bacteria, fungi, algae, lichen and moss. Thus microphytophages are categorised into mycophages, bacteriophages, phycophages, lichenophages and bryophages. Panphytophages consume both lower and higher plant materials and include further feeding categories like necrophages, zoophages and so on.

Macrophytophages are directly involved in the decomposition process as they bring about physical and chemical changes in the food substrate by triturition and digestion with the help of their enteric microbiota. Members of the primitive oribatid families like Phthiracaridae and Lohamanniidae exhibit significant roles in nutrient cycling by digesting both leafy and woody materials which help in the conversion of highly complex organic residues to simple and easily assimilable faecal pellets. As they decompose woody tissue, they are important in the cycling of elements like phosphorous, nitrogen, potassium and so on. Oribatid mites, are important in the metabolization of calcium within the ecosystem since they concentrate it in their calcareous exoskeleton.

Microphytophagous oribatid mites feed on the microbial colonies and facilitate the decomposition process in an indirect way. While grazing the microbial colonies, they activate the senescent colonies and help to release the trapped nutrients in the microbial mass. Through their active migratory movements in the horizontal and vertical directions, the microphytophagous oribatid mites enable to disseminate the microbial spores to different soil layers, thereby paving the initation of decomposition process.

The panphytophagous oribatid mites play dual roles in decomposition process, both directly and indirectly. They are twice as active as macrophytophages in processing dead organic matter. Rhizophagous oribatids provide channels of aeration, drainage and transfer of organic remains by clearing away the drying parts of the root system of the plants in the soil profile.

The extreme sensitivity exhibited by several species of oribatid mites towards the changing physico-chemical conditions of the soil enable them to act as biological indicators of soil conditions. Oribatid mites exhibit various horizontal and vertical migratory movements in the soil to cope with the altering environmental conditions. Seasonal migration of these mites towards the plant coverage is often correlated with the alterations in the temperature and humidity conditions of the soil. Similarly, a positive correlation is often observed between organic content of the soil and the oribatid population density. Thus, these mites are highly useful in studies of environmental pollution. An excellent example is *Zygoribatula exilis* which acts as a good indicator of air pollution.

The diverse roles of oribatid mites described so far, clearly depict the economic impact of these mites on man and his environment. However, much of the faunal diversity of oribatid mites still remains as an unexplored entity as far as India, particularly, Kerala is concerned. This is mainly because of the lack of knowledge, highly cryptic nature of these mites coupled with the great difficulties in their extraction, processing and identification. The present attempt is to fill up the above lacuna, to a certain extend and it involves the collection, preparation, identification and description of oribatid mites, particularly members of primitive families.

Chapter II

REVIEW OF LITERATURE

The review of literature presented here includes significant contributions made by various workers from India and abroad, on oribatid taxonomy. An attempt has been made to make the review more concise by focussing mainly on the taxonomic works on primitive oribatid mites, so as to make it in par with the objective of the present study.

Haller (1884) described *Michaelia paradox,* the first known species of the family Lohmanniidae. *Angelia murcioides* was erected by Berlese (1896) from Europe. Canestrini (1897) reported *Hermannia rubescens* from the New Guinean collection. Michael (1898) replaced the name *M. paradox* as *Lohmannia paradox*.

Pearse (1906) initiated studies on the oribatid fauna of India, who recorded 20 species of oribatid mites and established a new genus *Chaunoproctus* from Sikkim, Himalaya. Through a survey on the soil mites of Nilgiris, Ewing (1910) enriched our knowledge on the Indian oribatid fauna. Tullgren (1918) improved the extraction efficiency of Berlese funnels after making appropriate modifications. Berlese (1923) added a new species, *L. regalis* to the family Lohmanniidae. Sellnick (1928) pointed out the importance of oribatid mites in the maintenance of soil fertility and further reported a new species, *L. reticulata*. Changes occurring in the body chaetotaxy of oribatid mites during development were studied by Grandjean (1933, 1934a, 1938). The genus *Meristacarus* with *M. porcula* as type species was described by the author (1934b) from West Africa. A survey on the phthicracarid mites of North Eastern United States was conducted by Jacot (1938). The pattern of development of the genital and anal plates in oribatid mites during ontogeny was studied by Grandjean (1949). The same author (1950) erected and described 3 new genera and species of oribatid mites viz. *Annectacarus mucronatus, Cryptacarus promecus* and *Torpacarus omittens* from Venezuela and Panama. Further, he provided an outline for the classification of oribatid mites. A new species of the genus *Heminothrus* was erected by Aoki (1958a). Two new species of phthiracarid mites viz. *Phthiracarus japonicus* and *Steganacarus senex* were described by Aoki (1958b) from Japan.

Balogh (1958) reported a new genus *Mixacarus* with *M. integer* as type species from Angola. Hammer (1958) carried out an investigation on the oribatid fauna of Andes Mountains. Kunst (1959) described a new genus *Papillacarus* under the family Lohmanniidae. Studies on oribatid fauna were carried out by Sellnick (1959) from Polynesia. Balogh (1960) erected 3 new genera, *Paulinacarus, Millotacarus* and *Dendracarus* from Madagascar with descriptions of 3 species under *Paulinacarus*, viz. *P. levis, P. rugosus* and *P. nodosus,* one species of *Millotacarus* viz. *M. granulatus* and one species of *Dendracarus* viz. *D. pulchellus*. Bulanova Zachvatkina (1960) reported a new species viz. *P. pavlowski* from Soviet Union.

Aoki (1961 a,b,c) reported several new species of oribatid mites from Japan. During a survey on the oribatid mites of Ghana, Wallwork (1961) described a new genus and 2 species of the family Trhypochthoniidae. Balogh (1961) provided an outline for the classification of mites belonging to the family Lohmanniidae, which included identification keys for 25 genera and 140 species. Csiszar (1961a) reported 2 new genera viz. *Lepidacarus* and *Nesiacarus* with *L.ornatissimus* and *N. reticulatus* respectively as type species from Indonesian soils. With the description of several new species, Hammer (1962) conducted taxonomic studies on the oribatid fauna of Chili. Studies on the taxonomy and biology of 3 species viz. *Belba kingi*, *Ceratozetes gracilis* and *Platynothrus peltifer* were carried out by Hartenstein (1962 a, b, c). From Ghana. Wallwork (1962a) erected a new genus *Haplacarus* with *H. foliatus* as the type species together with members of genera like *Mixacarus*, *Meristacarus*, *Papillacarus*, *Annectacarus* and *Torpacarus*. The author (1962b) further provided notes on the taxonomy and distribution of oribatid mites from Ghana. Balogh (1962a) collected and identified some lohmanniid mites from the rain forest plain in the Amazone Valley, Eastern Peru, of which 3 species viz. *L. similis*, *M. neotropicus* and *J. inexpectatus* were new to science. The same author (1962b) described a new subspecies of *Meristacarus*, viz. *M. madagascarensis* from Madagascar.

Piffl (1963) described *H. notoneotrichus*, a new species of the genus *Heptacarus* from Egypt. Wallwork (1964) added 6 new genera and several new species and subspecies of oribatid mites, during a survey of soil mites in Tchad. Aoki (1965a) erected the genus *Vepracarus* with *V. ogawai* as type species together with 2 other new species, viz. *H. pairathi* and *P. undirostratus*. The same author (1965 b) erected a new subspecies of *Epliohmannia* viz. *E. pallida pacifica* from Hawaiian Islands.

Balogh (1965) provided a synopsis of the world genera of oribatid mites. From Iraq, Piffl (1966) reported a new species viz. *H. supertrichus*. Woolley (1966) recorded a new genus, *Euryacarus* with *E. petalus* as type species. A new species, *Trichthonius simplex* was reported by Aoki (1966a) from Japan. The same author (1966b) described *Malaconothrus japonicus* from Central Japan. Woolley (1967) correlated phthiracarid mouth parts with the xylophagous habit, during a discussion on the functional significance of the infracapitulum of oribatid mites. Information on the systematic position, distribution and habitat of 4 species of lohmanniid mites was provided by Perez-Inigo (1968) from Spain.

Balogh and Mahunka (1969) erected a new family Xenolohmanniidae for accommodating a new genus, *Xenolohmannia* and 6 new species from South America. Grandjean (1969) classified the suborder Oribatida into 6 major groups and renamed Perlohmanoidea as Mixonomata. Aoki and Fujikawa (1969) provided taxonomic notes on 2 species of the genus *Perlohmannia*, during a study on the oribatid mites of Hokkaido, Japan. Feider and Calugar (1969) illustrated the leg chaetotaxy of certain species of the genera *Phthiracarus* and *Hoplophthiracarus*. Aoki (1969) described a new subspecies of the euphthiracarid mite viz. *Protoribotritia abberans ensifer* from Japan.

Schubart (1970) erected a new species under the genus *Ameronothrus* viz. *A. schusteri*. During a survey of the family Malaconothridae of the lava cave at Mt. Fujisan, Yamamoto and Aoki (1971) reported a new species, *Trimalaconothrus nipponicus*. Kardar (1972) reported a new species of the genus *Papillacarus*, viz. *P. indicus*. Balogh (1972) provided a key for the identification of the oribatid genera of the world. Chakrabarti *et al*. (1972) reported a new species of *Cosmochthonius* viz. *C. bengalensis* and a new subspecies, *M. remigera indica* from West Bengal. From the districts of Nadia and 24- parganas, West Bengal, Chakrabarti and Bhaduri (1972) reported *C. tuberculatus* and *J. kuehnelti.*

Hammer (1973) reported 57 species of oribatid mites, including a new spcies of *Annectacarus* viz. *A. unilateralis*, from Tongtapu and Eua, the Tonga Islands and Upola , Western Samoa. Mahunka (1973) described 2 new species, *M. vanhonggui* and *Vepracarus koreanus* from Korea. Taxonomic studies carried out by Aoki (1973) on oribatid mites of Southern Japan yielded one new genus, 6 new species and a new subspecies. Bhattacharya *et al*. (1974), during a survey on the soil mites of Santinikethan in West Bengal described 3 new species viz. *A. longisetosus*, *C. dendrisetosus* and *P. simpliorstratus* and a new subspecies, *H. foliatus bengalensis*. They also reported *C. hirsutus* and *J. kuehnelti* during the survey. Prasad (1974) provided a key to the superfamilies of oribatid mites along with a list of known families of Indian oribatids. Chinone (1974) reported 6 new species and 2 new subspecies of the family Brachychthoniidae from Japan.

Shereef (1976) studied the biology of *P. aciculatus* and *L. egypticus* from Egypt. A collective summary of the taxonomic works of Berlese was provided by Van der Hammen (1977a, b, d, e). Three new species of *Eohypochthonius* were described by Aoki (1977) from Central Japan. Chakrabarti *et al*. (1977) reported a new species of the genus *Haplochthonius* from West Bengal. Haq (1978b) reported 7 new species of oribatid mites belonging to 7 genera from Kerala. Norton *et al.* (1978) erected a new species of *Epiolhmannia* and described 2 new species under the genus *Lohmannia* viz. *L. banski* and *L. carolensis* and *M. brevipes* from loblolly pine forest flour in North and South Carolina. The same authors proposed *Carolohmannia* as a subgenus under *Lohmannia*.

Bayoumi (1979) reported 17 species of oribatid mites from Egypt, of which *L. hispaniola* and *J. kuehnelti* were new to Egypt. Corpuz-Raros (1979a, b) described 4 new species, viz. *A. mahabaeus*, *M. tuloyus*, *V. ramirezae* and *P. cruzae* from Philippines. She redescribed *C. schauenbergi*, *H. foliatus*, *P. hirsutus* and *P. ramosus* also. Ghosh and Bhaduri (1979) described 2 new species viz. *A. monensis*. *Eremobelba indica* and a new subspecies, *H. foliatus bengalensis*, during their studies on the oribatid mites of Nagaland. Mc. Daniel *et al.* (1979) created a new genus, *Pseudocryptacarus* during their study on the mites collected from the Gulf region of South Texas. A new genus, *Sigmonothrus* was established by Chakrabarti *et al.* (1979) from West Bengal. Chakrabarti and Talukdar (1979) reported a new species of *Malaconothrus* from Assam. Bhattacharya and Banerjee (1979) reported a new species *Pilobatella berlesei* and a new subspecies, *E. pallida indica*. Balogh and Mahunka (1979) modified the system of classification of primitive oribatid groups through the introduction of new taxa in the families Phthiracaridae, Protoplophoridae and Epilohmannidae. Parry (1979) revised the British species of the genus *Phthiracrus* and described 7 new species. Okhubo (1979) erected the second species of the genus *Epilohmannoides* viz. *E. esculatus* from Japan. Norton (1979) added notes on the synonymous recombination and lectotype designation in Nathan Banks species of *Nothrus*.

Hammer (1980) reported *H. javensis* from Java. Mahunka (1980) collected 18 species of oribatid mites from Tunisia and described 2 new species, *L. hungarorum* and *P. pseudoaciculatus*. A revision of the family Euphthiracaridae was made by Aoki (1980) with the addition of a new species to the genus *Euphthiracarus* from Japan. Two new species of Phthiracaridae were erected by Niedbala (1980). A new oribatid family, Neohypochthoniidae was erected by Norton and Metz (1980) from the South Eastern U.S.A with a new genus and species viz. *Neohypochthonius porosus* and based on its body articulation and leg setation they suggested that the species represented an early derivative of a group ancestral to the Euphthiracaroidea.

Sanyal and Bhaduri (1981) recovered a new species, *Hoplophorella sunderbanensis* from West Bengal. Niedbala (1981) described a new species of phthiracarid mite, *S. absimillus* from South America. Balogh and Mahunka

(1981) described new species of lohmaniid mites from Neogea which included one new species viz. *N. australis* and one subspecies, *T. omittens paraguayensis*. Mahunka (1982a) erected a new genus, *Phthiracarica* and 7 new species from Costa Rica. Misra *et al*. (1982) reported a new species of phthiracarid mite, *H. manipuriensis* from North India. Sarkar and Subias (1982) reported a new species of *Malacoangelia* and erected 3 new subspecies from North India. Niedbala (1982a) reported 5 new species of phthiracarid mites from Central America. The same author (1982 b) described 3 new species of *Hoplophorella* from Kenya. He (1982c) described a new species of phthiracarid mite, *H. concinus* and recorded *P. clemens* and *P. robertis* from Nepal. *H. pandanus*, a new species of the family Lohmanniidae was reported by Senghbush (1982 a) from the Islands of Yap in Micronesia. The same author (1982 b) described another new species, *J. reticulatus* from Panope. Sanyal (1982) reported 3 new species, viz. *H. bhadurii, H. maharashtrensis* and *J. kuehnelti* from Maharashtra. Balogh and Mahunka (1983) provided a catalogue for the primitive oribatids of the Palaearctic region. From Uganda and U.S.S.R, 20 new species of phthiracarid mites were reported by Niedbala (1983 a, b, c, d, e). Sanyal and Bhaduri (1983) described a new species of *Trichthonius* from India.

A new species and a subspecies of lohmanniid mites, viz. *H. keralensis* and *L. ormatissimus rehmabia* respectively were described by Haq *et al.* (1983) from the soils of Kerala. Sarkar and Subias (1984) described 2 new species, *V. cornutus* and *P. foliatus* from India. From Truk and Saipan, Senghbush

(1984a, b) reported 2 new species viz. *L. pinnigera* and *A. granditrichosus*. Niedbala (1984) described 4 new species of phthiracarid mites belonging to 3 genera from India. Luxton (1985) provided a concise review on the oribatid mites of New Zealand, including 366 species belonging to 160 genera and 58 families. Sarkar (1985) yielded a new species of *Archegozetes*, viz. *A. tuberculatus* from Tripura. Niedbala (1985) divided the genus *Mesoplophora* in to 2 subgenera viz. *Mesoplophora* s. str. and *Panaplophora* along with the addition of 3 new species and redescription of other species. Mahunka and Zombori (1985) reported the variability of some morphological features in oribatid mites.

Niedbala (1986 a) described a new species of *Hoplophthiracarus*, viz. *H. inelegans* from Costa Rica. A catalogue for the known species of the superfamily Phthiracaroidea was provided by the above author (1986 b), with the addition of 4 new species from Poland, U.S.A. and Indonesia. He (1986c) analysed 200 species of phthiracarid mites based on their morphological features and evolutionary tendencies, while studying the systematics of Phthiracaroidea. A new species of *Heptacarus* was described by Bayoumi and Alhaufa (1986). Balogh and Balogh (1987a) reviewed the family Lohmanniidae including 25 genera and 140 species with comprehensive keys and drawings. Two new species closely related to *Steganacarus* (*Steganacarus*) *magnus*, *S.* (*S.*) *michaeli* and *S. (S.) hirsutus*, were described by Bernini and Avanzati (1987). Luxton (1987) described three new species of Crotonia, *C. capistrata, C. ardala* and *C. borbora* from Northern

Queensland. Wang Hu Fu and Norton (1988) reported 6 families, 13 genera and 29 species of crotonoid mites with the description of a new species of *Allonothrus*, from China. Niedbala (1988a) revised the superfamily Phthiracaroidea and divided the group into 2 families, 3 subfamileis, 5 tribes and 9 genera with 4 subgenera. He synonymised 11 genera of the family Phthiracaridae. The same author (1988b) divided the superfamily Mesoplophoroidea into 2 families, viz. Mesoplophoridae and Apoplophoridae with 4 genera. Sanyal and Bhaduri (1988) listed 132 genera under 57 families. in a review of the oribatid genera of Indian continent. Bernini and Avanzati (1988) redescribed the phthiracarid species, *S. magnus* from France. Balogh and Balogh (1988) provided a catalogue and identification key to the oribatid mites of Neotropical region.

Norton and Olszanowski (1989) described a new species of *Holonothrus* viz. *H. virungensis* from volcanic area in Ethiopian region and provided notes on the distribution of crotonoid mites. Perez-Inigo (1989) reported *V. gueyeae* from continental Africa and provided identification keys for 10 species. Ayyildiz and Luxton (1990) redefined the genus *Cosmochthonius* and provided a key to the known species. The authors redescribed *C. lanatus* and established a new species, *C. macrosetosus* from Turkey.

Balogh and Balogh (1990) provided an identification key to the orbatid fauna of Neotropical region with 830 figures contained in 142 plates. Mahunka (1990) added notes on the family Phthiracaridae and established a new subgenus and also provided an identification key to the genera. Li *et al.* (1991) described a new species of *Papillacarus* from Chongging, China. Niedbala (1991) described the origin, centres of speciation and rate of evolution of individual genera of phthiracaroid mites in different regions of the world. Judson (1991) reported the first African representative of the genus *Javacarus* viz. *J. jocelynae* from South West Cameroon. Two new lohmanniid species viz. *A. wallworki* and *C. grandjeani* were reported by Clement and Haq (1991) from Kerala. *Afronothrus arboreus*, a new species of the genus *Afronothrus* was described by Ramani and Haq (1992) from coconut palm in Kerala, India.

Haq and Jaikumar (1993) described a new species, *M. degradatus* from Kerala, India. From Yunnan of South China, Hu and Aoki (1993) reported a new species, *Phyllolohmannia yunae*. Schatz (1993) described a new species, *L. vulcania* from Galapagos Islands (Ecuador). Yamamoto *et al.* (1993a) reported three new species belonging to the genus *Trimalaconothrus*, viz. *T. yachidairaensis, T. azumaensis* and *T. undulatus* from a bog in the Yachidaira Moor, North Eastern Japan. Yamamoto *et al.* (1993b) described two news species of the family Malaconothridae, viz. *M. yinae* and *T. wayanensis* from subtrophical forests of Wu-yan-ling, East China. A new species of *Annectacarus* viz. *A. aokii* was described by Jaikumar *et al.* (1994) from Silent Valley ever green forest of Western Ghats of Kerala. Schatz (1994 a) recorded 2 new species of the genus *Torpacarus* viz. *T. remotus* and *T. izabalensis* and a new subspecies, *T. omittens galapagensis. H. enacantadae* and *N. schusteri* were recorded as new species by the same author (1994b) from Galapagos Islands, Cocos Island and Central America. Haq and Clement (1995) described 2 new species viz. *M. wynadensis* and *H. porosus* from Malabar, Kerala, South India. Two new species of the genus *Heptacarus* viz. *H. neotropicus* and *H. reticulatus* and one new species of the genus *Vepracarus* viz. *V. incompletus* were described by Mahunka (1995). Two new species of the genus *Malaconothrus*, viz. *M. rostropilosus* and *M. dipankari* were described and illustrated by Saha and Sanyal (1996). Yamamoto (1996) reported two new species belonging to the family Malaconothridae, viz. *M. kiiensis* and *T. magnilamellatus* from surface soil and moss in Wakayama Prefecture, Central Japan. Haq and Ramani (1997) described a new species of the genus *Lepidacarus* viz. *L. ennarpi* from Bengarum, an uninhabited Island of Lakshadweep. Sengupta *et al*. (1997) published a list of oribatid mites from Indian part of Himalaya, including 131 species, 77 genera and 45 families. Two new species belonging to the genus *Trimalaconothrus* viz. *T. nodosus* and *T. kurikii* were described by Yamamoto (1997) from a Sphagnum bog in Akai Moor, North Japan. A new species of the genus *Malaconothrus*, *M. iriomotensis* from Iriomote Island was reported by Yamamoto and Aoki (1997). Six new species of the genus *Torpacarus* viz. *T. lobatus*, *T. cylindricus*, *T. elegans*, *T. schatzi*, *T. foliatus* and *T. pseudocallipygus* were described by Stray (1998).

The morphological features of *Rhysotritia ardua* collected from Erzincan and Erzurum plains were reexamined and illustrated by Baran and Ayyildiz (2000) under light and scanning electron microscope. Bayartogtokh (2000) redescribed 2 species of the genus *Epilohmannia* viz. *E. cylindrica* and *E. spathulata*. The author reported new species viz. *E. spathuloides* and *E. shtanchaevae* from Central Japan and Central Mangoli respectively and provided a key to the Japanese and Mangolian species of Epilohmannoid mites. Mahunka (2000) described 2 new species, *Eupthiracarus cathayanus* and *R. corletti* from Persea in the Tai Mo shan country park. Niedbala (2000) analysed the diagnostic features of the genus *Apoplophora* and described two new species *A. ornata* and *A. phalerata*. A key to the species was also provided.

Coetzee (2001) described a new species of Lohmanniidae, *Papillacarus brinki* and briefly discussed two other species, viz. *Cryptacarus promecus* and *T. omittens* from the Holocene deposits at Florisbad, South Africa. Coetzee (2001a) described three new species of Lohmanniidae, *A. eksteeni, Paulianacarus grobleri* and *P. barlowi* from South Africa. A key to the species of *Annectacarus* and a table summarizing the species of *Paulianacarus* were also provided. Six species of nothroid mites viz. *N. lasebikani, N. incavatus, N. ifensis, N. seropedicalensis, P. nigeriensis and P. braziliensis* were reported by Badejo *et al*. (2002a) from Nigeria and Brazil.

A new species of the genus *Nothrolohmannia, N. baloghi* was reported by Norton (2003) from rainforest in Papua New Guinia and he also presented the diagnostic features of Hypochthonninae, Nothrolohmanninae, *Malacoangelia* and *Nothrolohmannia*. Penttinen *et al*. (2003) described a new species of the genus *Cosmochthonius, C. zanini* from the southern coast of Crimea, (Ukrain), Rhodes (Greece) and Turkey. The description was illustrated by SEM micrographs.

Niedbala (2004) presented the diagnostic features of the Ptyctimous mites described in the papers published after 1998 and a few species described in the papers published before 2004. Yamamoto and Coetzee (2004) described 5 new species of the genus *Trimalaconothrus, T. binodulus, T. duoaculeus, T. obseus. T. punctus* and *T. rectus* from South Africa. A key to species of the family Malaconothridae of South Africa was also provided.

Alphonsa et. al. (2005) described two new species of *Haplacarus, H. xavieri* and *H. davisi* from Malabar, Kerala. A new species of the genus *Crotonia*, *C. blaszaki* was described by Szywilewska *et al.* (2005) from Chile. A key to Neotropical species of *Crotonia* was also included. A new species of *Allonothrus, A. longinoi* was described by Szczykutowicz and Olszanowski (2006) from Costa Rica. The comparison of important morphological characters with all known neotropical species was also presented. Shiji *et al.*, (2007) described two new species belonging to the family Lohmanniidae, viz. *A. hammerae* and *C. keralensis* from the Calicut University Campus, Kerala. A key to the genus *Cryptacarus* was also provided.

Chapter III

MATERIALS AND METHODS

1. Sampling Localities

Studies on the primitive oribatid mites included in the present study were initiated in 2002 and continued upto 2008. During the period of study, soil and litter samples were collected randomly from selected sites (sites 1-6) distributed over 3 districts of North Kerala, viz. Kozhikode(KKD), Malappuram(MLP) and Wayanad (WAD). In the Kozhikode district, three sites (sites 1-3) were selected for sample collection viz. Mullankunnu (MRP), Janakikadu (JKD) and Ayanikad (AKD). In the Malappuram district, Calicut University Campus (CUC) and Kizhisseri (KZH) were the sites (sites 4-5) selected for collection. In the Wayanad district, the soil and litter samples were collected from a coffee plantation at Panamaram (COP) (site 6).

Site 1 (Plate -1, Fig. 1)

Site-1 included in the present study comprised of a vast area of Rubber plantation located at Mullankunnu (MRP), Kozhikode district. The litter fragments of *Havea braziliensis* (Willd. ex Juss.) Muell. -Arg. along with underlying soils were collected from this site.

Site 2 (Plate -1, Fig. 2)

Site-2 was a forest area located at Janakikadu (JKD), supporting a variety of flora and fauna. The litter fragments of *Syzygium cumin* (L.)

Skeels, *Terminalia arjuna* (Roxb. ex DC.) Wight lc Arn., *Albizia libbeck* (L.) Willd. etc. along with underlying soils were collected for the extraction of oribatid mites included in the present study.

Site 3 (Plate -1, Figs. 3 and 4)

Site 3 comprised of 3 localities at Ayanikad (AKD), a residential area. The first locality (3a) (Plate-1, Fig. 3) was an area of mixed vegetation (M) comprising plants like *Artocarpus heterophyllus* Lam.**,** *Cocos nucifera* L., *Mangifera indica* L. and *Caryota urens* L. The second locality (3b) (Plate-1, Fig. 4) was a water logged area (W), which was constantly disturbed by human interference for regular washing and cleaning purposes. The site was devoid of any major vegetation and hence was devoid of any litter accumulation. However, the soil at the site was always water saturated. Site 3c, was also a wet area near the kitchen yard (K). The samples collected from the area contained the soil as well as leaf litters of *Piper nigrum* L. and *Psidium guajava* L.

Site 4 (Plate -1, Figs. 5-11)

This site comprised of four localities of Calicut University Campus (CUC) (4a-d). The collection sites selected in the Calicut University Campus included 4 localities (4a-4d), of which the Botanical Garden (BG) (4a) (Plate-1, Figs. 5 and 6) constituted the major site of collection. Leafy and woody litter of plants like *Mesua ferrea* L., *Dillenia indica* L., *Michelia alba* DC., *A. heterophyllus* Lam., *Terminalia catappa* L. and *Manikara hexandra* (Roxb.)

Dubard along with underlying soils were collected occasionally from site 4a. The premises of Ladies Hostel (LH) (Plate-1, Fig. 7) were also considered for the collection of soil and litter samples and were marked as site 4b. The major litter ingredients of plants like *M. indica* L., *C. nucifera* L. and *A. heterophyllus* Lam. along with underlying soils were sampled from various areas of this site. Site 4c (Plate-1, Figs. 8 and 9) comprised of the premises of the Department of Zoology (ZD) from where the litter of *Anacardium occidentale* L. along with soil were collected for the extraction of oribatid mites. The premises of quarters (QT) (Plate-1, Figs. 10-11) in the campus were also selected for the collection of soil samples, (4d). Leaf litter of *A. heterophyllus* and *C. nucifera* were collected along with underlying soil from this site for extraction.

Site 5

Site-5 was located at Kizhissery (KZH) of Malappuram district where the vegetations included *Phyllanthus emblica* L. and *C. nucifera* L. The soil samples along with the leafy and woody litter were collected from this site for extraction of oribatid specimens.

Site 6 (Plate -1, Fig. 12)

The site 6 included in the present study comprised of a vast area of coffee plantation located at Panamaram, Wayanad district. The thick accumulation of coffee litter was the characteristic feature of this site. Hence sampling was restricted to coffee litter and underlying soil strata.

2. Sampling

Soil and litter samples were collected from the sites described above with the help of a shovel. The upper few centimetres of the soil, along with partially decomposed litter were scooped carefully and transferred to polythene bags. Early morning hours were preferred for the collection of soil samples. The samples were labelled and immediately brought to the laboratory for extraction of mites. Samples were handled carefully during collection and transportation to avoid disturbance and mortality of the mite specimens harboured by them.

3. Extraction of Mites

The extraction technique adopted was based on the principle of Berlese's (1905) original funnel apparatus. The collected samples were subjected to extraction under a series of modified Berlese-Tullgren Funnel apparatus (Plate-2, Figs. 1-3) constructed locally for the purpose. The frame of this rectangular unit (183cm x 46cm x 170cm) was made up of steel and resting on four legs. The bottom and top of the unit were covered by rows of wooden planks, upper row with 13 holes and lower row with 12 holes, for accommodating the funnels and sample containers. Each funnel was provided with a collecting vial beneath it, which rested on a spring over the iron sheet. The apparatus contained a total of 25 units.

Each unit was composed of three parts:

A. A heat source

B. A sample container set

C. A collecting vial

A. Heat Source

The heat source of each unit was provided with an electric bulb, the intensity of which was decided by considering the thickness and moisture content of the soil sample to be extracted. Though the distance between the bulb above and the sample below was normally 12 cm, it could be increased or reduced by raising or lowering the wooden planks with the help of screws provided at the corners. When the soil was comparatively dry, 40 watt bulb was used and 60 or 100 watt bulbs were used for the extraction of moist soil samples.

B. Sample Container Set

Each sample container was made of brass and was circular with a diameter of 15 cm and height of 10 cm. This was attached to fine wire mesh of 0.8 mm size and 15 cm in diameter, which served as the bottom of the sample container. There was a gap between the base and lower rim of the sample container, for the escape of bigger animals. Below the sample container was a rounded resting shield, also made of brass having a diameter of 17 cm with larger mesh size of 0.5 cm. The brass funnel which contained the resting shield and sample container was having a length of 22 cm and mouth diameter of 15 cm. The funnel was provided with raised edges, so as to hold well the sample container on the holes in the wooden plank. The tail region of the funnel was having a diameter of only 2 cm. It was conical in shape with steep and smooth inner sides.

C. Collecting Vial

A specimen tube of 6 cm length served as the collection vial. The collecting vial was held tightly to the lower end of the funnel with the help of a spring fixed to an iron sheet.

The extraction unit was kept in a separate room and the room temperature and the temperature of the soil under extraction were noted at different periods. The combined effect of heat and light caused gradual desiccation of the soil sample, there by forcing the fauna to move away from the soil sample. Those soil arthropods thus reached the fine mesh screen and fell into the collecting vial, containing 70% alcohol through the funnel.

4. Separation of Mites

After extraction, the contents of the collecting tubes were transferred into a watch glass and thoroughly examined under a stereomicroscope. The mites extracted were picked up with a brush and kept in 70% alcohol contained in a cavity block.

5. Clearing and Mounting

The colleted mites were then passed through alcohol grades like 90% and absolute alcohol in cavity blocks for complete dehydration of specimens. The mites were then cleared in clearing medium prepared by mixing equal proportions of absolute alcohol and lactic acid. The time needed for clearing varied, depending on the degree of sclerotization of the mites.

For routine examination, temporary mounts were prepared in glycerine or lactic acid. Permanent mounts were made in polyvinyl alcohol/ Hoyer's medium (Baker and Wharton, 1952).

Preparation of Mounting Media

a. Polyvinyl medium

1. Elvanol 74-24 (Du port polyvinyl alcohol) was dissolved in four volumes of water at 90^{0}C.
2. The solution was filtered.
3. Concentrated the clear filtrate on a water bath until the solution became syrupy.
4. Twenty two parts of lactic acid were added to 56 parts of the PVA solution and used for slide mounting.

b. Hoyer's Medium

Chloral hydrate	: 200 gms
Gum arabic	: 30 gms
Distilled water	: 50 ml
Glycerine	: 20 ml

50ml of distilled water was taken in a beaker and 30gms of gum arabic crystals were added after making it a fine powder. 200gms of chloral hydrate were then added and thoroughly mixed with 20ml of glycerine, filtered and used for mounting.

6. Identification of Mites

Identification of the various oribatid specimens, particularly those of primitive taxa was made following identification keys of Balogh (1972), Balogh and Mahunka (1983) and Balogh and Balogh (1988). In addition, relevant literature on various taxa from the concerned authors were also referred for the comparison and confirmation of species. Detailed studies on the morphological characters of the various species were carried out under a Zeiss research microscope. Drawings of the various species included in the study were made by means of a mirror type camera lucida attached to a Meopta research microscope. Accurate measurements of the specimens were made using an ocular micrometer and recorded in µm.

Chapter IV

MORPHOLOGICAL CHARACTERS OF ORIBATID MITES

Oribatid mites are characterised by heavily sclerotized body. The body of an oribatid mite, dorsally can be divided into an anterior proterosoma and a posterior hysterosoma. The proterosoma represents the anterior part of the original prosoma and the hysterosoma consists of the posterior part of the prosoma bearing legs III and IV as well as the original opisthosoma. The podosoma is the region carrying legs I and II. Metapodosoma represents the region between legs III and IV. The propodosoma and metapodosoma together constitute the podosoma. The large dorsal sclerite of the body is the prodorsum. The gnathosoma is located in the antero-ventral region of proterosoma.

1. Dorsal Region (Plate-3, Fig.1)

a. Prodorsum

The anterior tip of the prodorsum is the rostrum. The flat, lath or plate like outgrowths extended from the base of the bothridium towards the rostrum is called lamella. If these outgrowths are rib like or protruding like a bar from the plane of the prodorsum, they are called costulae. Lamellae may be separate or connected by a transverse ridge or translamella. Prodorsum bears 5 pairs of setae viz.

1. Rostral setae (*ro*)
2. Lamellar setae (*le*)
3. Interlamellar setae (*in*)
4. Anterior exobothridial setae (*exa*)
5. Posterior exobothridial setae (*exp*)

A sensillus (*ss*) (Plate-3, Fig.2) arises from each bothridium (*bo*) and shows variation in size and shape in various genera and species.

b. Notogaster

The prodorsum is separated from the notogaster by a dorsosejugal suture. The notogaster is undivided or rarely separated into 2-4 parts by transverse sutures. In primitive oribatids, there are usually 16 pairs of notogastral setae which will be 10 or 14 pairs in higher oribatids. Grandjean (1949) applied different terminology to define various setal types. Thus, when the setal number is 16 pairs the notation is as follows:

First row : c_1, c_2, c_3

Second row : d_1, d_2, d_3

Third row : e_1, e_2

Fourth row : f_1, f_2

Fifth row : h_1, h_2, h_3 and

Sixth row : ps_1, ps_2, ps_3

When the setal number is 14 or 15 pairs the notation changes as:

First row : c_1, c_2, c_3

Second row : *da*, *la*

Third row : *dm, lm*

Fourth row : *dp, lp*

Fifth row : h_1, h_2, h_3 and

Sixth row : ps_1, ps_2, ps_3

Here '*d*' indicates dorsal, '*l*' lateral, '*a*' anterior, '*m*' medial and '*p*' posterior positions. When the number of notogastral seta is 10 pairs, the notation changes to

First row : *ta, te, ti*

Second row : *ms*

Third row : r_1, r_2, r_3

Fourth row : ps_1, ps_2, ps_3

Here the letter '*a*' stands for anterior '*e*' for exterior and '*i*' for interior. Some primitive oribatids have more than 16 pairs of notogastral setae. These setae which in most cases differ from normal setae are called neotrichial setae and the condition is called neotrichy.

Certain groups of oribatids have wing-like anterolateral projections called pteromorphs (*ptm*) which sometimes extend beyond the body and may curve ventrally over the legs. Pteromorphs may be movable or immovable.

Most of the oribatid mites are characterised by special respiratory organs of the notogaster viz., area porosae or sacculi or pori. The area porosae are portions thinner than the cuticle of the notogaster and are supplied with fine pores. They vary in number and shape. Higher oribatids usually carry four pairs of area porosae viz., *Aa*, A_1, A_2 and A_3. In addition to these, *Ad* and *Apa* two other area porosae, were also detected in few types. If the area porosae sink bag like into the cuticle, with only a slit or dot-like opening on the surface, they are called sacculi. They are named s_a, s_1, s_2 and s_3. If area porsae disappear with only a point like pore in their place, we have the pori (*pa*, p_1, p_2 and p_3). They may also take the form of slits on the notogaster, called fissures and are denoted by *ia, im, ih, ips* and *ip*.

2. Lateral Region

A chitinous, longitudinal ridge called tutorium (*tu*) with a free apex may be present on each side laterally in higher oribatids. Pedotecta (pd_1, pd_2 and pd_3) are structures which partly cover or protect the bases of legs. The ventral plate laterally produced into projections of various shapes called discidia (*dis*) which protect the base of IVth leg. In some oribatids, a wedge shaped structure arises from leg IV, called the custodium (*cus*).

3. Ventral Region (Plate-3, Figs. 3-5)

a. Gnathosoma (Plate-3, Fig.4)

It is the region bearing the oral organs or the mouth parts and is situated in an anterior cavity or the camerostome. The basal part of the gnathosoma is called subcapitulum or infracapitulum, which consists of an unpaired mentum, a dorsal neck or cervix, the paired genae and their continuation in the rutellum (*ru*). The articulation between the mentum and genae is called the labiogenal articulation which is of 4 types.

1. Anarthric type - Without special articulation
2. Stenarthric type - Labiogenal articulation directed posteriorad so that the mentum appears triangular.
3. Diarthric type - Labiogenal suture transverse with a large quadrangular mentum. Genae and rutelli are large.
4. Suctorial type - Mentum and genae are fused and no suture is present. Rutelli are modified into tubes.

The infracapitular region bears setae, the number of which varies. Usually mentum and genae bear one pair of setae each (*h* and *a* respectively). In addition to this, genae also bear 1-2 pairs of minute setae (m_1 and m_2). In higher oribatids, usually only a single pair of minute seta (*m*) present. The chelicerae (Plate-3, Fig. 5) of oribatid mites are of five types. 1) a wide or chewing type and 2) an elongated picking or peloptoid type. Chewing type of chelicerae possess two setae (*cha* and *chb*), and a fixed digit (digitus fixus) and a movable digit (digitus mobilis). Both the digits bear teeth. Peloptoid chelicerae have only one seta. The pedipalps are formed by 2-5 segments. The setation of each segment is related to that of the ambulatory legs.

b) Epimeral Region

The epimeral or coxisternal region is the area between the infracpitulum and genital plate. This region is covered over by four epimeral plates viz. *ep_1, ep_2, ep_3* and *ep_4*. The epimeral plates are bordered by chitinous thickenings called the apodemata. A total of 5 apodemata *apo_1, apo_2, apo_3 apo_4* and *aposj* (apodemata sjugalis) are distinguished. The epimeres carry varying number of setae which are denoted by a formula of four figures, i.e., the epimeral setal formula. The number of setae is denoted by a letter of alphabet from middle to margin.

c) Ano-genital Region

The ventral region of the body behind the area of epimeres is occupied by the genital and anal plates, called the ano-gential region. In primitive groups, the genital and anal plates touch each other and occupy the entire length of genito-anal region. However, in higher oribatids the genital and anal plates do not meet each other and are situated on a distinct ventral plate. A pair of genital plates, an unpaired preanal plate, a pair of anal plates and a pair of laterally located adanal plates are seen on the ventral plate. Except preanal plate, all the above mentioned plates carry setae of varying number and nature. Genital plates in primitive forms are divided by a transverse suture. The genital and anal areas may also have porous fields, area porosae postanalis (*Apa*) and slit organs or fissures (*iad, ian*). The ventral plates may be ornamented variously.

4. Legs (Plate-3, Fig.6)

Adult oribatid mites possess 4 pairs of legs, each with 5 segments viz., trochanter, femur, genu, tibia and tarsus. Chaetotaxy of legs vary from species to species as well as from legs I to IV. The chaetotaxy of different segments is indicated by a formula. The leg setae are of 4 major types.

1. Normal setae: They are the most abundant setiform organs on the legs and are homogeneous with a median cavity and contain actinochitin.

2. Solenidia: Solenidia are hollow, thin walled and can be easily distinguished from other setiform organs by the lack of actinochitin. They are of the following 4 types.

   a. Baculiform - When they have the same diameter throughout

   b. Ceratiform - When they taper towards the tip

   c. Tactile - When they are very long and flagellate

   d. Piliform - When they are elongated and with fine tip

The solenidial notation varies with segments and accordingly they are denoted as sigma (σ) when they are on genu, *phi* (φ) when they are on tibia and omega (ω) when they are on tarsus.

3. Eupathidic setae: Eupathidic setae are usually present on the tarsus of leg I and they represent modified setae having a hollow canal, penetrating the small root and a large alveolus. They are formed as a result of regressive evolution.

4. Famuli: They are seen only on the tarsal segments and can be distinguished by their unique shape. They are like solenidia or eupathidia but stand separate by the presence of actinochitin. Their internal surface is rugose and are also formed by regressive evolution.

Chapter V

OBSERVATION

The results of the survey carried out on the primitive oribatid mites of North Kerala during the present investigation revealed the presence of 35 species belonging to 20 genera under 10 families and 8 superfamilies (Table 1). Species richness of primitive oribatid mites was particularly striking at the 4th site viz., Calicut University Campus, which disclosed the presence of 30 species of these mites belonging to 16 genera recognized under 6 families and 5 superfamilies.

The 8 primitive superfamilies of oribatid mites recorded during the study were Mesoplophoroidea, Phthiracaroidea, Hypochthonoidea, Cosmochthonoidea, Brachychthonoidea, Lohmannoidea, Epilohmannoidea and Nothroidea. The 10 families, under which the 35 species could be accommodated were Apoplophoridae, Phthiracaridae, Hypochthoniidae, Cosmochthoniidae, Sphaerochthoniidae, Brachychthoniidae, Lohmanniidae, Epilohmanniidae, Trhypochthoniidae and Malaconothridae.

Of these, the family Lohmanniidae contributed the maximum generic composition with 6 genera and 25 species. The families, Apoplophoridae Sphaerochthoniidae and Brachychthoniidae showed the minimum generic representation as they comprised a single genus and a single species each. The generic diversity of individual family of the primitive oribatid mites could be expressed in a descending order as follows:

Lohmanniidae> Trhypochthoniidae> Phthiracaridae> Hypochthoniidae> Cosmochthoniidae> Epilohmaniidae> Malaconothridae> Apoplophoridae> Spherochthoniidae> Brachychthoniidae.

The species diversity of the primitive oribatid mites at each site varied according to the geographical and floral pecularities of the sites. Out of the six sites surveyed, the Calicut University Campus possessed the highest species diversity, occupying 25 species (71.4%) belonging to 16 genera, under 6 families and 5 super families. The site 2, Janakikad, harboured 11 species (31.4%) grouped under 6 genera 4 families and 3 superfamilies. The third study site at Ayanikad disclosed the presence of 9 species (25.7%) belonging to 9 genera under 5 families and 5 super families. The site 1, 5 and 6 harboured 4 species (11.4%) each coming under 4 genera, 3 families and 3 superfamilies. The species diversity of mites could be presented as follows:

CUC>JKD>AKD>MRP=KZH=COP

Among the 10 families, the family Lohmanniidae exhibited the highest species diversity, with 6 genera and 15 species. The genus *Annectacarus* was represented by 5 species, of which the species *A. nortoni* could be recognized as new to science. The genus, *Haplacarus* was represented by 3 species viz., *H. foliatus*, *H. keralensis* and *H. porosus*. The genera, *Cryptacarus, Javacarus* and *Meristacarus* were represented by two species each and among these, *M. unilateralis* was erected as new to science.

The genus *Papillacarus* was represented by a single species *P. baloghi* which also could be assigned as a new taxon.

The genus *Allonothrus* of the family Trhypochthoniidae was represented by 3 species, viz. *A. russeolus*, *A. sinicus* and *A. keralensis*, of which the latter species was erected as new to science. The genera *Hoplophthiracarus, Cosmochthonius, Epilohmannia* and *Archegozetes* were found represented by 2 species each.

The remaining genera, *Apoplophora, Atropacarus, Rhysotritia, Eohypochthonius, Malacoangelia, Spherochthonius, Brachychthonius, Malaconothrus* and *Trimalaconothrus* were represented by a single species each, of which *A.* (*H.*) *sensillatus*, *E. payyoliensis* and *M. hygricola* were erected as new to science during the present study.

Thus, the results of the present survey conducted on the primitive oribatid mites of a few selected sites at North Kerala, enabled to assign 7 species, belonging to 7 genera and 4 families and 4 superfamilies as new to science. Hence 25.7% of the total collection was considered as new species.

Chapter VI

SYSTEMATIC POSITION OF THE SPECIES DESCRIBED

MACROPHYLINA OR ORIBATEI INFERIORS

A. PTYCTIMA

I.	Superfamily	:	Mesoplophoroidea Van der Hammen, 1959
	Family	:	Apoplophoridae Niedbala, 1984
	Genus	:	*Apoplophora* Aoki, 1980
	1	:	*Apoplophora pantotrema* (Berlese 1913)
II.	Superfamily	:	Phthiracaroidea Grandjean, 1954
	Family	:	Phthiracaridae Perty, 1841
	Genus	:	*Hoplophthiracarus* Jacot, 1933
	2	:	*Hoplophthiracarus pakistanensis* (Hammer, 1977)
	Genus	:	*Atropacarus* Ewing, 1917
	Subgenus	:	*Atropacarus* (*Hoplophorella*) Neidbala, 1986
	*3	:	*Atropacarus (Hoplophorella) sensillatus sp. nov.*

B. ARTHRONOTA

III.	Superfamily	:	Hypochthonoidea Balogh, 1961
	Family	:	Hypochthoniidae Berlese, 1910
	Genus	:	*Eohypochthonius* Jacot, 1938
	*4	:	*Eohypochthonius payyoliensis sp. nov.*
	Genus	:	*Malacoangelia* Berlese, 1913
	*5	:	*Malacoangelia hygricola sp. nov.*

IV.	Superfamily	:	Cosmochthonoidea Grandjean, 1947
	Family	:	Cosmochthoniidae Grandjean, 1947
	Genus	:	*Cosmochthonius* Berlese, 1910
	6	:	*Cosmochthonius zanini* Penttinen and Gordeeva, 2003.

C. HOLONOTA

V.	Superfamily	:	Lohmannoidea Grandjean, 1967
	Family	:	Lohmanniidae Berlese, 1916
	Genus	:	*Annectacarus* Grandjean, 1950
	7	:	*Annectacarus hammerae* Shiji *et. al.*, 2007
	*8	:	*Annectacarus nortoni* sp. nov.
	Genus	:	*Cryptacarus* Grandjean, 1950
	9	:	*Cryptacarus keralensis* Shiji *et. al.*, 2007
	Genus	:	*Haplacarus* wallwork, 1962
	10	:	*Haplacarus keralensis* Haq *et. al.*, 1984
	Genus	:	*Javacarus* Balogh, 1961
	11	:	*Javacarus porosus* Hammer, 1980
	Genus	:	*Meristacarus* Grandjean, 1934
	*12	:	*Meristacarus unilaterals* sp. nov.
	Genus	:	*Papillacarus* Kunst, 1959
	*13	:	*Papillacarus baloghi* sp. nov.
VI.	Superfamily	:	Epilohmannoidea Grandjean, 1969
	Family	:	Epilohmanniidae Oudemans, 1923
	Genus	:	*Epilohmannia* Berlese, 1910
	14	:	*Epilohmannia pallida pacifica* Aoki, 1965
	15	:	*Epilohmannia pallida indica* Bhattacharya and Banerjee, 1980.

VII.	Superfamily	:	Nothroidea Grandjean, 1954
	Family	:	Tryhypochthoniidae Willmann, 1931
	Genus	:	*Allonothrus* Van der Hammen, 1953
	16	:	*Allonothrus sinicus* Wang Hu Fu and Norton, 1988
	*17	:	*Allonothrus keralensis* sp. nov.
	Genus	:	*Archegozetes* Grandjean, 1931
	18	:	*Archegozetes longisetosus* Aoki, 1965
	Family	:	Malaconothridae Berlese, 1916
	Genus	:	*Trimalaconothrus* Berlese, 1916
	19	:	*Trimalaconothrus duoaculeus* Yamamoto *et. al.*, 2004.

Chapter VII

DESCRIPTION OF SPECIES

Superfamily : Mesoplophoroidea Van der Hammen, 1959.

Family : Apoplophoridae Niedbala, 1984.

Genus : *Apoplophora* Aoki, 1980.

Sensillus setiform with unilateal short branches of varying number. Aspis with 4 pairs of smooth or finely ciliate setae. Notogaster convex with 8 pairs of smooth or pectinate setae. Ventral plate with 9-10 pairs of setae. Genital plate with 6 pairs of setae and anal plate with 4 pairs (rarely 3 pairs) of setae. Anal and genital openings round, separated from each other by a wide bridge.

***Apoplophora pantotrema* (Berlese, 1913)**

(Plate-4, Figs.1-7)

Colour : Dark brown

Measurements : Length of Aspis : 210-252 µm

Width of Aspis : 140-182 µm

Length of Notogaster : 280-378 µm

Width of Notogaster : 182-252 µm

Dorsal Region (Figs.1-2)

Prodorsum triangular with a pointed rostrum with its tip turned downwards. Seta *ro* 82 µm long, thick, inserted far behind the rostral apex. Seta *le* resembles *ro* in length and appearance while *in* short, 41 μm long and thicker than *ro* and *le*. Seta *ex* short, measuring 37 μm. Sensillus setaceous and barbed unilaterally, the basal barbs short which progressively increase towards the apex. Bothridial opening circular. All prodorsal setae unilaterally barbed. Prodorsal integument porose.

Notogaster convex with 8 pairs of unilaterally barbed setae. Setal length increases towards posterior region. Notogaster ornamented with foveoles, arranged in a reticulate and often irregular pattern.

Ventral Region (Figs. 3-7)

Infracapitulum (Fig.3) with 3 pairs of smooth setae. Rutella with 3-4 well developed dendites. Epimeral setal formula 2-1-2-2, (Fig.4) all setae smooth. Epimeral surface porose. Genital plates (Figs. 5 & 7) triangular with 6 pairs of smooth setae, 3 of which arranged vertically, one below the other, while the other 3 setae arranged linearly in a longitudinal row. Four anal setae (Fig. 6 & 7) present on each anal plate, all barbed unilaterally.

Legs

All legs monodactylous.

Materials Examined

Twelve specimens recovered from soil samples collected from the Botanical garden (Site-4a) of the Calicut University Campus, Kerala, India, collected by Shiji. M.T on 10-09-2002.

Remarks

The present specimen shows close resemblance to *A. pantotrema* (Berlese 1913) described from Java, except in the size of notogastral and anal setae and possession of epimeral setal formula of 2-1-2-2.

Superfamily: Phthiracaroidea Perty, 1841

Family: Phthiracaridae Perty, 1841

Genus: *Hoplophthiracarus* Jacot, 1933

Body surface usually covered with concavities. Dorsal region of prodorsum not fused with lateral region. Furrows usually present on back of prodorsum. Lamellar setae usually very short. Sensillus usually 'histricinus' type. Seta c_1 on the notogaster shorter than the distance between setae c_1 and d_1. Nine pairs of genital setae present. Adanal setae inserted away from the paraxial margin and seta ad_1 longer than the anal setae. All setae on the ano-adanal plate normal.

***Hoplophthiracarus pakistanensis* Hammer, 1977**

(Plate- 5, Figs.1-7)

Colour : Brown

Measurement : Length of Aspis : 196-238µm

Width of Aspis : 168 -182µm

Length of Notogaster : 392-462µm

Width of Notogaster : 366-399µm

Dorsal Region (Fig.1 & 2)

Dorsal and lateral regions of aspis long and narrow, lateral carina reaches the sinus. Well marked furrows present on the back of aspis (Fig.2). Sensillus long with narrow pedicel and a distal club, the latter with a hyaline membrane. Seta *ro* thick and rough with pointed tip. Seta *le* short and thick. Seta *in* robust, serrated.

Notogaster with 15 pairs of normal, robust setae covered with spines. Seta c_3 inserted near the anterior margin, c_1 further away and c_2 far away. Notogastral integument porose.

Ventral Region

Gnathosomal setae (Fig.3) 3 pairs, all roughened, *a* the longest. Gnathosomal region ornamented with foveoles. Chelicerae (Fig.4) well developed with 2-3 teeth on the fixed digit and 3-4 teeth on the movable digit. Epimeral setal formula 1-1-1-1. All setae smooth. Genital setae 6 (4+2): 3, all setae smooth (Fig.5). Ano-adanal plate with thick punctations laterally. Anal setae 2 pairs and of smooth nature (Fig.6). Adanal setae 3 pairs, all of which roughened, seta ad_2 longest. Seta ad_3 shortest.

Legs

All legs monodactylous. Chaetotaxy of leg I (Fig. 7): 1-4-4-5-17.

Materials Examined

Fifteen specimens collected from soil and litter samples of Botanical Garden (Site 4a), Calicut University Campus, Kerala, India collected by Shiji. M. T. on 02-06-2003.

Remarks

The present specimen resembles *Hoplophtiracarus pakistanensis* (Hammer, 1977) collected from Pakistan in all characters except in the nature of rostral and anal setae.

Superfamily : Phthiracaroidea Perty, 1841

Family : Phthiracaridae Perty, 1841

Genus : *Atropacarus* Ewing, 1917

Subgenus : *Hoplophorella* Niedbala, 1986

Fifteen pairs of gastronotic setae present. As a general rule, only 2 lyrifissures present, *ia* and *im*. Members possess 9 pairs of genital setae and 5 pairs of setae on the fused ano-adanal plate. Seta ad_2 inserted slightly away from the paraxial margin.

***Atropacarus* (*Hoplophorella*) *sensillatus*. sp. nov.**

(Plate-6, Figs.1-8)

Colour : Pale yellow

Measurements: Length of Aspis: 238 µm (210-238 µm)

Width of Aspis : 154 µm (140-154 µm)

Length of Notogaster : 434 µm (420-434 µm)

Width of Notogaster : 308 µm (294-322 µm)

Dorsal Region (Fig. 1 & 2)

Prodorsum

Aspis (Fig. 2) bifurcate in nature with deep incision. Seta *ro* thick, curved inwards. Seta *le* short and spiniform. Seta *in* lanceolate and veined. Sensillus long with a short pedicel, inflated in the middle. Head of *ss* hyaline with irregular margin and with distinct midrib.

Notogaster

Notogaster with 15 pairs of clubbed and roughened setae (Fig. 3). Posteriorly, notogaster produced into a caudal appendage. Notogastral integument heavily porose.

Ventral Region

Infracapitulum (Fig. 4) with 3 pairs of thin, smooth setae, *h* shortest and *a* and *m* more or less equal. Infracapitulum porose. Chelicerae (Fig.5) with 3-4 well developed teeth and setae *cha* and *chb* almost equal in size. Rutella with broad well developed dendites. Epimeral setal formula 1-0-1-1 (Fig.6). Seta *1a* much longer and thicker than the other setae, setae *1a* and 3a roughened. Genital plate porose with foveoles. Genital setal formula 7 (4+3) : 2 (Fig. 7). Ano-adanal plate with 2 pairs of smooth anal setae and 3 pairs of adanal setae. Seta ad_2 foliate with spines, seta ad_3 shortest.

Legs (Fig. 7)

All legs monodactylous. Chaetotaxy of leg I (Fig. 8):1-4-4-6-18. Trochanter I with a single, thin seta. Genu I with 2 solenidia σ_1 and σ_2 .

Seta *d* closely associated with σ_1. Setae xt_1 and xt_2 on tibia I barbed. Setae (*tc*) thick, barbed and with curved tip. Seta *s* smooth. Setae (*u*) and *pv′* barbed.

Materials Examined

Holotype ♀: Paratypes; 17 ♀♀ collected from soil and litter samples from site 3a at Ayanikkad, Calicut (Dt), Kerala, India, collected by Shiji. M.T on 21-10-2002.

Remarks

The subgenus *Atropacarus* (*Hoplophorella*) was erected by Niedbala (1986) based on the type species, *A.* (*Hoplophorella*) *cucullatum*. The present specimen in comparison with 23 known species of the subgenus revealed some resemblance to *A.* (*H.*) *floridae* described by Jacot (1933) and *A.* (*H.*) *scapellata* described by Aoki (1965) in various characters. But it possesses some character deviations from the above 2 species and hence is assigned to a new taxon. It differs from *A.* (*H.*) *floridae* by the nature of notogastral setae and lanceolate nature of interlamellar setae. The present species differs from the *A. (H.) scapellata* by the possession of 7(4+3) : 2: arrangement of genital setae and nature of notogastral setae.

The unique features of the species are as follows:

1. Clubbed and roughened notogastral setae.
2. 7 (4+3): 2 arrangement of genital setae
3. Nature of sensillus.

Superfamily: Hypochthonoidea Balogh, 1961

Family: Hypochthoniidae Berlese, 1910

Genus: *Eohypochthonius* Jacot, 1938

Fourteen pairs of notogastral setae present. Seta e_1 and e_2 reduced and represented only by their alveoli. Shoulder without humeral tubercles.

***Eohypochthonius payyoliensis* sp. nov.**

(Plate-7, Figs. 1-5)

Colour :Yellowish brown

Measurements: Length: 296µm (Range 288-300µm)

Width : 124µm (Range 124-128µm)

Dorsal Region (Figs. 1 & 2)

Prodorsum

Rostral tectum with 3 teeth, 2 placed close together and one far anterior. Seta *ro* 40µm long, forwardly directed, situated far beyond the rostral margin, foliate, smooth and straight. Seta *le* 40µm, long resembles *ro* in appearance, but directed backwards. Seta *in* measures 24µm, foliate, arising more or less at the level of *bo.* Both setae *exa* and *exp* foliate, *exp* minute in appearance. Sensillus (*ss*) (Fig. 2) pectinate with 10 branches on one side and 5 on the other side. Lateral crests present and directed forwards. Median crests arise from the median region of prodorsal band, which diverge anteriorly and meet the insertion of *le.* Several downwardly directed branches connected together forming a network present on the prodorsum in between prodorsal band and dorsosejugal suture. Posterolateral walls of the prodorsum produced into shoulder like downward outgrowth, one on each side. Prodorsal integument bears fine punctation.

Notogaster

Notogaster elongate and cylindrical. A prominent transverse furrow present on the notogaster medially. Another furrow present anteriorly, above setae c_1-c_3, below dorsosejugal suture. Sixteen pairs of foliate notogastral setae of varying size present on notogaster. Setae e_1 and e_2 represented only by alveoli and seen in the notogastral furrow. Posteriormost setae flexed ventrad. Notogastral integument finely punctate.

Ventral Region (Fig.3)

Infracapitular setae 4 pairs *a*, m_1, m_2 and *h*, all thin, simple and smooth. Seta *a* longer than *m* and *h.* Chelicerae (Fig.4) with 3-4 sharp teeth on each digit. Seta *cha* minute. Seta *chb* long, thin and smooth. Epimeral setal formula 3-1-3-4. All setae thin, smooth and of varying size. Setae *1a*, *2a*, *3a* and *4a* longer than others.

Anogenital setae thin and simple. Genital plates with transverse suture, almost medially. Each plate carries 10 setae, 5 on anterior and 5 on posterior halves. Two anal and 3 adanal setae present. The length of adanal setae increases posteriorly. Whole ventral plate bears punctations.

Legs

All legs monodactylous with a stout claw. Leg segments bear punctations arranged in a zigzag manner. Chaetotaxy of leg I (Fig. 5) 0-5-5-5-20. Femur I carries 5 thin setae. Genu I carries single solenidion σ. Tibia I bears 2 solenidia, φ_1 and φ_2 along with 3 other setae. Tarsus I carries 20 setae including 2 solenidia ω_1 and ω_2; of which ω_1 stout and blunt. A famulus (ε) seen in between ω_1 and ω_2.

Materials Examined

Holotype: ♀, Paratypes; 25♀♀ collected from soil and litter samples from site, 3b at Ayanikkad, Calicut district, Kerala, India, collected by Shiji. M. T. on 15-09-2003.

Remarks

The genus *Eohypochthonius* was erected by Jacot (1936) based on the type species, *E. gracilis* from North Carolina, USA. The present new species can be easily separated from *E. gracilis* by the possession of a shoulder like lateral downward outgrowth from the postero lateral side of prodorsum. By the absence of translamellar line, highly reduced setae e_1 and e_2 represented by alveoli, nature of lateral crest, presence of median crest, presence of cilia like structures forming a network between dorsosejugal suture and prodorsal band, the present species can be clearly distinguished from *E. crassisetiger* Aoki, 1959 and the nature of notogastral and prodorsal ornamentation of the present new species enables its separation from *E. gracilis gracilis*, Jacot, *E. africanus*, Mahunka, 1978, *E.* (*Eohypochthonicus*) becki Balogh and Mahunka, 1979, *E. salicifolius* Hammer, 1979 and *E. vermicularis* Hammer, 1979.

The unique characters of the present species are listed below:

1. Shoulder like lateral outgrowth from the postero-lateral wall of prodorsum.
2. Presence of cilia like structures forming a network between dorsosejugal suture and prodorsal band.
3. Presence of median crest.
4. Punctated nature of prodorsal and notogastral integument.
5. Nature of sensillus.

Superfamily : Hypochthonoidea Balogh, 1961

Family : Hypochthoniidae Berlese, 1910

Genus : *Malacoangelia* Berlese, 1913

Sixteen pairs of notogastral setae. Setae e_1 and e_2 placed on intercalary sclerite of transverse suture, smaller than the remaining setae. Notogastral setae slightly dilated like a blade. A lenticulus present, behind seta c_1.

***Malacoangelia hygricola* sp. nov.**

(Plate-8, Figs. 1-4)

Colour : Light brown

Measurements : Length : 432 µm (Range 420-436 µm)

Width : 292 µm (Range 290–294 µm)

Dorsal Region (Fig. 1)

Prodorsum

Rostrum flat with horn like projections laterally. Seta *ro* situated marginally, leaf like with distinct veins. Seta *le* with distinct unbranched midrib. Seta *in* foliate, curved upwards and inserted near *bo*. Seta *exp* simple, thinner and shorter than other prodorsal setae while *exa* foliate. s*s* unilaterally barbed and bifurcated at its tip. Distinct median and lateral ridges present on prodorsum as shown in Fig. 1. Prodorsal integument ornamented with short spine like outgrowths.

Notogaster

Notogaster transparent, broad and ornamented with spine like structures. Sixteen pairs of notogastral setae present, all foliate with distinct midrib except e_1 and e_2. The latter two setae comparatively small and inserted on the transverse ridge. Lenticulus with double layered outer wall and characteristic striations. An anterior ridge runs above the level of lenticulus on notogaster. Lateral ridges present on notogaster, below the transverse ridge. Posteriormost notogastral setae with 'T' shaped midrib and hyaline body.

Ventral Region (Fig. 2 & 4)

Infracapitulum (Fig.4) bears 4 pairs of thin and smooth setae, *a*, m_1, m_2, and *h*. Epimeral setal formula 3-1-3-4. All setae short, thin and smooth Ano-genital plate longer than wide. Each genital plate carries 10 setae, 4 long setae inserted in antiaxial row and 6 small setae in paraxial row, all setae simple and thin. Ano-adanal plate carries 2 pairs of thin and smooth anal setae and 3 pairs of smooth, adanal setae. Seta ad_2 longer than ad_1 and ad_3. Ventral plate ornamented with spiny configuration.

Legs(Fig. 3)

All legs monodactylous. Chaetotaxy of leg I (Fig.4) 0-6-4-5-21. Setae *d, bv,* v'' and l' on femur I foliate with distinct midrib. Genu I with a single, small solenidion σ, all other setae foliate. Tibia I bears 2 solenidia φ_1 and φ_2. φ_1 thick and short. φ_2 thin and elongate. Setae xt_1 and xt_2 foliate. Solenidia ω_1 and ω_2 present on tarsus I in addition to 18 other setae and a famulus. ω_1 thick with a blunt tip. Famulus (ξ) present, near ω_1. Setae *(u),* m'' and n' faintly barbed. All leg segments bear reticulations.

Materials Examined

Holotype ♀: Paratypes 17♀♀ collected from soil samples of site 3b at Ayanikkad, Calicut (Dt.), Kerala, India, collected by Shiji M. T. on 06.09.2003.

Remarks

Berlese (1913) erected the genus *Malacoangelia* with *M.remigera* as type species based on the presence of 16 pairs of notogastral setae, e_1 and e_2 on intercalary sclerite of the transverse suture and smaller than the remaining ones, 'T' shaped rostral setae and a transverse lenticulus behind seta c_1. Chakrabarti *et al.* (1972) erected *M.remigera indica* as a subspecies from West Bengal, India. Another species viz., *M. similis* was also reported from India by Sarkar and Subias (1972). The present species can be easily distinguished from the type species by the possession of median and lateral ridges, nature of lenticulus, prodorsal hairs and sensillus, horn like projections on the prodorsum and incomplete antero lateral ridges on the notogaster. The new species differs from *M.remigera indica*, by the presence of median and lateral ridges on the prodorsum, the bifurcated nature of sensillus and the nature of rostral setae. The present species can be easily separated from the *M. similis* by the unilaterally barbed nature of sensillus, prodorsal and notogastral ornamentation and nature of *le, ro* and lenticulus.

The unique characters of the species include the double walled nature of lenticulus, nature of median ridge on prodorsum and nature of sensillus.

Superfamily : Cosmochthonoidea Grandjean, 1947

Family : Comochthoniidae Grandjean, 1947

Genus : *Cosmochthonius* Berlese, 1910

Generic Diagnosis

Notogaster subdivided by three transverse sutures into 4 shields. Seta *c* arising on shield *Na*, seta *d* on shield *Nm*, seta *e* in furrow 2, seta *f* in furrow 3, setae *h* and *ps* on shield *PY*. Prodorsal setae as well as setae *h* and *ps* short or medium long, densely (pencillately) ciliate or plumose. Setae *c* and *d* simpler, though still densely ciliate. Setae *e* and *f* very long and usually rigid. Sixteen pairs of notogastral setae present, seta *ps* shifted to ventral side. Ten pairs of genital, four pairs of anal and four pairs of adanal setae present. Epimeral setal formula 3-2-3-4 claw formula of legs 2-3-3-3.

***Cosmochthonius zanini* Penttinen, *et al.*, 2003**

(Plate- 9, Figs. 1-2)

Colour : Brown

Measurements : Length: 359 μm – 372 μm

Width : 197 μm – 201 μm

Dorsal region (Fig. 1)

Dorsal region of body except the dorsosejugal suture, covered by thick cerotegument with irregular pores and big holes and having reticulate appearance. Cerotegument denser on transversal sutures. Cuticle on dorsal side of body with foveolae, where as cuticle on dorsosejugal region with thin longitudinal lines.

Prodorsum (Fig.1)

Prodorsum covered by cerotegument, denser on margins. Rostrum round with a blunt apex. Transverse cuticular ridge present in between bothridia (*bo*), at the base of prodorsum. Seta *ro* phylliform, brush shaped with bi or trifurcate bristles. Setae *le* and *in* biramous with bi-or trifurcate bristles. Seta *exa* dorsoventrally flattened, round and brush shaped with bi-or trifurcate bristles. Seta *exp* short and barbed. Sensillus long, fusiform with longitudinal rows of bristles.

Notogaster (Fig. 1)

Notogaster oval in shape with wary margins. All notogastral plates (*Na, Nm,* Nm_2*, PY*) covered by thick cerotugument, denser on the transverse sutures and lateral margins, forming a ridge like appearance. Sixteen pairs of notogastral setae present. First notogastral plate *Na* with 4 pairs of setae, c_1, c_2, c_3 and c_p and second plate Nm_1 with 2 pairs of setae, d_1 and d_2. Setae *c* and *d* thin and ciliate. Setae c_1 (52 µm) < c_2 (55 µm) = c_3. Distance between c_1-c_1 (31µm) > c_1-c_2 (21µm) = c_2-c_3. Seta d_1 (34 µm) <d_2 (52µm) and d_1-d_1 (9µm)<d_1-d_2 (26 µm). Setae *e* and *f* bipectinate and inserted on narrow, transverse intercalary sclerites between the plates Nm_1-Nm_2 and Nm_2 – *PY* respectively. Seta e_1 (149 µm) and e_2 (143µm) longer than f_1 (139µm) and f_2 (104µm). The distance e_1-e_1 (11 µm) < e_1-e_2 (12 µm), where as f_1-f_1 (19 µm)> f_1-f_2 (12 µm). Setae *h* and *p*, except ps_3 phyllliform and thick with *bi* or trifurcate bristles. Setae h_1, h_2, h_3 and ps_1 close to the margin, whereas setae ps_2 and ps_3 located ventrally.

Ventral region (Fig. 2)

Infracapitulum with 4 pairs of setae, *a, h,* m_1 and m_2. Setae *h* long, slender and biramose. Setae *a* and *m* also biramose. Labiogenial articulation diarthric. Epimeral setal formula 3-2-3-4, setae long slender and biramose.

Genital plates with 10 pairs of setae, biramose, 6 pairs of setae close to median line and 4 pairs farther off as show in Fig.2. The anal and adanal plates with 4 pairs of setae each, anal setae thick and densely ciliate than the adanal setae. All anal state of equal size, where as adanal setae ad_1 the longest and ad_4 the shortest.

Legs

Leg 1- bidactylous, II-IV tridactylous.

Material Examined

Three specimens collected from the soil and litter samples, at the premises of quarters, Calicut University Campus, Kerala, India collected by Shiji. M.T on 05-03.2006.

Remarks

The present specimen shows resemblance with the known species, *C. zanini* Penttinen *et al.*, 2003 in most of the characters and hence fixed so.

Superfamily: Lohamannoidea Grandjean, 1967

Family: Lohmanniidae Berlese, 1916

Genus: *Annectacarus* Grandjean, 1950

Genital plates without transverse suture. Anal and adanal plates fused. Pre-anal plate narrow. Two paris of anal and 4 pairs of adanal setal present. Notogastral and epimeral region with neotrichy.

Annectacarus hammerae **Shiji *et al.*, 2007**

(Plate-10, Fig. 1-6)

Colour : Brown

Measurements : Length : 516 µm (Range: 507-516µm)

Width : 258 µm (Range: 256-270µm)

Dorsal Region (Fig.1 & 2)

Prodorsum

Rostral tectum entire. Seta *ro* measures 70µm, barbed bilaterally , inserted at the rostral tip. Seta *le* 98µm long, unilaterally barbed, *in* 70µm long, inserted near *bo* and barbed. Both *exa* and *exp* barbed and each measures 98µm. Lamellae on either side produced into condyles near insertion point of *exa*. Sensillus (*ss*) (Fig.2) pectinate with 14 branches on one side and 6-7 short branches on the other side. Lateral margin of prodorsum bears foveoles of semilunar nature. The region between lamellae carries polygonated punctations. Few area porosae scattered on prodorsum, particularly between *bo*.

Notogaster

Notogaster cylindrical with a rounded posterior margin. It bears punctations arranged polygonally. A few area porosae seen on the nototgaster, in between setae c_1 and c_2 on either side. Notogaster with 24 pairs of long unilaterally barbed setae. Median setae c_1, d_1 and e_1 short and roughened. Seta f_1 placed medio-laterally than other median setae. Pygidial neotrichy present. Fissure *im* present near the insertion point of e_2 on either side of the notogaster. Foveoles of semilunar nature seen on lateral and posterior borders of notogaster.

Ventral Region (Fig. 3)

Infracapitulum (Fig. 4) with 5 pairs of setae. Seta *a* smooth and foliate. Setae m_1, m_2, m_3 and *h* barbed. Chelicerae (Fig. 5) stout with 2-3 stout teeth on each digit, *chb* about 3 times longer than *cha*. Epimeral setal formula 5-4-3-3. Setae *1a, 2a, 3a* and *4a* small and smooth while other setae barbed. Epimeral region ornamented with polygonated punctations. Fissure *ia* seen on lateral side of epimere III. Genital plates without transverse suture. Each genital plate carries 10 barbed setae, arranged in 2 rows of 6 short paraxial and 4 long antiaxial setae. Pre-anal plate narrow with a postero-median projection. Anal and adanal plates fused. Four pairs of long adanal setae and 2 pairs of small anal setae present, all barbed in nature.

Legs

All legs monodactylous. All leg segments with punctations arranged polygonally. Chaetotaxy of leg I (Fig.6) represented by formula 0-5-5-5-18. Trochanter I with a tooth like structure. Femur I with a dorsal notch, a tooth and a keel in ventral position. All setae on femur I barbed. Genu I bears a solenidion σ, closely associated with seta *d.* Tibia I bears 2 solenidia φ_1 and φ_2, the latter longer than the former. Tarsus I with 2 solenidia, ω_1 and ω_2, ω_1 stout with blunt tip. Seta *ft′* barbed, seen closely associated with ω_2. Setae (*p*), *s* and *m* smooth. Setae (*tc*), (*a*) and *pv′* barbed. Tarsus I ends in a pretarsus and claw, the latter with a ventral tooth.

Materials Examined

Twenty six specimens collected from soil and litter samples of premises of Ladies Hostel (Site 4b), Calicut University Campus, Kerala, India collected by Shiji. M. T. on 19-07.2002.

Remarks

The present specimen resembles *A. hammerae* described by Shiji *et al.*, 2007 from Kerala in all respects.

Superfamily : Lohmannoidea Grandjean, 1967

Family : Lohmanniidae Berlese, 1916

Genus : *Annectacarus* Grandjean, 1950

***Annectacarus nortoni* sp. nov.**

(Plate-11, Figs.1-4)

Colour : Yellowish brown

Measurement : Length – 533µm (Range – 497-577µm)

Width – 333µm (Range- 279-306 µm)

Dorsal Region (Fig. 1)

Body elongated with broadly conical anterior and round posterior ends. Microsculpture of integument includes reticulated polygons with fine punctations.

Prodorsum

Anterior margin of rostral tectum entire, without incision. All prodorsal setae distinctly barbed. Setae *ro* 79µm long, uniformly barbed, inwardly curved, inserted on a ridge, slightly behind the anterior margin of rostrum. Seta *le* unilaterally barbed, inserted below the level of *ro* and measures 111µm. Seta *exa* unilaterally barbed and 93µm long. Seta *exp* roughened unlike setae *ro* and *in*. Seta *in* inserted close to the cup shaped *bo*, uniformly barbed and measure 93µm. Sensillus (*ss*) pectinate with 13-15 long branches on the lower surface (Fig.3) and 4-6 short barbs on the upper surface. Three area-porosae seen at the interlamellar region, between setae *in*, but below their level.

Notogaster

Notogaster cylindrical and elongate with pygidial neotrichy. Notogastral setae 24 pairs with pronounced size variation. Setae c_1, d_1 and e_1 short, narrow and smooth, each measuring 22µm in length. All other notogastral setae long and unilaterally barbed. A few area porosae arranged in the form of an incomplete band below the insertation point of seta d_2 (in paratypes). Fissure *im* located near the insertion of seta e_2.

Ventral region (Fig. 2)

Infracapitulum bears 4 pairs of barbed setae, *a, h,* m_1 and m_2. Epimeral neotrichy present and setae show size variation. Epimeral setal formula 7-4-3-4. Paraxial and a single pair of antiaxial setae on epimere I short and smooth, while the remaining setae long and barbed. A few porose areas of varying size arranged on epimeral region as shown in fig.2. Genital plate entire, bearing 10 pairs roughened setae arranged in two rows, 6 pairs of short setae arranged paraxially and 4 pairs of long setae inserted antiaxially. Pre-anal plate narrow with a slight median concrescence posteriorly. Two pairs of short anal and 4 pairs of long adanal setae present on the fused ano-adanal plates, all setae finely barbed. Fissure *in, ip* and *in* located ventrally.

Legs (Fig. 4)

All legs monodactylous and punctated. Chaetotaxy of leg I represented by the formula 0-5-5-5-18. All setae except *l* on femur I barbed. Setae l' smooth and comparatively small. Genu I bears 2 solenidia σ_1 and σ_2, the latter longer than the former. Seta l' of genu I smooth and thin while l'' thick and barbed. Tibia I bears a long solenidion φ, a thin and smooth seta l', and barbed setae *d*, xt_1 and xt_2. Tarsus I with 18 setae including 2 solenidia ω_1 and ω_2; ω, thick and blunt; pv', pv'' and ft″ barbed, others smooth.

Material Examined

Holotype ♀; paratypes 9♀♀ collected from soil and litter samples from Janakikadu, Mullankkunnu, Calicut, Kerala, India on 30.01.2006.

Remarks

Grandjean (1950) erected the genus *Annectacarus* with *A. micronatus* as the type species. The present specimen can be separated from *A. mucronatus* Grandjean, 1950 by the absence of notogastral line between the setae h_1 and comparatively short nature of setae c_1, d_1 and e_1. The new species differs from *A. africanus* Balogh, 1961 by the barbed nature of neotrichial setae and the possession of 24 pairs of notogastral setae instead of 21 in *A. africanus*. The unilaterally barbed nature of notogastral setae in the new species separates it from *A. insculptus* and *A. sejugatus* Wallwork, 1962, the latter two species possess bilaterally barbed notogastral setate. The absence of notogastral bands in the present species helps to separate it from *A. insculptus* which possesses the bands. The epimeral setal formula (7-4-3-4) of the present species distinguishes it from *A. unilateralis* Hammer, 1973 (7-5-3-3). The possession of 4 pairs of infracapitular setae distinguishes the new speices from *A. longisetosus* Bhattacharya *et al.*, 1974 which possesses 7 pairs of infracapitular setae. The possession of 24 pairs of notogastral setae and larger and thicker nature of *seta* f_1 differentiate it from *A. parallelus* Berlese, 1916, *A. hainanenisis* Hu and Wang (1990) and *A. eksteeni* Coetzee, 2001 (all these possess 21 pairs of notogastral setae and f_1 and c_1 are of equal size). The possession of 24 pairs of notogastral setae distinguishes the present species from *A. mahabaeus* Corpuz-Raros, 1979 which possesses 21 pairs of notogastral setae. The longer and unilaterally barbed nature of notogastral setae with the exception of the short and smooth median setae c_1, d_1 and e_1 distinguishes the new species from *A. granditrichosus* Sengbusch, 1984. The new species differs from *A. krachan* Mahunka, 1995 by the possession of 24 pairs of notogastral setae compared to the 18 pairs in the latter. The possession of epimeral setal formula (7-4-3-4) in the new species makes it distinct from *A. wallworki* Clement and Haq, 1991 in which the epimeral setal formula is 6-4-3-3. The absence of notogastral bands and the possession of 24 pairs of unilaterally barbed notogastral setae distinguishes the new species from *A. aoki* Jaikumar *et al.*, 1994, which possess 18 pairs of bilaterally barbed notogastral setae. The present specimen is separated from the known Indian species, *A. trivandricus* Haq, 1978 by the epimeral setal formula 7-4-3-4 (5-4-3-4 in *A. trivandricus*), absence of aggenital plate, absence of incision at the anterior margin of rostral tectum and the sensillus with 4-6 small barbs on the upper side and 13-15 long branches on the lower-side.

The unique combination of features of the present species by which it keeps identity separate from all known species of the genus *Annectacarus* are:

1. Possession of 24 pairs of unilaterally barbed notogastral setae.
2. Epimeral setal formula of 7-4-3-4.
3. Smooth nature of median setae c_1, d_1 and e_1.

Superfamily : Lohmannoidea Grandjean, 1967

Family : Lohmanniidae Berlese, 1961

Genus : *Cryptacarus* Grandjean, 1950

Genital plates with transverse suture. Anal and adanal plates fused. Pre-anal plate narrow. Two paris of anal and 4 pairs of adanal setae present. Notogaster and epimeral region with neotrichy.

***Cryptacarus keralensis* Shiji *et al.*, 2007**

(Plate-12, Figs. 1-6)

Colour : Golden yellow

Measurements : Length : 369 µm (Range 360-377 µm)

Width : 160 µm (Range 155-164 µm)

Dorsal Region (Fig.1 & 2)

Prodorsum

Rostral tectum broadly round. Seta *ro* highly branched and inserted far below the rostral apex, directed anteriorad. Seta *le* inserted slightly below and exterior to the insertion of *ro*, on the lateral ridge. Seta *le* resembles *ro* in appearance, but distinctly shorter. Seta *in* also bilaterally branched and inserted very near to *bo*. Setae *exa* and *exp* almost of equal size and resemble other prodorsal hairs in appearance. Sensillus (Fig. 2) pectinate with 15-16 long branches on one side and 7-9 small branches on the other side. Prodorsum bears lateral spiny outgrowths above the level of insertion of *exa*. Prodorsum carries tubercles of varying size and inner punctations except at the extreme lateral margins. Prodorsal area lying just above the dorsosejugal suture bears feebly developed foveoles.

Notogaster

Notogaster cylindrical with parallel and wavy margins. Posterior margin of notogaster rounded with an irregular, more or less wavy outline. Notogastral integument bears closely set polygonal tubercles of varying size and nature, which often contain fine punctations. All notogastral setae bilaterally branched. Pygidial neotrichy prominent with comparatively short setae.

Ventral Region (Figs. 3-5)

Infracapitulum (Fig. 4) bears 5 paris of setae *a*, m_1, m_2, m_3 and *h*. Seta *a* thin and barbed while others bilaterally branched. Mentum bears polygonal tubercles with punctations. Rutella with prominent dendites and concavities. Chelicerae (Fig.5) well developed with pronounced teeth. Seta *chb* long while *cha* minute. Epimeral setal formula 6-4-4-4, all setae branched. Epimeral surface bears foveolae and punctations. Genital plates divided by a transverse suture into an upper smaller and a lower larger plate. Each half carries 3 setae in paraxial and 2 setae in antiaxial position. All setae short slightly branched. Aggenital plates triangular. Pre-anal plate narrow with posteromedian region projecting downwards. Ano-adanal suture feebly developed. Anal setae 2 pairs, branched. Adanal setae 4 pairs, branched and longer than the anal setae. Ano-adanal plates bear punctations. Fissure *ih* more or less transverse. Ventral plate lying exterior to genital and anoadanal plate fovealated variously.

Leg (Fig. 6)

All legs monodactylous. Chaetotaxy of leg I (Fig. 6) 1-4-5-5-19. Reticulations and punctations seen on all leg segments. Femur I with a ventrally extended keel and a dorsal notch. Setae d, l', l'', v'' present on femur I. Seta l' thin and feebly barbed, others branched. On Genu I solenidia σ_1 and σ_2 closely associated with seta *d*. Tibia I bears long solenidion φ, 2 branched setae xt_1 and xt_2. Seta *d* smooth. Solinidia ω_1 and ω_2 present on tarsus I. Setae *pv′* and *pv″* branched, (*a*) barbed and others smooth. Famulus (ε) close to ω_1. Claw with a ventral tooth

Materials Examined

Ten specimens collected from soil and litter samples at the area of mixed vegetation (Site 3a), Ayanikkad, Kerala, India, collected by Shiji. M. T. on 24.09.2002.

Remarks

The present specimen shows close resemblance to *Cryptacarus keralensis* Shiji, *et al*., 2007 collected from Kerala in all characters

Superfamily : Lohmannoidea Grandjean, 1947

Family : Lohmanniidae Berlese, 1916

Genus : *Haplacarus* Wallwork, 1962

Generic Diagnosis

Genital plates without transverse suture. Anal and adanal plates fused Pre-anal plate wide. One pair of anal and 4 pairs of adanal setae present. Notogastral and epimeral regions without neotrichy.

***Haplacarus keralensis* Haq *et al.*, 1984**

(Plate-13, Figs.1 & 3)

Colour : Yellowish brown

Measurement : Length : 660 µm – 676 µm

Width : 314 µm – 345 µm

Dorsal region (Fig.1)

Body elongated with conical anterior and round posterior ends. Body ornamented with uniformly distributed papillae and fine, punctations except in places of notogastral bands.

Prodorsum

Prodorsum roughly triangular. Rostral tectum smooth and entire. All prodorsal setae foliate and serrated except seta *exa*, the latter being smooth. Seta *ro* inserted far below the anterior end of the rostrum, and directed forward. Seta *le* inserted below the level of rostral seta. Seta *in* long, thick and directed downwards. Seta *exa* long and smooth. Seta *exp* sickle shaped. Bothridium (*bo*) cup shaped. Sensillus (*ss*) pectinate with 10-13 branches. Prodorsum with a band which extends between the insertions of seta e*xp*. A few area porosae located near the median excrescence of lamellar ridge, below the insertion point of *le*.

Notogaster

Notogastral papillae arranged along the margin provide a wavy appearance. Sixteen pairs of notogastral setae present, all foliate and serrated. Seta ps_1 curved inwards, distally. Ten notogastral bands present, of which s_1, s_2, s_4 and s_9 incomplete. Notogaster ornamented with uniformly distributed papillae.

Ventral Region (Fig.2)

Infracapitulum with 4 pairs of setae. Seta *a* smooth while setae m_1, m_2 and *h* thick and roughened. Area porosae present on the mentum between the insertion points of setae *h*. Epimeral setal formula 3-1-3-3. Setae *1a, 1c, 3b, 3c* and *4c* comparatively thick foliate and weakly barbed. The triangular aggential plate located anterolateral to each genital plate. Genital plates with 10 pairs of setae, each plate with 4 pairs of smooth and thick antiaxial setae and 6 pairs of roughened and thin paraxial setae. Pre-anal plate broad with a posteromedian projection. Anal and adanal plates fused, bearing one pair of anal and 4 pairs of adanal setae. Anal setae smooth and smaller than the thick, foliate and weakly barbed adanal setae. Fissures *ia, im* and *ih* located ventrally. Area porosae located on the ventral plate, as figured.

Legs

All legs monodactylous.

Material Examined

Thirteen specimens collected from soil and litter samples from Botanical garden, Calicut University Campus, Kerala, India, collected by Shiji. M.T on 17.06.2006.

Remarks

The present specimen resembles *H. keralensis* described by Haq *et al.* (1984) in most of the characters. However, the number of incomplete bands and the epimeral setal formula show variation.

Superfamily : Lohmannoidea Grandjean, 1967

Family : Lohmanniidae Berlese, 1916

Genus : *Javacarus* Balogh, 1961

Genital plates without transverse suture. Anal and adanal plates fused. Pre-anal plate wide. Anal setae absent. Four pairs of adanal setae present. Notogastral and epimeral region without neotrichy.

***Javacarus porosus* Hammer, 1980**

(Plate-14, Figs.1-5)

Colour : Brown

Measurements : Length : 658-700µm

Width : 336-350µm

Dorsal Region (Fig. 1)

Prodorsum more or less triangular in outline. Anterior border of rostrum entire. Seta *ro* measures 98 µm, straight and inserted far below the rostral apex. Seta *le* inserted laterally below the insertion point of *ro* and it measures 126 µm. Seta *in* 112µm, placed below the level of *bo*. Setae *exa* and *exp* present, each measuring 112 µm and 84 µm respectively. Seta *exa* falcate in nature. All other prodorsal setae foliate with distinct midrib and faintly dentate. A band extends between setae *in*. A pair of lateral ridges present. Bothridium (*bo*) cup shaped. Sensillus (*ss*) pectinate with 8-10 branches. Prodorsum bears tubercles except on the lateral region.

Lateral margins of notogaster parallel, and posterior region rounded. Notogastral seate 16 pairs foliate and slightly roughened. The dorsal setae short with more or less dull tip, while the marginal ones longer and thinner at the tip. Seta c_1 directed forwards. Seta e_2 short. Seta ps_1 slightly incurved. Nine notogastral bands formed of bead like structures present, all bands complete, but very irregular. Between the bands tubercles present, especially at the posterior region. A few area porosae seen in between setae c_1 and c_2.

Ventral Region (Fig.2)

Intracapitulum (Fig.3) bears 4 pairs of setae *a, h,* m_1, and m_2. Setae *a, h* and m_1 thin, all setae faintly dentate. Chelicerae (Fig.4) well developed with stout pronounced teeth. Seta *chb* longer than *cha*. Pedipalp 5 segmented. Palpal chaetotaxy represented by the formula 0-1-0-1-8.

Epimeral setal formula 3-1-3-4, all setae roughened. Epimere I bears few area porosae. Genital plates without transverse suture. Each genital plate carries 10 setae, paraxial row of 6 small, smooth setae and antiaxial row of 4 elongate roughened setae. Pre-anal plate wide with a postero-median projection. Anal and adanal plates fused. Anal setae absent. Four pairs of adanal setae present, all foliate and roughened. A few area porosae seen lateral to the ano-genital region. Fissure *ip* present near the insertion point of h_3.

Leg (Fig.5)

All legs monodactylous. Chaetotaxy of leg I represented by the formula 1-4-4-4-18. All leg segments with fine punctations. Trochanter-I bears a single roughened seta. Setae *d* and *l″* on femur I thick and barbed; others smooth. Genu-I bears 2 solenidia, σ_1 and σ_2. Seta *l′* thick and barbed. The solenidion φ on tibia-I long and seen in close association with seta *d*. Setae xt_1 and xt_2 thick and barbed. Tarsus -I carries 18 setae including ω_1 and ω_2. ω_1 thicker than ω_2 and with a blunt tip. Setae (*ft*) thick and barbed and *pv″, s, m″, (p)* and (*a*) smooth.

Materials Examined:

Seven specimens collected from soil and litter samples of site 4b, Ladies Hostel premises, Calicut University Campus, Kerala, India, collected by Shiji. M.T on 10.10.2002.

Remarks:

The present specimens resemble *J. porosus* described by Hammer (1980) from Java in most of the characters. However, the nature of prodorsal and notogastral setae shows slight deviation.

Superfamily : Lohmannoidea Grandjean, 1967

Family : Lohmanniidae Berlese, 1916

Genus : *Meristacarus* Grandjean, 1934

Genital plates without transverse suture. Anal and adanal plates separated. Pre-anal plate wide. Anal setae absent. Four pairs of adanal setae present. Nostogastral and epimeral region without neotricy. Anal plates narrow and band like.

***Meristacarus unilateralis* sp.nov.**

(Plate-15, Figs. 1-7)

Colour : Dark brown

Measurements : Length: 980µm (Range: 938-980µm)

Width : 532µm (Range: 504-574µm)

Dorsal Region (Fig. 1)

Prodorsum

Rostrum entire and more or less pointed anteriorly. All prodorsal setae long, barbed with pointed tip, barbs absent at the extreme tip. Seta *ro* 154µm long and inserted on a transverse ridge. Seta *le* measures 210µm, seen laterally on the lamellar ridge. Lateral sides of prodorsum lying exterior to lamellar ridge heavily porose. Setae *exa* and *exp* present, measuring 126µm and 168µm respectively. Seta *in* 168µm long, inserted more or less at the level of *bo*. Sensillus possesses a central rachis and bears 18 branches, the length of which decreases towards the apex (Fig.2). Basal portion of *ss* devoid of any branches. A distinct prodorsal band extends between the 2 bothridial cups, formed of single, double and often triple layers of porose foveoles. Prodorsal integument porose and bears irregularly arranged area porosae. Single or clustered foveoles of smooth nature also present. Lateral borders of prodorsum bear tooth like projection, arranged on either side.

Notogaster

Nine notogastral bands, composed of small foveoles arranged in single, double or occasionally triple layers seen on notogaster. Bands 4 and 5 connected medially forming loops as shown in Fig.1, bands 8 and 9 arched anteriorad. Circular area porosae of varying size irregularly scattered or aggregated on the notogaster. Sixteen pairs of notogastral setae of varying size present on notogaster. Median setae, c_1, d_1, e_1 and f_1 small while lateral setae comparatively longer. Seta e_1 inserted more interior than the other median setae. Distance between e_1-e_1 less than that of c_1-c_1 and d_1-d_1. All notogastral setae slightly foliate, bearing barbs unilaterally except at the extreme base and tip (Fig.3) Fissure *im* seen near the insertion of seta e_2.

Ventral Region (Fig.4)

Infracapitulum (Fig.5) porose and bears scattered area porosae. Setae *h*, m_1 and m_2 almost equal in size. Seta *a* the smallest of infracaptitular setae. All setae feebly barbed. Chelicerae (Fig.6) well developed with 3-4 teeth on the fixed digit and 2-3 teeth on the movable digit. Seta *cha* minute while *chb* elongate, smooth and slender. Pedipalp 5 segmented (Fig.5) with a chaetotaxy of 0-1-0-2-10.

Epimeral surface porose and with scattered area porosae. Epimeral setal formula 3-1-3-3. Seta *1b* thicker and more barbed. Seta *2a* small and roughened. Seta *3a* smaller than *3b* and *3c*. Setae *4a*, *4b* and *4c* almost equal in size. Fissure *ia* seen laterally, exterior to epimere III.

Genital plates entire, bearing 10 pairs of roughened setae, arranged in two rows, an antiaxial row of 4 and paraxial row of 6 setae. Antiaxial setae comparatively longer than the paraxial setae. The distance between g_1-g_2 comparatively greater than that of the remaining setae. Pre-anal plate narrow with a median posterior projection. Ano-adanal setal formula 0+4. Adanal setae heavily barbed and their length increases posteriorly. Ventral plate lying exterior to ano-genital plate ornamented with scattered area porosae. Fissure *ip* visible on the ventral plate as represented in Fig. 4

Legs

All legs monodactylous with a stout claw. Integument of all legs heavily punctate and porose. Chaetotaxy of leg I (Fig.7) 0-5-5-5-19. Femur I carries 4 setae, all of which barbed in various degrees. Femur I carries a well developed notch dorsally and a keel ventrally. Seta *l′* of femur I thick and longer than others. Genu I bears 2 solenidia (σ_1 and σ_2). Seta *d* thin, smooth and seen closely associated with σ_2. Seta l″ of genu I long, thick and barbed. Tibia I carries a long whip like solenidion (φ). Seta *d* coupled with φ. Seta xt_1 thicker and longer than xt_2. Seta l′ barbed. Tarsus I carries 19 setae, including 2 solenidia ω_1 and ω_2. ω_1 stout and blunt while ω_2 sharply pointed. A famulus (ε) seen closely associated with ω_1. All setae except *s* and (*p*) barbed variously. Setae (*tc*) and (*u*) basally stout and with hooked tips. Seta (*pv*) somewhat plumose.

Materials Examined

Holotype ♀: paratypes 13 ♀♀ collected from soil samples of coffee plantation (Site 6), Wayand district, Kerala, India collected by Shiji. M. T on 29.11.2002.

Remarks

The genus *Meristacarus* was erected by Grandjean (1934) with *M. porcula* as the type species from central America. The genus presently contains 15 species erected from various countries: including India. The present new species on comparison with the other known species of the genus shows similarities with the 2 known Indian species, *M. wynadensis* described by Haq and Clement (1991) and *M. degradatus* Haq and Jaikumar (1993) in the general appearance and body ornamentation as well as arrangement of body setae. However, the species can be easily separated from *M. wynadensis* based on the presence of the following features.

1. Differences in the number, nature and arrangement of notogastral bands.
2. Unilaterally barbed nature of notogastral setae.
3. Presence of 18 branches on the sensillus.
4. Barbed nature of infracapitular and epimeral setae.
5. Difference in the nature and arrangement of genital setae.
6. Difference in leg chaetotaxy.

The new species appears distinct from *M. degradatus* in the following features.

1. Nature of sensillus
2. Unilaterally barbed nature of notogastral setae.
3. Nature and arrangement of notogastral bands.
4. Smaller nature of seta c_1.
5. Epimeral setal formula of 3-1-3-3.
6. Genital setal formula 6+4 and porose nature of genital integument.

Based on the possession of above combination of features, the species has been assigned to the status of a new one, viz., *M. unilateralis*. The unique features of the new species include:

1. Difference in the nature and arrangement of notogastral bands.
2. Unilaterally branched nature of notogastral setae.
3. Difference in the nature and arrangement of genital setae.

Superfamily : Lohmannoidea Grandjean, 1967

Family : Lohmaniidae Berlese, 1916

Genus : *Papillacarus* Kunst, 1959

Generic diagnosis

Genital plates with transverse suture. Anal and adanal plates separated. Pre-anal plate narrow. Two pairs of anal and four pairs of adanal setae present. Pygidium with weak neotrichy, epimeral region with weak neotrichy. Pygidial setae setiform and ciliate.

***Papillacarus baloghi* sp. nov**

(Plate-16, Figs.1-6)

Colour : Reddish brown

Measurement : Length: 577 µm (Range 532–578 µm)

Width : 269 µm (Range 268–311 µm)

Dorsal Region

Body elongated with conical anterior and round posterior ends. Microsculpture of the integument consists of reticulum of polygons with fine punctations.

Prodorsum

Anterior margin of rostrum undulating. Sclerotized angular process present on lateral borders of prodorsum. All prodorsal setae spinose except at the base and distal portion. Seta *exp* slightly longer than others. Bothridium (*bo*) cup shaped. Sensillus (*ss*) pectinate with 15-17 cilia on the lower surface and 3-4 barbs on the upper surface (Fig.5). Prodorsal transverse band with round ends, seen just below the interlamellar setae. A clear area devoid of punctations located below the band, between the latter and the dorsosejugal suture.

Notogaster

Notogaster cylindrical with almost parallel lateral margins. Dorsosejugal region lying just below the suture demarcated by closely set transverse wrinkles, resembling a band like structure. Notogaster bears one complete and 4 incomplete bands. Notogastral neotrichy present, especially at the posterior region, total number of notogastral setae 60. Setae c_1, d_1 and e_1 short and sparsely barbed. Seta f_1 longer than the anterior dorsocentrals. Pygidial neotrichial setae mostly unilaterally barbed, rarely bilaterally barbed. Submarginal and marginal setae of notogaster similarly shaped as prodorsals. Notogaster bears spiculate papillae, numerous on the posterior region.

Ventral region (Figs.2-4)

Infracapitulum with 5 pairs of setae, *a, h,* m_1, m_2 and m_3 (Fig.). Seta *a* simple others asymmetrically barbed. Infracapitulum densely punctate. Chelicerae (Fig.3) stout with 2-3 teeth on each digit. Seta *cha* 3 times longer than *chb*. Rutellum stout, bearing 3-4 dendrites (Fig.4). Epimeral surface densely punctate with setal neotrichy. Epimeral setal formula 9-4-3-4. Setae of *a* series and *1d* short, fine and smooth. Other setae bilaterally but asymmetrically barbed. Genital plates divided unequally by a transverse suture into anterior and posterior sections, each section with 5 pairs of setae. Paraxial setae barbed, while antiaxial setae smooth. Aggenital plate triangular. Pre-anal plate narrow, small and posteriorly bifid. Anal and adanal plates separate, 2 pairs of anal and 4 pairs of adanal setae present, all unilaterally barbed. Fissures *ia, im* and *ih* located ventrally. Ventral plate including the genital and anal plates densely punctate.

Legs

All leg segments monodactylous and punctate. Chaetotaxy of leg I, 1-4-5-5-16. Femur I with ventral keel. All setae spinose. Genu I bears 2 solenidia σ' and σ'', the latter longer than the former. Seta l'' and d of genu spinose while l' smooth. Tibia 1 bears one solenidion φ and 4 setae, of which setae l' and xt_1 smooth and d and xt_2 spinose. On tarsus 1, 2 solenidia ω_1 and ω_2 present. The former with blunt tip while the latter tapering distally. Most of the tarsal setae smooth. Claw stout.

Material Examined

Holotype ♀; paratypes 21 ♀♀ collected from soil and litter samples taken from a wet area near the kitchen yard, Ayanikadu, Calicut, Kerala, India collected by Shiji. M.T on 15.06.2005.

Remarks

The species of the genus *Papillacarus* Kunst 1959 are divided in to two groups by the nature of setae c_1, d_1 and e_1. The present specimen belongs to the group of species with c_1, d_1 and e_1 short and barbed. Though the new specimen shows resemblance with *P. aciculatus* Berlese, 1904, *P. pseudoasciculatus* Mahunka, 1980, *P. ondriasi* Mahunka, 1974 in general nature and certain features, various differences could be noticed as described below:

It differs from *P. asciculatus* Berlese, 1904 by the presence of notogastral bands, spinose nature of prodorsal and notogastral setae, possession of epimeral setal formula of 9-4-3-4 instead of is 8-4-3-4 of *P. asciculatus*. The present specimen differs from *P. pseudoasciculatus* Mahunka, 1980 by the presence of notogastral bands, epimeral setal formula of 9-4-3-4 compared to 8-4-3-4 in *P. pseudoasciculatus*, nature of sensillus, seta e_2 more than half as long as f_2 and the spinose nature of prodorsal and notogastral setae. The new specimen can be distinguished from *P. ondriasi* Mahunka, 1974 by the presence of equally long setae c_1, d_1 and e_1, the length of which increase in sequence in *P. ondriasi* Mahunka, 1974. Moreover, the spinose nature of the prodorsal and notogastral setae and the symmetrically ciliate nature of neotrichial setae also enable to distinguish the new species from *P. ondriasi* Mahunka, 1974.

The possession of the following combination of characters enables to distinguishes the new species from the various other known species of the genus:

1. Spinose nature of prodorsal and notogastral setae
2. Epimeral setal formula 9-4-3-4.
3. Presence of notogastral bands
4. Presence of equally long setae c_1, d_1 and e_1

Superfamily : Epilohmannoidea Grandjean, 1969

Family : Epilohmanniidae Oudemans, 1923

Genus: *Epilohmannia* Berlese, 1910

Postero-hysterosomatic articulation dichoid,. Ano-genital region schizogastric type (i.e., genital and anal plates separated by a straight line). Eight pairs of genital setae arranged in 2 longitudinal rows (5+3).

***Epilohmannia pallida pacifica* Aoki, 1965**

(Plate-17, Figs.1-6)

Colour : Brown

Measurement : Length : 340-348 µm

Width : 123-139 µm

Dorsal Region (Fig.1)

Prodorsum elongated, broader posteriorly with a maximum width at the level between *bo*. Seta *ro* short 20 µm long fine and barbed, the left seta being inserted anteriorly than the right one. Seta *le* measures 32 µm, longer than *ro* and sparsely barbed. Seta *in* more than twice longer than *ro*, barbed, measuring 44 µm. Setae *exa* and *exp* short, more or less equal in length. Sensillus (Fig.2) with a fusiform head, bearing stout barbs.

Dorsosejugal suture more or less straight. Fourteen pairs of barbed notogastral setae present, posterior setae curved ventrally. Notogastral integument finely punctate.

Ventral Region (Fig.3)

Infracapitulum (Fig.4) stenarthric type. Infracapitular setae 3 pairs, barbed. Seta *a* more elongate than *m* and *h*. Chelicerae (Fig.5) well developed with 3-4 teeth on the movable digit and 2-3 teeth on the fixed digit. *chb* longer than *cha*. Epimeral setae thin and slightly barbed. Epimeral setal formula 3-1-3-3. Setae *1a, 2a, 3a* and *4a* shorter than *1b, 3b, 3c, 4b* and *4c.*

Seta *1c* smallest among the epimeral setae. Epimere I bears lateral ridges. Each genital plate more or less rectangular, bearing a transverse ridge. Each plate bears 7 barbed setae, arranged in 2 rows, 4 paraxial and 3 antiaxial in position. Aggenital setae 4 pairs, barbed, ag_4 elongate. Anal aperture longer than the genital aperture. Three anal and 3 adanal setae present, all barbed and length of which increases posteriorly. Ventral plate ornamented with fine punctations and scattered foveoles.

Legs

All legs monodactylous. Chaetotaxy of leg I (Fig.6) 1-3-5-6-16. Trochanter I bears a single barbed seta. All setae on femur I barbed. Genu I bears 2 solenidia, σ_1 and σ_2, the latter shorter than the former. Seta *d* closely associated with σ_2. Tibia I carries a single long solenidion φ. Tarsus I carries 16 setae including 3 solenidia ω_1, ω_2 and ω_3. ω_1 stout and blunt. Setae (*p*) eupathidic, *s* smooth while setae *(u)* and *(a)* thick and barbed. All leg segments punctated.

Materials Examined

Seventeen specimens collected from soil and litter samples of Botanical Garden (Site 4a), Calicut University Campus, Kerala, India, collected by Shji. M. T on 13.01.2003.

Remarks

The present specimens resemble *E. pallida pacifica* erected by Aoki (1965) in all respects.

Epilohmannia pallida indica **Bhattacharya and Banerjee, 1980**

(Plate-18, Figs.1-5)

Colour : Brown

Measurements : Length: 336-348µm

Width : 151-159 µm

Dorsal Region (Fig.1)

Prodorsum broad with a maximum width at the level between *bo*. Prodorsal integument bears fine punctations. Seta *ro* short, 20 µm long and barbed, the left seta being inserted anterior to that of right one. Seta *le* 28µm in length and barbed. Seta *in* the longest of prodorsal hairs reaching 44µm. Setae *exa* and *exp* shorter than other prodorsal setae, each measures 12µm in lengh. Sensillus (*ss*) (Fig.2) distally thickened to form a spindle, bearing barbs

Dorsosejugal suture more or less straight. Posterior margin of notogaster rounded. Notogastral integument with fine punctations. Fourteen pairs of barbed notogastral setae present.

Ventral Region (Fig.3)

Rutella short, robust and slightly keeled on the lateral surface. Infracapitulum stenarthric type. Infracapitulum bears 3 pairs of setae viz., *a, m* and *h,* a thicker and longer than others. Chelicerae (Fig.4) well developed with 3-4 teeth on the movable digit and 2-3 teeth on the fixed digit, *chb* longer than *cha*. Epimeral setal formula 3-1-3-3, all setae thin and barbed, seta *3a* with prominent insertion point. Epimere I with a connecting ridge. Genital plate more or less rectangular, each plate a little broader posteriorly and bears a transverse ridge which runs on the entire ventral plate. Eight setae present on each plate, all barbed and arranged in two rows, 5 paraxial and 3 antiaxial in position. Three anal and 3 adanal setae present, all barbed and length of which increases posteiorly. Ventral integument wrinkled with fine punctations.

Legs

All legs monodactylous. Chaetotaxy of leg I (Fig.5) 1-3-5-6-16. Trochanter I bears a single barbed seta. All setae on femur I barbed. Genu I bears 2 solenidia, σ_1 and σ_2, the latter shorter than the former. Tibia I carries a single long solenidion φ. Tarsus I carries 16 setae including 3 solenidia ω_1, ω_2 and ω_3, ω_1 stout and blunt. Setae (*p*) eupathidic. Seta *s* smooth, setae (*u*) and (*a*) thick and barbed. All leg segments punctated.

Materials Examined

Fourteen specimens collected from soil and litter samples of Site 4a, Botanical Garden, Calicut University Campus, Kerala, India, collected by Shiji M. T. on 29-11-03.

Remarks

The present specimen resembles *E. pallida indica* erected by Bhattacharya and Banerjee (1980) in all respects.

Superfamily: Nothroidea Grandjean, 1954

Family : Tryhypochthoniidae Willmann, 1931

Genus: *Allonothrus* Van der Hammen, 1953

Exoskeleton heavily sclerotised. Sluggish in nature. Prodorsum with varying number of ridges. Lamellar setae very conspicuous. Areolae present on the hysterosoma. Dorsal hairs leaf or fan shaped. Adults without seta f_1. Number of adanal, anal and aggenital setae represented by the formula 3,2,0 respectively. Genital plates broad and without sutures. Sensillus resembles that of *Nothrus*.

***Allonothrus sinicus* Wang Hu-Fu and Norton (1988)**

(Plate-19, Figs. 1&2)

Colour : Golden yellow

Measurements : Length: 492-504µm

Width : 246-254µm

Dorsal Region (Fig.1)

Prodorsum

Prodorsum triangular with a pointed rostral apex. Lateral margin of prodorsum with 2-3 small teeth. Two pairs of ridges also present on prodorsum. Lateral ridge extended from the middle of the prodorsum to the base of seta *ro*. Median ridge diverging poseteriorad, well separated anteriorly. Seta *ro* tapering and barbed, measuring 42µm. Setae *le* and *in* foliate, distally rounded, heavily barbed and measure 70µm and 56µm respectively. Sensillus clavate, serrated, with a median ridge.

Notogaster

Broad and ornamented with areolae of polygonal appearance. Fifteen pairs of foliate barbed notogastral setae present. Setae d_1, d_2 and e_1 fan shaped, truncated distally, others rounded. Seta f_1 absent. Fissures *ia* and *im* located as shown in Fig.1. Aperture of the lateral abdominal gland represented by a very distinct, chitinised ring, just above seta f_2.

Ventral Region (Fig.2)

Gnathosoma with 3 pairs of setae, *a, h,* and *m*. Seta *m* short and spiny. Gnathosomal region porose. Epimeral setal formula 3-1-3-3., all setae smooth. Genital setae 7 pairs, g_1-g_5 barbed, g_6 and g_7 well spaced. Anal plate bears 2 pairs of lanceolate setae. Three pairs of adanal setae present, broad, all densely barbed.

Legs

All legs tridactylous.

Materials Examined

Nineteen specimens collected from the soil and litter samples of Site 4b, Ladies Hostel premises, Calicut University Campus, Kerala, India, collected by Shiji M.T on 10.10.2002.

Remarks

The present specimen resembles *Allonothrus sinicus* described by Wang Hu-Fu and Norton (1988) from Japan in all respects.

***Allonothrus keralensis* sp. nov.**

(Plate-20, Figs.1-6)

Colour : Reddish brown

Measurements: Length: 644 µm (Range 616-686 µm)

Width : 350 µm (Range 336-364 µm)

Dorsal Region (Fig. 1)

Prodorsum

Prodorsum triangular with a pointed rostral apex. Seta *ro* barbed, simple, 42µm long. Seta *le* heavily barbed, club shaped, longer among prodorsal setae, 98µm long. Seta *in* smallest, measuring 35µm, leaf like., placed on a transverse ridge. Seta *ex* absent. Sensillus rod like with a slightly swollen roughened head. A pair of thin but chitinised lateral ridges present, which extends from the middle of the prodorsum to the lateral margins. Central ridges narrow and placed in between lateral ridges. Inner ridge present having a shape as shown in the Fig.1. A transverse ridge present, other than prodorsal band, in between *bo*. Prodorsal integument heavily porose.

Notogaster

Broad and ornamented with areolae of polygonal appearance. Fifteen pairs of fan shaped, barbed notogastral setae present, of which c_2 the smallest. Seta f_1 absent. Aperture of the lateral abdominal gland represented by a very distinct chitinised ring, just above seta f_2. Fissure *ia* located near the insertion point of c_2, *im* located above the insertion point of seta e_2.

Ventral Region (Fig. 2)

Infracapitulum (Fig.3) bears 3 pairs of setae. Seta *a* smooth, *m* shortest and spiny while *h* longest, thick and barbed. Gnathosomal region porose. Chelicerae (Fig.4) with 4 teeth on the fixed digit and 3-5 teeth on the movable digit. Seta *chb* barbed and longer than the smooth seta *cha*. Epimeral seta formula 3-1-3-3. Setae *1a, 1c, 2a, 3a, 4b* thick and shorter than the barbed setae *1b, 3b* and *4a*. Setae *3c* and *4c* foliate and barbed. Fifteen pairs of barbed genital setae (Fig. 5) the length of which decreases posteriorly and the posteriormost 2 pairs appear roughened and well spaced. Two pairs of anal setae present, an_1 roughened, an_2 smooth. Three pairs of adnal setae, all roughened and foliate. Anal and adanal fissures located as shown in Fig.2. Genital and anal plates with small punctations. Lateral region of the ventral plate heavily porose with less sclerotised foveoles.

Legs

All legs tridactylous with three claws. Leg I with a chaetotaxy of (Fig.6), 2-6-6-6-13. Trochanter I bears 2 foliate barbed setae. All setae on femur I foliate, barbed, vary in size. Genu I bears a single solinidion σ. Seta *l′* thin and smooth, seta *v′* thick and smooth, all other setae foliate and barbed. Tibia I bears long solenidion φ. Setae *v′* thick and smooth, while others foliate and barbed. Tarsus I with a short solinidion ω which ends in a blunt tip. Setae *s, m′, pv′* smooth, all other setae roughened.

Materials Examined

Holotype ♀; paratypes 35 ♀♀ collected from soil and litter samples of site 4b of Ladies Hostel premises, Calicut University Campus, Kerala, India collected by Shiji, M.T. on 17.09.02.

Remarks

The present species differs from *A. russelous* Wallwork (1960) in having 15 pairs of genital setae instead of 13-14 in *A. russeolous* and in the nature of adanal setae. The new species can be easily distinguished from *A. monodactylous* Wallwork (1960) by the possession of tridactylous legs and 15 pairs of genital setae. Presence of strongly curved lateral ridge, 10 pairs of genital setae and smooth nature of adanal setae are the characters which distinguish *A. indicus* Bhaduri and Chaudhuri (1968), from the new species. The new species shows close resemblance to *A. giganticus* Haq (1978) by the presence of 3 ridges on the prodorsum, nature and arrangement of setae *le* and *in* as well as in the notogastral, anal and adanal setae and tridactylous legs. However by the possession of the following unique features, the new species distinctly stand separate from *A. giganticus* as well as other known species.

1. Fifteen pairs of barbed genital setae
2. Comparatively thinner nature of lateral ridge on the prodorsum.
3. Nature of median and inner ridges on the prodorsum.
4. Presence of 2 transverse ridges on the prodorsum between *bo*.

Superfamily : Nothroidea, Grandjean, 1954

Family : Trhypochthoniidae, Willmann, 1931

Genus : *Archegozetes*, Grandjean, 1931

Generic Diagnosis

Bothridium present. Rostral setae removed from each other. Seven pairs of genital setae. Two pairs of adanal setae. Legs monodactyl.

***Archegozetes longisetosus* Aoki, 1965**

(Plate- 21, Figs.1-3)

Colour : Reddish brown with yellow tinge

Measurements : Length: 835-985 µm

Width : 495-587 µm

Dorsal region (Fig 1)

Body narrow anteriorly and very broadly spherical posteriorly. Both anterior and posterior ends conical. Body ornamented with dense punctation.

Prodorsum

Prodorsum triangular with a pointed rostral tectum and a broad base. Prodorsal setae 3 pairs, all of which barbed. Seta *ro* setiform with its distal quarter smooth, measuring 131 µm and inserted far below the rostral tip. Setae *le* and *in* somewhat flagellate 177µm and 262 µm in length respectively and ciliated from base to tip, densely ciliated towards their apex. Bothridium (*bo*) bell shaped. Sensillus (*ss*), 185 µm long, flagellate with very small barbs. A group of area porosae present at the interlamellar area, in between the setae *in*. Prodorsum laterally bulged, at the level of bothridium.

Notogaster

The notogaster more or less oval shaped and its shape generally determined by the presence of egg mass within the viscera. Notogaster bears 15 pairs of flagellate-setaceous and barbed setae of varying length as follows:

c_1, c_2 – 185 µm; c_3 – 93 µm

d_1, d_2 – 154 µm; d_3 – 185 µm

e_1, e_2 – 93 µm

f_2 – 46 µm

h_1, h_2, h_3 – 124 µm

ps_1, ps_2, ps_3 – 139 µm

All notogastral setae scaresely barbed proximally and heavily barbed distally. Latero abdominal gland (*Age*) seen as a round dark brown spot on either side of the notogaster, near setae e_2, f_2 and h_2. The glandular opening (*gla*) located very close to the point of insertion of seta f_2. Lyrifissures *ia*, *im* and *ip* visible dorsally, *ia* near c_3, *im* between d_3 and e_2 and *ip* near h_2.

Venter (Fig.2)

Infracapitulum bears setae *a*, *m* and *h.* Seta *m* very small while *a* and *h* smooth and long, *a* being thicker and longer than *h*. A transverse submental plate (*smp*) separates the infracapitulum from the epimeral region. Epidermal setal formula 3-1-3-3. Setae *1b, 3b,* and *4b* smooth and long and others rough and short. Seven pairs of ciliated genital setae present, of which the anterior four pairs (g_1-g_4) located very close together and the remaining 3 pairs (g_5-g_7) widely separated. Anal plates longer than broad, each of which bears 2 short barbed setae. Adanal plates extend anteriorly towars the genital area. Three pairs of adanal setae present, all barbed and their length decrease from ad_1-ad_3. Lyrifissures *ian* and *iad* located on the ventral plate.

Legs

All legs monodactylous (Fig.3). Chaetotaxy of leg I- 1-6-5-6-20. All setae barbed, except setae (*ft*) (*tc*) and (*p*) which are smooth. Trochanter-I possesses a tooth like structure. Genu I- with 2 solinidia, σ_1 longer than σ_2. Solinidia (φ_1) on tibia I, coupled with xt_2. Tarsus I bears 3 solenidia ω_1, ω_2 and ω_3. ω_1 thick and blunt, as long as ω_3 and about two third as long as ω_2.

Material Examined

Sixteen ♀♀ collected from soil and litter samples from a rubber plantation, Mullankunnu, Calicut, Kerala India, collected by Shiji. M.T on 23.07.05.

Remarks

The present specimen agrees with *A. longisetosus* Aoki, 1965 in all characters and hence fixed so.

Superfamily : Nothroidea Berlese, 1885

Family : Malaconothridae Berlese, 1916

Genus: *Trimalaconothrus* Berlese, 1916

Generic Diagnosis

Body widening posteriorad. Medium sized, yellowish brown to fuscous animals. Epimeral setal formula 3-1 (2-3)-3. Genital plates with 4-12 pairs of setae. Anal plates with one pair and adanal plates with three pairs of setae. Tarsi longer, thinner, fastigial hairs (*ft*) thin, setiform. Legs tridactylous. Solenidion on tarsus of palp setiform.

***Trimalaconothrus duoaculeus* Yamamoto *et al.*, 2004.**

(Plate-22, Figs. 1 & 2)

Colour : Yellowish brown

Measurements: Length: 600-652 µm

Width : 303-345 µm

Dorsal Region (Fig. 1)

Prodorsum

Rostrum narrow and rounded anteriorly. All prodorsal setae thin and smooth. Seta *le* inserted near prodorsal margin. Interlamellar setae longer than setae *ro* and *le*. Seta *exa* very short and thin. Lamellar ridge conspicuous, extending anteriorly to the base of rostral seta. Interlamellar ridge present at the posterior part of prodorsum. A median oblique ridge present posterior to *in* and *ex*. *ss* and *bo* absent. Prodorsal integument finely punctate.

Notogaster

Postero-lateral side of notogaster gently swollen. Fifteen pairs of notogastral setae present, all setae smooth and thin. Relative lengths of notogastral setae as follows: $h_2 > e_2 > ps_2 > h_1 > c_3 = cp = d_2 = f_2 = ps_1 > c_1 = c_2 = d_1 = e_1 = ps_3 = h_3$. Two pairs of faint, parallel longitudinal ridges present on notogaster. A transverse ridge present posteriorly on notogaster just infront of setae ps_1, where notogaster shows a deep concavity. Notogastral integument finely punctate.

Ventral Region

Infracapitulum with a single pair of thin and smooth seta. Epidermal setal formula 3-1-2-3; all setae short, thin and smooth. Genital plates with 7-8 pairs of thin, short and smooth setae. Anal plates bear a single pair of minute setae. Adanal plates with 3 pairs of short and smooth setae. Ventral integument finely punctate.

Legs

All legs tridactylous.

Material Examined

Nine ♀♀ collected from the soil and litter samples of Botanical garden, Calicut University Campus, Kerala, India, collected by Shiji. M.T on 24.01.2007.

Remarks

The present specimen shows close resemblance to *T. duoaculeus* Yamamoto *et al*, 2004 described from South Africa, except in the presence of transverse prodorsal band and possession of 7-8 pairs of genital setae.

Chapter VIII

INTRODUCTION

Oribatid mites represent one of the numerically abundant arthropod groups in the organic horizons of most soils. They play a multitude of roles in the soil ecosystem, leading to the acceleration of organic decomposition and enhancement of soil fertility and productivity. Comminution of litter by these mites, especially by the members of the primitive taxa greatly increases the surface area of exposed tissue, which subsequently could be better exploited by microbes, either within the animal or after egestion as faecal pellets. Thus, the grazing activity of these mites serves as a key to enhance the microbial activity, especially that of the bacteria and oribatid faecal pellets are known foci of high nutrient status with adequate moisture status and pH characteristics for the replenishment of microbes. Further, the greater surface to volume ratio of these faecal pellets when compared to the original leaf litter leads to greater decomposition per unit time. In addition, browsing activity of these mites on litter serves to rejuvenate senescent microbial colonies, which will subsequently invade fresh litter and hasten the decomposition process. Oribatid mites are also known to vector microbial spores to different soil layers through their active horizontal and vertical migratory movements, to initiate the decomposition process.

Oribatid mites exhibit juvenile polymorphism and immature stages devour a variety of ingredients available in their natural microhabitats.

These mites are often designated as generalist feeders, but with varied rates of selection among the food items. Majority of the primitive taxa are known to exploit varied types of litter. Occasionally, the feeding habits of the immatures deviate profoundly or in certain ways from those of the adults. There are instances, where the rates of feeding by immatures exceed greatly those of the adults and hence juvenile contribution is more often towards degradation process. Quite often, unusal feeding trends are also displayed by the immature stages like coprophagy, necrophagy, predation, cannibalism etc., which are very rare among the adult mites.

All the features discussed above, necessitates the conduct of detailed studies on the breeding habits of these mites under laboratory conditions, for making a proper assessment of their functional aspects in the soil ecosystem. Hence in the present study attempts were made to trace the feeding habits of a few selected species of these mites viz., *E. payyoliensis, M. hygricola*, *P. baloghi*, *A. keralensis* and *A. longesetosus.* Studies on the breeding biology of these species were also made under laboratory condition at a temperature-humidity condition of 30 $\underline{+}1^{0}$C and 70-75% RH. Detailed studies were also made on the morphological characters of the immature stages as well as the adults of these mites, and were presented as figures and plates.

Chapter IX

REVIEW OF LITERATURE

Michael (1884, 1888) initiated biological studies of oribatid mites providing data on the developmental stages of species like *Damaeus nitens*, *Notaspis bipilis* and *Cepheus palmicinictum*. He reared them in specially constructed culture cells made up of plastic rings mounted on microslides and recorded their duration of development as 32, 60 and 345 days respectively.

Vizthum (1923) reported fungi and lower plants as food for rearing oribatid mites. Jacot (1930) studied the role of oribatid mites as a fungal spore carriers. He (1933) noticed 'aparity', a phenomenon in which the young ones come out after the death of the mother in Notaspid oribatids with the exception of the genus *Galumna*. Grandjean (1933, 1939) conducted detailed studies on the changes occurring in the chaetotaxy and morphology of various developmental stages of oribatid mites. The life histories of some Havaiian oribatids was studied by the same author (1934), by culturing them in the laboratory.

Jacot (1937) implemented a new method for rearing oribatid mites in special culture cells lined with plaster of paris-charcoal mixture. Forsslund (1938) provided data on the feeding habits of oribatid mites through culture experiments and by gut content examination of field collected mites. Jacot (1939) noticed the preference of phthiracarid mites to decaying leaf and woody tissues. Strenzke (1949) observed viviparity among the members of the family Ameronothridae, common in the marine littoral zone. The developmental pattern of the genital and anal plates in a few species of oribatid mites was observed by Grandjean (1949). In the following year (1950) the author provided data on the development of Lohmanniid species and observed the behaviour of *Camisia segnis* and *Platynothrus peltifier* by rearing them on filter paper substrate. Taberly (1951) followed the method adopted by Grandjean, to conduct studies on the biology and development of *Trhypochthonius tectorum*.

Hammen (1952) described the deutonymph of *Fuscozetes fuscipes* along with morphology of the immature forms of four common species. Pauly (1952) reported that the mode of sperm transfer in oribatid mites was through spermatophore deposition. The postembryonic development of *T. lectorum* was studied by Taberly (1953). Grandjean (1954) proposed a phylogenetic system of classification for families based on comparative development of oribatids. Van der Hammen (1955) described the morphological details of various life stages of *A. magna* and *A. schuilingi*, including the chaetotaxy. Sengbusch (1954) developed a method that could be successfully used for rearing free living mites and he studied the developmental pattern of three oribatid species viz., *G. nervosa, G. elimatus* and *G. longipluma* by culturing them on moss and algae.

Rhode (1955) constructed culture vials using a mixture of plaster of paris and charcoal in dram vials for rearing oribatid mites and he conducted studies on the life history of Phthiracarid mites. He (1956) published a paper giving details of further improvement in the rearing of small arthropods including oribatid mites.

Pauly (1956) studied the biology of three species of oribatid mites, viz., *Belba geniculosa, B. gracilipes* and *B. clavipes* and he reported that the first species completed its development in 150 days while the latter two took only 75 days. He also studied the spermatophore deposition in these species. Grandjean (1956a) reported the occurrence of copulation, though a very rare phenomenon among oribatid mites. Taberly (1957) provided information on the spermatophore deposition and picking up of the same by females in 10 species of oribatid mites. Detailed studies on the developmental stages of 8 species of oribatid mites were made by Wallwork (1958). Sengbusch (1958) studied the feeding behaviour of 21 species of forest soil oribatid mites on the basis of their relation to selective decomposition of litter material in Hemlock yellow birch forest floor and categorized these species into three main feeding groups, viz. non-selective feeders, selective feeders and indeterminates. Sitnikova (1959) gave an account on the life cycle of *B. boreus* by culturing it on leaves and potatoes.

Wallwork (1960a) conducted behavioural studies on oribatid mites from West Africa and North America with respect to their tolerance to ecological factors and he observed that the West African species had an upper critical and lethal temperature. Graeves (1960) observed the zoophagous trend of *Galumna* sp. which fed on the living body of a fly larva. Sengbusch (1961) conducted studies on spermatophore deposition and sperm transfer in oribatid mites. Bhattacharya (1962) studied the feeding habits and life cycles of soil mites and mentioned about their food preferences. Hartenstein (1962) provided an account on the food preferences of 20 species of oribatid mites by providing test food items in the laboratory. The same author (1962a) provided information on the biology of *P. peltifer*. Further, he (1962b) assessed the ability of *S. diaphanum* in the decomposition of coniferous needles and deciduous leaf petioles. The occurrence of direct copulation in oribatid mites was confirmed by Schuster (1962) and he distinguished three types of feeders among oribatid mites viz. primarily wood or leaf feeders, primarily fungivores, but feed on wood and leaf tissue and strictly fungivores. Woodring (1963) reviewed the nutritional and reproductive aspects of oribatid mites. Hayes (1963) observed the feeding preference of phthiracarid mites and explained their role in litter decomposition process. Sengbusch (1963) discussed the mechanism of maintaining a higher relative humidity in culture vials for rearing oribatid mites. Gasdorf and Goodnight (1963) observed a proportional increase in lignin and decrease in cellulose in the faeces of oribatid mites. According to Lebrun (1964) higher oribatid mites could complete their development faster than the primitive oribatid mites. Murphy and Jalil (1964) traced the biology of oribatid mites of the genus *Tectocepheus* and recorded two generations per year for the species and assessed the role of immatures in food processing.

Block (1965) examined the immature stages of *P. peltifer* and *D. clavipus* and elucidated the fact that in soils of pine moorland, under a subarctic climate these species had a single annual generation. Jalil (1965) traced the life cyle of *Hermannia scabra* giving diagnostic characters of immature stages based on his observations in the field and laboratory. Berthet and Gerard (1965) reported the highest number of eggs laid based on their statistical study on the micro distribution of oribatei. Block (1966) conducted studies on seasonal fluctuation in the population density of oribatid mites which he correlated with their reproductive cycles. Rockett and Woodring (1966) studied the biology of *Pergalumna omniphagus* and *Ceratozetes jewelli* in relation to temperature changes which influenced the metabolic rate, ovarian development and egg production. Woolley (1967) examined the infracapitulum of Phthiracarid mites and explained its morphological adaptation for xylophagy. Lions (1967) illustrated and described the prelarva of the primitive oribatid mite *R. ardua*. Wallwork (1967) reported the coprophagous nature of many oribatid mites. Cancela De Fonseca (1969) studied the biology of *Damaeus quadrihastatus* and described the spermatophores of the species. Arlian and Woolley (1969) described the morphological details of life stages of *Liacarus cidarus*. Based on the studies carried out on the ecology and biology of *Nothrus palustris*, Lebrun (1969) concluded that smaller species completed their life cycle faster than the larger species. Web (1969) measured the rate of oxygen consumption in *N. silvestris* and noted that the larvae of the species had relatively low respiratory rate.

Cancela Da Fonseca (1970) noted that there was a considerable variation in size of adult *S. magnus*. Woodring (1970) made a comparative study on the homology and function of male and female reproductive systems of 30 species of oribatid mites belonging to 22 families.

Lebrun (1970) mentioned that developmental period of *N. palustris* was influenced by availability of food source, conditions of light and temperature. Shereef (1970) observed the feeding preference and reproductive rate of oribatid mites by feeding species of *Pencillium* and *Aspergillus*. Arlian and Woolley (1970) noted the food preference of *L. cidarus* by providing them with variety of food substances and recorded that the life cycle was completed by feeding on *Cladosporium* sp. Baulmer (1970) studied the biology and ecology of *Hermannia scabra* in West Germany and noticed that in this species oviposition occurred during the driest period of the year. Sengbusch and Sengbusch (1970) traced the duration of life stages of *Oppia nitens* at 20^0C upto the F_2 generation. Trave (1970) described the immature stages of *Neoribates* sp. Perkins (1971) reported that *Orthogalumna terebrantis* completed its development from egg to adult within 10 days. Shereef (1971) made a comparative study of the life cycles of oribatid mites from U.S.S.R. and noted that the favourable diet differed for different species. Butcher *et al.* (1971) studied the embryonic development and spermatophere deposition in different species of oribatid mites.

Spain and Luxton (1971) reported that certain oribatids could digest cellulose and other plant polysaccharides. Zinkler (1971, 1972) reported that the digestive ability of oribatid mites to be higher than that of Collembola. Luxton (1972) provided information on the nutritional biology of oribatid mites. Jalil (1972) reared *P. peltifer* in laboratory at 25^0C, and confirmed the occurrence of this species in the united states. A culture cell with asbestos bottom was introduced by Seniczak (1972) for culturing oribatid mites in the laboratory.

Tadros (1973) noted that yeast was not acceptable to the mites, though several investigators have found yeast as a preferred food for oribatid mites. Lions (1973) reported the occurrence of prelarva in *Zetorchestes falzonii*, *Epilohmannia sp*. and *Sphaerozetes sp*. Dinsdale (1974) described the morphology and mechanism of functioning of the gnathosoma of phthiracarid mite. Some of trophic aspects and information regarding spermatophore deposition of *D. verticillipes*, *H. gibba* and *S. magnus* were discussed by Cancela Da Fonseca (1975). Del Fosse *et al.* (1975) studied the feeding mechanism of the water hyacinth mite, *Orthogalumna terebrantis*, in Argentina. Luxton (1975) carried out the calorimetric studies of orbatid tissue and expressed it in terms of life histories and metabolic rates. Cordo and De Loach (1976) reported the ovipositional specificity and feeding habits of the water hyacinth mite, *O. terebrantis* in Argentina. They observed that gravid females cut round holes of 0.1 mm diameter with their mouth parts and inserted the egg deep into the aerenchyma cells of the host. Laboratory and filed studies on the life cycle of *Hermannia subglabra*, *P. peltifer* and *Ameronothrus schneiden* was done by Weigmann (1975).

The role of *O. terebrantis* in the control of water hyacinth was reported by Sankaran (1976). Shereef (1976) reared two species of Lohmanniid mites, *P. aciculatus* and *Lohmannia egypticus* from Egypt, providing them rotton wood, decaying roots and dry leaves as food and reported that they took 71 and 101 days respectively to complete the life cycle. He also provided a detailed descriptions of the morphological characters of all stages of the two species with figures. Cordo and De Loach (1976) traced the developmental stages and the behaviour of adults and immatures of the water hyacinth mite *O. terebrantis* in Argentina. Haq and Prabhoo (1976) studied the food preference of 10 species of oribatid mites by gut content analysis and feeding experiment from the soils of Kerala. Based on the observation on the feeding habits of 20 species of oribatid mites from the soils of the southernmost region of Kerala, Haq (1976) categorized these mites in to macrophytophages (40%), microphytophages (10%) and panphytophages (50%). The feeding, locomotory and defaecatory activity o the algivorous oribatid mite *Ameronothrus marinus* was observed by Schutle (1976), under defined conditions in the laboratory.

Suzuki (1977) described the immature stages of the Lohmanniid mite, *Perlohmannia gigantica*. Webb (1977) studied the general biology and life cycle of *S. magnus* and reported that the duration of development from egg to adult was 400 days. The morphological aspects in the evolution of the family Ameronothridae was discussed by Weigmann and Schute (1977). Mitchel (1977) reviewed the existing data on the oribatid life histories and related the information to their physical and biological environment. Haq (1978) studied the postembryonic development of *A. longisetosus* and *L. ornatissimus* which took 50 and 176 days respectively for completing their life cycle Norton *et al.* (1978) described the nymphal stages of *Epilohmannoides terrae*. Seniczak (1978) noticed that the larva and nymphs of *Achipteria coleoptrata* and those of *A. nitens* and *Parachipteria willmanni* were appeared very much similar, at first glance. Behan and Hill (1978) studied the feeding habits of 25 species of oribatid mites from North America by gut content analysis and found that 50% of them were panphytophagous. Webb (1979) analysed the morphological changes that had taken place from one juvenile instar of *S. magnus* to the next and the morphometric differences between the instars. The factors influencing spermatophore deposition and sperm transfer in oribatid mites were discussed by Travenicek (1979) through his studies on 9 species of Liacarid mites. Nutritional biology of 14 species of oribatid mites in high alpine areas of Tyrol was studied by Schatz (1979). Luxton (1979) estimated the rate of food processing by oribatid mites and also reviewed the nutritional biology of these mites. A comparative study of the duration of life cycles of 4 species of oribatid mites, *L. ornatissimus*, *A. longisetosus, G. flabellifera orientalis* and *G. longipluma* from the soils of Kerala was done by Haq and Clement (1980). Seniczak (1980) described the morphology of immature stages of *Trichoribates trimaculatus* and *T. novas*.

Fernandez (1981) described the spermatophores of *E. mauri* from Argentina. Haq and Clement (1981) studied the influence of preferred food, moisture content and presence of female, on spermatophore deposition by *P. malabarica*. Luxton (1981) conducted a series of biological studies on oribatid mites and described the field population, developmental biology, vertical distribution and seasonal population changes. Haq (1982) classified 10 species of oribatid mites, on the basis of food specificity, into three major feeding categories, namely, microphytophages (20%) macrophytophages (40%) and panphytophages (40%). He also concluded that rate of reproduction was enhanced by preferred food. West (1982) traced the life histories of three species of sub-Antarctic oribatid mites. Based on their studies on the feeding habits of 16 species of oribatei from cultivated and uncultivated blanket bog at glenamoy, Ireland, Behan and Hill (1983) reported that 15 species were panphytophagous, a feeding habit considered ecologically advantageous to the mites. Waitzbauer (1983) studied the process of spermatogenesis and structure of spermatophore in *Hermannia* *gibba*. Haq and Ramani (1984) completed the studies on the postembryonic development of *Paralamellobates bengalensis*, inhabiting the leaves of *Dioscorea alata*.

Nannelli and Bernini (1984) concluded through their studies on the post embryonic development of *C. pegazzanoae* that, the young oribatid mites were more similar to one another than to their respective adults. The developmental stages of two species of phthiracarid mites viz. *S. magnus* and *P. anonymum* were studied by Harding and Easton (1984). Haq (1984) noted that *H. hirsutus* bored tunnels in the wood which provided a favourable microhabitat for oviposition and physical protection for immature stages. Ramani and Haq (1987a) studied the influence of temperature on the duration of development of *Scheloribates decarinus* inhabiting the weed, *Chromolaena odorata*. Further the authors (1987b) traced the postembryonic development of *S. decarinatus* under laboratory conditions. Schenker (1983) studied the temperature tolerance of an alpine oribatid species viz. *Epidamaeus diversipillus* and he reported that the species completed its life cycle within 119 $\pm$ 6.8 days at a temperature of 29^{o}C. Haq and Ramani (1987) observed that the females of *P. longiporosus* laid solitary eggs inside the aerenchyma cells of waterhyacinth leaves. Haq (1987) extracted different bacterial colonies from faeces of immature stages of *H. hirsutus*. Taberly (1987) provided a review of thelyotkus parthenogenesis among oribatid mites.

Fujikava (1988) studied the biology of *O. nova* and found that all specimens collected were females. The feeding biology, population ecology and occurrence of parthenogenesis in *M. nasilis* were studied by Norton *et al.* (1988). Norton (1988) found that the larvae of 2 undescribed species of mite genus *Leptus* were attached to the heavily sclerotised cuticle of 10 species of orbatid mites. Seniczak (1988) discussed the morphology of immature stages of two species of moss mites viz. *E. torulosus* and *E. ocultus*. The influence of temperature on the life cycle and development of *P. peltifer* was observed by Taberly (1988).

Kaneko (1989) discussed the reproductive pattern and duration of life cycle of 4 species of oribatids viz. *Eohydroppia magnus, Ischeloribates lanceolatus, Quadroppia quadricarinata* and *Archoplophora villosa*. The morphology of immature stages of moss mites, *Melanozetes mollicomus* and *M. meridianus* was described by Seniczak (1989a). He (1989b) described the morphology of immature stages of *Fuscozetes fuscipes* and *F. setosus*. Alberti *et al.* (1989) summarized the available data on spermatophore structure among oribatid mites using light and electronmicroscopic studies. Haq (1989) discussed some interesting aspects of oribatid behaviour and explained the unusual reproductive strategies like aparity, viviparity, parthenogenesis and aggregation of immature stages in these species.

Norton (1990) made an elaborate study on various aspects of oribatid mites viz. taxonomy, biology and ecology. Palmer and Norton (1990) experimentally proved the occurrence of thelytokous parthenogenesis in 15 species of oribatid mites. The various life history strategies exhibited by oribatid mites were described by Lebrun *et al.* (1991). Trave and Olszanowski (1991) studied the postlarval development of the leg chaetogaxy of some species of genera *Crotonia* and *Holonothrus*. Wauthy and Fain (1991) studied the morphological diversity of legs in the larvae and nymphs of *T. maniculatus*.

According to Palmer and Norton (1992) the oribatid mite taxon Desmonomata reproduced by thelytokus parthenogenesis and they noted males as nonfunctional. Sumangala and Haq (1995) traced the development stages of *O. terebrantis* in a single leaf of *E. crassipes*. Norton *et al.* (1993) described different reproductive modes exhibited by oribatid mites. The influence of food on the development of *Allonothrus giganticus* was studied by Ramani and Haq (1993). They concluded that the mite completed its development in 30-32 days on yeast while it took 42-46 days when partly decomposed wood was given as food. Smriz (1994) studied some aspects of life history of oribatid mites under conditions of extreme humidity combined with microorganisms. The biology, life cycle and ecophysiology of the Antarctic mite, *Alaskozetes antarcticus* was traced by Block and Convey (1995).

Irmler and Pfadenhauer (1996) studied the succession of litter population by oribatids in different forest types. Marie *et al*. (1997) observed the phenomenon of obligate thelytoky in oribatid mites who recommended an alternative hypothesis for the inducement of thelytoky. They also studied its relevance to the observed diversification of thelytokous oribatid mites. Segmentation of oribatid mites during development was reported by Weigmann (2001). Behan and Paoletti (1999) provided details of general ecology, biology and life history of oribatid mites. According to them the oribatid mites with low metabolic rate, slow development and low fecundity cannot respond rapidly to resource scarcity. Edsberg Hagvar (1999) observed that oirbatid mites *S. striculus*, *R. ardua* and *A. ovatus* developed inside decomposing spruce needles.

Kuriki (2000) studied life histories of oribatid mites in sphagnum mines. Schuster *et al*., (2000) artificially infected 6 species of adult orbatid mites and 2 immature stages with eggs of *M. expansa* with success in the case of adults. Maraun *et al*. (2001) studied sexuality and asexuality in oribatid mites on molecular basis. He (2001a) derived an evolutionary and phylogenetic conclusion through a study on sexual and parthenogenetic oribatid mites. Ramani and Haq (2001) examined the feeding habits of the Indian oribatid mites *Hoplophthiracarus rimosus* and *Lohmannia sp*. and their potential role in biodegradation.

Smrz and Norton (2004) examined the nutritional biology of the oribatid mite *A. longisetosus*. Schneider *et al.* (2004) summarized the existing knowledge on the feeding biology of oribatid mites. They concluded that oribatid mites were generalists with a certain degree of specialization concerning their food resources. Alphonsa and Haq (2006) described the breeding behaviour and postembryonic development of the lohmanniid mite *H. davisi*. The authors (2007) correlated the structure of the gnathal appendages of oribatid mites with the feeding habits of these mites.

Heethoff *et al*. (2007) presented the gross morphology of the reproductive system of *A. longisetosus* as obtained by SEM techniques and the application of X-ray synchrotron microtomography for the observation of the internal anatomy of whole microarthropods. The variability of gastronotic setae among the juveniles of two species of *Hydrozetes* viz. *H. lemnae* and *H. thienemanni* was illustrated by Seniczak and Seniczak (2008).

Chapter X

MATERIALS AND METHODS

1. Culturing and Rearing

Detailed biological studies on selected species of primitive oribatid mites were carried out in the laboratory by extracting adequate number of live specimens from the soil or litter samples collected from the various sites described in Chapter III. The live mites recovered through Berlese funnel extraction were reared in plastic vials of length and width 3.7cm and 3.5cm respectively, based with plaster of paris-charcoal mixture. Moistened, powered leaf litter collected from respective habitat were offered as food during rearing.

Developmental studies were carried out in special culture cells prepared by fixing spherical acrylic rings of 2.6cm diameter, in petridishes filled with plaster of paris-charcoal mixture. When the culture rings were properly set, live mites isolated species wise under a stereozoom microscope were transferred in to these rings with the aid of a moistened camel hair brush. Preferred food items comprising the leaf litter or other test food were provided during rearing under laboratory conditions. A few drops of 1% thymol solution were added to each of the rearing cells as a fungicide.

2. Food Choice Test

During the present study, food choice test was carried out for 5 species viz. *E. payyoliensis, M. hygricola, P. baloghi, A. keralensis* and

A. longisetosus. Since *A. longisetosus* was recognized as a widely distributed and very active one with extremely diverse nutritional habits, it was subjected to a detailed study by providing more food items.

For food choice test, a variety of food items of diverse origin were (Table 2) offered individually to the mites reared in the laboratory. The test food items comprised a variety of substances like yeast, 7 species of fungi, mushroom, moss, decomposed leaf litter, faecal pellets of mites, cotton thread, filter paper, rice, hard plastic, artificial sponge and live animals like earth worm and juveniles of millipedes. The feeding response of the species to each of the above food item was recorded through frequent observation. Presence of the mites on the food substances, feeding activity, signs of feeding, production of faecal pellets, egg deposition etc. were considered as an index to assess and categorize the levels of feeding.

3. Developmental Studies

Developmental studies were initiated in the laboratory by offering the most preferred food item in fresh culture cells. The culture cells were regularly observed at fixed intervals to locate the eggs or spermatophores of individual species. As and when the eggs were located in the culture cells, they were transferred to special culture rings, prepared by fixing acrylic rings of 2.6 cm diameter in a mixture of plaster of pairs-charcoal (4:1 ratio) contained in a petridish. The culture ring was covered with a cover glass, and observed under a stereozoom microscope to record the changes occurred during days of incubation. Frequent observation was made to collect data on hatching, duration of active and quiescent stages, moulting etc. For the ease of observation, the larva and the subsequent nymphs were kept in separate culture rings. A few eggs and life stages were treated in alcohol series (70%, 90% and 100%) and slide mounted for studying morphological details. The entire process of development was studied under controlled temperature-humidity conditions of $30 \pm 1^{0}C$ and 70-75% RH.

Chapter XI

OBSERVATION

1. Postembryonic Development of *Eohypochthonius payyoliensis* sp. nov.

E. payyoliensis, a representative of the family Hypochthoniidae, was subjected to laboratory feeding experiments to locate its most preferred food items. As a result, the decomposed leaf litter of *P. guajava* and the fungus *Colletotrichus sp.* were selected as the preferred food items, for rearing the species in order to study its breeding biology and postembryonic development, under controlled conditions. The study was carried out at the temperature and humidity conditions of 30 $\pm$ i^{0}C and 70-75% respectively.

Oviposition

Gravid females of *E. payyoliensis* generally laid oval, transluscent, smooth and solitary eggs, either on the culture base or on the food substance provided. No selection for any concealed or secluded oviposition sites was disclosed by the species.

Incubation and Hatching

Incubation period ranged from 15-16 days. On the 10th day of incubation, the transparency of the eggs was found lost and they turned milky-white in colour. The last stage of incubation was marked by the formation of a lid like structure or operculum, through which the hexapod larva emerged out, by protruding out the anterior part of its body and legs.

Duration of Life Stages

The newly emerged larva remained inactive for 10-15 minutes near the egg case. It appeared translucent and sluggish. After this hardening period, the larva exhibited slow movements and became more active on the detection of its preferred food items. Concomitant with the feeding activity, the colour of the larva also got changed to light golden yellow. This feeding period was found extended to 8-11 days and then the larva entered into the 1st quiescent phase for 3-5 days. Prior to quiescence, the larva ceased feeding, became lethargic and its body appeared swollen and elongated. Prior to moulting the quiescent stage became transparent and a weakened area developed at the anterolateral region of the body. Slits developed along the weakened area and due to the pressure exerted by the moulting individual, the slit got widened in both directions and the protonymph slowly emerged out by the gradual backward movements of its body. The process of moulting was similar in all the subsequent nymphal stages. After emergence, the nymph remained inactive for a few minutes and then started moving and feeding. The protonymph fed actively for a period of 8-10 days, and it became quiescent for 4-5 days. On subsequent moulting, the deutonymph emerged and its active period was recognized to be 8-9 days. The deutonymph became quiescent for 4-5 days and then moulted in to the tritonymph. The tritonymph was the largest of the juveniles and its active period lasted for 7-8 days. The period of quiescence of the tritonymph was found completed with in 4-5 days and on subsequent moulting the adult emerged. The newly emerged adult female reproduced parthenogenetically and resumed oviposition 8-10 days after its emergence. Thus the post-embryonic development of the species was found completed with in 66-70 days and the duration of F_1 generation of the species was 74-80 days.

Morphological Description of Life Stages of *E. payyoliensis* sp. nov.

Egg (Plate-23, Fig. 2)

Measurement : Length: 118-120 µm

Width: 105–106 µm

Freshly laid eggs appeared transluscent, slightly oval in appearance and with a smooth outer surface.

Larva (Plate-23, Fig. 3; Plate-24, Figs. 1 & 2)

Measurement : Length : 205-208 µm

Width : 105-1068 µm

The newly emerged larva was distinguished by the possession of 3 pairs of legs, small size and transparent body. Gradually the colour changed to light golden yellow.

Prodorsum

Prodorsum roughly conical with a broadly round rostral apex. Rostral tectum with 3 teeth, 2 placed close together and one far anterior. Seta *ro* 25µm long, foliate and smooth, situated far beyond the rostral apex.

Seta *le* 30µm, resembles *ro* in appearance. Seta *in* measures 18 µm arising at the level of bothridium (*bo*). Setae *exa* and *exp* measure 14 µm and 6 µm respectively, *exp* very minute in appearance. Sensillus (*ss*) pectinate with 7-8 branches arranged unilaterally. Lateral cresets present, directed forwards. Prodorsal band extends between the bothridial cups. Prodorsal integument finely punctate.

Notogaster

Notogaster oval with a straight anterior border. Anterior notaspis (NA) separated by a dorsal transverse suture from the posterior pygidium (PY). Thirteen pairs of notogastral setate present. Setae e_1 an e_2 represented by their alveoli located on the transverse suture. The remaining setae long and foliate with midrib. Setate h_1 and h_2 flexed ventrad and setae h_3 located ventrally. Notogastral integument finely punctate.

Ventral region

Infracapitulum bears 3 pairs of setae *a, m*, and *h*, all thin and smooth. Seta *a* longer than *m* and *h*. Epimeral setal formula 2-1-2. All setae thin and smooth. Genital area not developed. Anal plates also not developed. Adanal plates with 3 pairs of setae, all thin and smooth. Ventral plate bears fine punctations.

Legs

Three pairs, all monodactylous.

Protonymph (Plate-23, Figs. 4 & 5; Plate-24, Figs. 3 & 4)

Measurements: Length : 224-227 µm

Width : 112 -114 um

Protonymph easily distinguished from the larva by its larger body size, possession of 4 pairs of legs and presence of a single pair of suckers at the genital area. Body white in colour initially and gradually acquired golden yellow colouration.

Prodorsum

Prodorsum flat with a blunt rostral apex. Rostral tectum not smooth, bearing 3 teeth, 2 placed close together and one towards anteriorly. All prodorsal setae foliate and smooth. Seta *ro* 29 µm inserted far below the rostral apex. Seta *le* measures 32 µm. Seta *in* measures 17µm, inserted near the bothridium (*bo*). Setae *exa* and *exp* measure 22µm and 8µm respectively. Seta *exp* being very minute in size. Sensillus (*ss*) pectinate with 8-9 branches on the lower surface and a few barbs on the upper surface. Prodorsal band located between bothridia (*bo*). A cochlea shaped tectum developed at the prodorsal posterior corner.

Notogaster

Notogaster oval in shape. Dorsosejugal suture straight. Anterior notaspis (NA) separated from posterior pygidium (PY) by a transverse suture. Sixteen pairs of notogastral setae present, all long, smooth and foliate. Setae e_1 and e_2 located on the transverse suture and each pair represented by a single seta. The alveoli of other setae located on the transverse suture. All posterior most setae flexed ventrad. Setate ps_2 and ps_3 located ventrally. Notogastral integument finely punctate.

Ventral region

Infracapitulum bears 4 pairs of setae, *a*, m_1, m_2 and *h*. All setae thin and smooth. Seta *a* longer than *m* and *h*. Epimeral setal formula 3-1-3-1, all setae thin and smooth. Genital plates with a single pair of short, smooth and thin setae and a pair of suckers. Anal region with 3 pairs of thin adanal setae. Anal plates not developed.

Legs

Four pairs, all monodactylous.

Deutonymph (Plate-23, Fig. 5; Plate-25, Figs. 1 & 2)

Measurements: Length : 254 – 257 µm

Width : 119 -122 µm

Deutonymph distinguished from the previous stages by its slightly bigger size, golden yellow colour and possession of 2 pairs of genital suckers.

Prodorsum

Prodorsum with a blunt rostral apex and a broad base. Lateral surface bears 3 pairs of teeth. All prodorsal setae smooth and foliate. Seta *ro* measures 34 µm, forwardly directed, and situated far beyond the rostral margin. Seta *le* 38µm long, directed backwards. Seta *in* measures 19 µm and inserted more or less at the level of *bo*. Seta *exa* 27 µm long and directed forwards. Seta *exp* very short and measures 10µm. Setae *ro*, *le*, and *exa* thick and long while setae *in* and *exp* thin and short. Prodorsal band present, in between *bo*. Sensillus pectinate with 8-9 branches on the lower surface and a few barbs on the upper surface. Cochlea shaped tectum present on the posterolateral wall of the prodorsum, one on each side. Prodorsal integument finely punctate.

Notogaster

Notogaster oval with broad anterior and round posterior ends. A notogastral furrow present anteriorly above setae c_1-c_3 and below the dorsosejugal suture. Dorsal transverse suture separates the anterior *NA* from the posteriors *PY*. Sixteen pairs of notogastral setae of varying size present, all foliate and smooth. Setae e_1 and e_2 represented by a single seta. The insertion points of other setae located on the transverse suture. All posterior setae flexed ventrad. Seta ps_3 located ventrally. Notogastral integument punctate.

Ventral region

Infracapitulum with 4 pairs of setae *a*, m_1, m_2 and *h*. All setae thin and smooth. Seta *a* longer than *m* and *h*. Epimeral setal formula 3-1-3-3, all setae thin and smooth. Genital plates with 2 pairs of suckers and 5 pairs of genital setae, all thin, short and smooth. Two pairs of anal setae and 3 pairs of adanal setae present, all thin and smooth.

Legs

Four pairs, all monodactylous.

Tritonymph (Plate-23, Fig. 6; Plate-25, Figs. 3 & 4)

Measurement: Length: 261-264 µm

Width : 123-124 µm

Tritonymph could be distinguished from the previous stages by the larger body size, possession of 3 pairs of genital suckers and pale brown colouration.

Prodorsum

Prodorsum roughly triangular with a more elongated, blunt rostrum bearing 3 teeth on either side, as that of the previous stages. All prodorsal setae foliate and smooth. Seta *ro* 35µm long, inserted far below the rostral apex and directed forwards. Seta *le* measures 38µm and directed downwards. Seta *in* measures 18µm, inserted at the level of bothridium, *bo*. Seta *exa* 27µm long, directed forwards. Seta *exp* 15 µm long. *ss* pectinate with 8-9 branches on the lower surface and a few barbs on the upper surface. Prodorsal band present. Cochlea shaped tectum present on the posterolateral wall of the prodorsum, one on each side. Prodorsal integument finely punctate.

Notogaster

Notogaster oval in shape. An anterior notogastral furrow present, above setae c_1-c_3 and below the dorsosejugal suture. Anterior notaspis (NA) separated from posterior pygidium by a dorsal transverse suture. Sixteen pairs of notogastral setae of varying size present, all foliate and smooth. Setae e_1 and e_2 represented by a single seta and the alveoli of other setae located on the transverse suture. All posteriormost setae flexed ventrad. Seta ps_3 located ventrally. Notogastral integument ornamented with fine punctations.

Ventral region

Infracapitulum bears 4 pairs of setae, *a*, m_1, m_2 and *h*, all thin and smooth. Seta *a* longer than other setae. Epimeral setal formula 3-1-3-4. All setae thin and smooth. Genital plates bear 8 pairs of setae and 3 pairs of suckers, all setae thin and smooth. Pre-anal plate narrow. Adanal plates bear 3 pairs of setae and the anal plates with 2 pairs, all thin and smooth. Ventral plate ornamented with fine punctations.

Legs

Four pairs, all monodactylous.

Table 3: Duration of Development of Life Stages of *Eohypochthonius payyoliensis* sp. nov. at 30$\pm$ 1^{0}C (in days)

	Egg	Larva	Quiescent	Protonymph	Quiescent	Deutonymph	Quiescent	Tritonymph	Quiescent	Total
1	16	10	5	10	4	8	4	7	4	68
2	15	8	4	10	4	8	5	8	5	67
3	15	10	5	8	5	9	5	7	5	69
4	15	11	3	10	4	8	5	8	4	68
5	16	8	3	8	5	9	4	8	5	66
6	15	9	4	8	5	9	5	8	4	67
7	16	8	4	8	5	9	5	7	4	66
8	16	11	5	9	4	8	4	8	4	69
9	16	11	3	10	5	9	4	8	4	70
10	15	10	4	9	5	8	4	7	4	66
Range	15-16	8-11	3-5	8-10	4-5	8-9	4-5	7-8	4-5	66-70

Table 4: Appearance of Notogastral Setae at Different Stages of Development of *Eohypochthonius payyoliensis* sp. nov.

Stage	Rows						Total number of setae	Setae appeared anew
	First	Second	Third	Fourth	Fifth	Sixth		
Larva	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	- -	13	13
Protonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	3
Deutonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	-
Tritonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	-
Adult	c_1, c_2, c_3	d_1, d_2, d_3	- -	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	12	-

Table 5: Appearance of Epimeral Setae at Different Stages of Development of *Eohypochthonius payyoliensis* sp. nov.

Stages	Epimere				Setae appeared anew	Epimeral setal formula
	I	II	III	IV		
Larva	*1a, 1b*	*2a*	*3a, 3b*	-	5	2-1-2
Protonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a*	3	3-1-3-1
Deutonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	2	3-1-3-3
Tritonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c, 4d*	1	3-1-3-4
Adult	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c, 4d*	-	3-1-3-4

Table 6: Appearance of Genital Setae at Different Stages of Development of *Eohypochthonius payyoliensis* sp. nov.

Stage	Genital setae	Total number of genital setate	Setae appeared anew
Larva	-	-	-
Protonymph	g_1	1	1
Deutonymph	g_1-g_5	5	4
Tritonymph	g_1-g_8	8	3
Adult	g_1-g_{10}	10	2

Table 7: Appearance of Adanal and anal setae at different stages of development of *Eohypochthonius payyoliensis* sp. nov.

Stage	Adanal Segment			Anal Segment		
	Seta	Number	Seta appeared anew	Seta	Number	Seta appeared anew
Larva	ad_1, ad_2, ad_3	3	ad_1, ad_2, ad_3	-	-	-
Protonymph	ad_1, ad_2, ad_3	3	-	-	-	-
Deutonymph	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	an_1, an_2
Tritonymph	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	-
Adult	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	-

2. Postembryonic Development of *Malacoangelia hygricola* sp. nov.

Breeding behaviour and postembryonic development of a new hypochthoniid member viz., *M. hygricola sp. nov.* were studied by offering its preferred food viz., decomposed leaf litter of *P. nigrum* at a temperature of 30 ± 1^{0}C and relative humity of 70-75%.

Oviposition

The gravid females reproduced parthenogenitically and laid solitary eggs on the culture base. The eggs were seen as covered by the culture medium. The eggs appeared oval in shape, transluscent and with a smooth outer surface.

Incubation and Hatching

The incubation period lasted for 14-18 days. Towards the end of incubation, the eggs became milky white in colour. The last stage of incubation was marked by the formation of a slit along the longitudinal axis and the hexapod larva emerged out by protruding out the anterior part of its body and legs.

Duration of Life Stages

The newly emerged larva appeared very small and delicate and it remained inactive for about 20 minutes, distinguished as the hardening period. After this, it slowly wandered about in the culture cell in search of preferred food. On detection of the food item, it started feeding and slowly devoured the leaf litter. After an active period of 14-17 days, the larva entered into the 1st quiescence which was preceded by the arresting of feeding activity and acquisition of swollen body and sluggish nature. The period of 1st quiescence lasted for 7-9 days and during this phase, the instar showed an increase in length and became swollen in appearance. Towards the end of this phase, anterolateral slits developed and the moulting individual emerged out backwards, leaving the remnants of the exuvium intact. The duration of quiescence and the process of moulting were similar in all the subsequent stages. The newly moulted protonymph was white coloured and which actively fed for a period of 21-25 days. The quiescent phase of the protonymph lasted for 7-9 days and it moulted subsequently to the deutonymph. The off-white coloured deutonymph was comparatively larger than the protonymph and its active period extended for 20-25 days and it underwent a quiescent phase of 7-9 days. The tritonymph, which got emerged after moulting of the quiescent phase was off-white in colour with pale brown shades on the prodorsum and legs. It was more active and its feeding activity was comparatively high and its feeding period lasted for 24-26 days. Subsequently, the tritonymph passed through a quiescent phase of 7-9 days duration and underwent the moulting process resulting in the emergence of the adult. Hence the total duration of *M. hygricola* from egg to adult was 132-137 days.

The newly emerged adults started oviposition after 10-14 days of emergence. Thus the total duration of F_1 generation was found completed within 142-151 days.

Morphological Description of Life Stages of *M. hygricola* sp. nov.

Egg (Plate-23, Fig. 8)

Measurements: Length: 117-119 μm

Width : 108 – 109 μm

Freshly laid eggs appeared transluscent and oval in shape with a smooth outer surface.

Larva (Plate-23, Figs. 9 & 10; Plate-26, Figs. 1 & 2)

Measurements: Length: 290-294 μm

Width : 177-180 μm

The newly emerged larva small in size, pale white in colour and processes 3 pairs of legs.

Prodorsum

Prodorsum broad and flat with a round rostral apex. Seta *ro* leaf like and inserted marginally. Setae *le*, *in, exa* foliate with distinct midrib. Seta *exp* thinner and shorter than the other prodorsal setae. Sensillus *ss* pectinate with 18 small branches. Prodorsum sparsely punctate.

Notogaster

Notogaster bears 12 pairs of setae, all foliate with distinct midrib, except e_1 and e_2, the latter two pairs of setae very small, thin and spiny and inserted on the transverse ridge. Lenticulus with double layered outer wall and striations, present anteriorily on the notogaster at the base of setae c_1. Posterior notogastral setae with a 'T' shaped midrib and hyaline body. Seta h_2 and h_3 localed ventrally. Notogaster ornamented with fine punctations.

Venteral region

Infracapitulum with 3 pairs of setae, *a, m* and *h*, all thin and smooth. Epimeral setal formula 2-1-2, all setae short, thin and smooth. Genital plates not developed. Ano-adanal plate with 2 pairs of smooth adanal setae.

Legs

Three pairs, all monodactylous.

Protonymph (Plate-23, Fig. 11; Plate-25, Figs. 3 & 4)

Measurements: Length: 301 – 305 µm

Width: 198-200 µm

Protonymph could be easily distinguished from the larva by its larger size and possession of four pairs of legs. The newly moulted protonymph appeared white initially and gradually changed to pale white.

Prodorsum

Rostrum flat with horn like projections, laterally. Seta *ro* leaf like, smooth, incurved and inserted marginally. Setae *le, in* and *exa* foliate with a distinct midrib. Seta *exp* simple, thin and shorter than the other prodorsal setae. Sensillus (*ss*) pectinate with its 18-20 branches arranged unilaterally.

bo bell shaped. Prodorsal integument ornamented with fine spine like structures.

Notogaster

Notogaster possesses 16 pairs of setae all setae foliate with distinct midrib, except e_1, and e_2. The latter two pairs small thin and spiny and inserted on the transverse ridge. Lenticulus with double layered outer wall and characteristic striations seen as in larva. Posterior notogastral setae with 'T' shaped midrib and hyaline body. Setae ps_2 and ps_3 located ventrally. Integument of notogaster ornamented with spiny out growths.

Ventral region

Intracapitulum bears 4 pairs of setae *a*, m_1, m_2 and *h*. Epimeral setal formula 2-1-2-1, all setae smooth and thin. Genital plates carry 1 pair of thin and smooth setae and a pair of suckers. Anoadanal plates carry 3 pairs of adanal setae, all thin and smooth.

Legs

Four pairs, all monodactylous.

Dutonymph (Plate-23, Figs. 12 & 13; Plate-27, Figs. 1 & 2)

Measurement: Length : 358-362 µm

Width : 236-239 µm

Deutonymph could be distinguished from the previous stages by its larger size, off white colour with pale brown shades on prodorsum and legs.

Prodorsum

Prodorsum crown shaped, broader at the base. Rostrum flat with lateral horn like projections. Seta *ro* leaf like, smooth and curved inwards. Setae *le*, *in* and *exa* foliate with distinct midrib. Seta *exp* short, thin and smooth. Sensillus (*ss*) pectinate with 18-20 branches unilaterally. *bo* bell shaped.

Notogaster

Dorosejugal suture straight. Notogaster broadly oval. Sixteen pairs of notogastral setae present, all foliate, with distinct midrib except setae e_1 and e_2. Setae e_1 and e_2 short spiny, smooth and inserted in the ridge. Lenticulus present as in the previous stages. Posteriormost notogastral setae with 'T' shaped midrib and hyaline body. Setate ps_2 and ps_3 ventrally inserted.

Ventral region

Infracapitulum bears 4 pairs of setae, all thin and smooth. Epimeral setal formula 2-1-3-3. Genital plates bear 3 pairs of setae. Ano-adanal plate bears 3 pairs of adanal setae. Setae on epimeral, genital and adanal plates thin and smooth.

Legs

Four pairs, all monodactylous.

Tritonymph (Plate-23, Fig. 14; Plate-27, Figs. 3 & 4)

Measurements: Length: 388-392 µm

Width : 251-254 µm

Tritonymph forms the largest among the immature stages, distinguished by its pale brown coloured body.

Prodorsum

Prodorsum crown shaped with broad base. Rostrum flat with horn like lateral projections. Seta *ro* inserted marginally, foliate with veins. Setae *le, in*, and *exa* foliate with distinct midrib. Seta *exp* short, thin and smooth. Sensillus (*ss*) pectinate bearing 18-20 branches on one side and its tip bifurcated. Lateral ridges present on the prodorsum. Prodorsal integument, wrinkled and ornamented with spiny outgrowth.

Notogaster

Sixteen pairs of notogastral setae present, all foliate with distinct midrib, except setae e_1 and e_2, the latter setae inserted on the transverse ridge, short and thin. Lenticulus present. Posteriormost notogastral setae with 'T' shaped midrib and hyaline body.

Ventral region

Infracapitulum bears 4 pairs of setae, *a*, m_1, m_2 and *h* all thin and smooth. Epimeral setal formula 3-1-3-4. Genital plates carry 8 pairs of setae, 4 pairs long, inserted in an antiaxial row and 4 pairs short, the remaining inserted in paraxial row. Anoadanal plates with 2 pairs of anal and 3 pairs of adanal setae. All ventral setae thin and smooth. Ventral plate ornamented with spiny outgrowths.

Legs

Four pairs, all monodactylous.

Table 12: Appearance of Genital Setae at Different Stages of Development of *Malaccanglia hygricola* sp. nov.

Stage	Genital setae	Total number of genital setate	Setate appeared anew
Larva	-	-	-
Protonymph	g_1	1	1
Deutonymph	g_1-g_3	3	2
Tritonymph	g_1-g_8	8	5
Adult	g_1-g_{10}	10	2

Table 13: Appearance of Adanal and Anal Setae at Different Stages of development of *Malacoangelia hygricola* sp. nov.

Stage	Adanal Segment			Anal Segment		
	Seta	Number	Seta appeared anew	Seta	Number	Seta appeared anew
Larva	ad_1, ad_2	2	ad_1, ad_2	-	-	-
Protonymph	ad_1, ad_2, ad_3	3	ad_3	-	-	-
Deutonymph	ad_1, ad_2, ad_3	3	-	-	-	-
Tritonymph	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	an_1, an_2
Adult	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	-

Table 9: Duration of Development of Life stages of *Malacoangelia hygricola* sp. nov. at 30±1^{0}C (in days)

	Egg	Larva	I Quiescent	Protonymph	II Quiescent	Deutonymph	III Quiescent	Tritonymph	IV Quiescent	Total
1	16	15	9	25	7	22	8	26	8	136
2	15	15	9	22	9	22	8	25	9	134
3	18	17	7	21	7	20	7	26	9	132
4	18	15	9	22	8	20	9	24	7	132
5	15	14	8	25	8	25	7	25	8	135
6	14	17	8	22	9	22	8	25	8	133
7	14	14	8	22	7	24	9	26	9	133
8	15	16	7	25	8	20	9	25	7	132
9	15	15	9	21	8	25	9	26	8	136
10	18	16	7	22	8	25	8	24	9	137
Range	14-18	14-17	7-9	21-25	7-9	20-25	7-9	24-26	7-9	132-137

Table 10: Appearance of Notogastral Setae at Different Stages of Development of *Malaccanglia hygricola* sp. nov.

Stage	Rows						Total number of setae	Setae appeared anew
	First	Second	Third	Fourth	Fifth	Sixth		
Larva	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	- -	13	13
Protonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	3
Deutonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	-
Tritonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	-
Adult	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	16	-

Table 11: Appearance of Epimeral Setae at Different Stages of Development of *Malacoanglia hygricola* sp. nov.

stages	Epimere				Setae appeared anew	Epimeral setal formula
	I	II	III	IV		
Larva	*1a, 1b*	*2a*	*3a, 3b*	-	5	2-1-2
Protonymph	*1a, 1b*	*2a*	*3a, 3b*	*4a*	1	2-1-2-1
Deutonymph	*1a, 1b*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	2	2-1-3-3
Tritonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c, 4d*	2	3-1-3-4
Adult	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c, 4d*	-	3-1-3-4

3. Postembryonic Development of *Papillacarus baloghi* sp. nov.

Lohmanniid mites play an important role in the decomposition process and the degradation of leaf litter. Being a very active Lohmanniid representative, *P. baloghi* was subjected to laboratory feeding experiments to trace its most preferred food items. Varied rates of feeding by the immatures and adults of this species on leaf litter, leading to the accumulation of large quantities of faecal pellets in the culture cells revealed its promising role in degradation of leaf litter. Accordingly, the leaf litter of two species of plants viz., *P. nigrum* and *A. integrifolia* were selected as the preferred food items in the laboratory for studying its breeding biology. The study was carried out in the laboratory under controlled temperature-humidity conditions of 30 $\pm$ 1^0 C and 70-75% respectively.

Oviposition

Gravid females were found depositing solitary, oval and white eggs which were seen scattered among the food materials, on the culture base or among the faecal matter. A female laid an egg at a time interval of 4-7 days. A single female was found to lay 34-42 eggs during its life time.

Incubation and Hatching

Incubation period ranged from 14-17 days. During initial days of incubation, the egg became thick white in appearance. After 4-6 days of oviposition, a cone like projection appeared on the egg surface. Within another 6-7 days, a weak area (in V shape) appeared at the opposite end.

After 5 days, due to the pressure exerted by the developing larva, a medio-lateral slit formed which extended in both directions along the weak area. During hatching, a lid like structure developed and the larva emerged out by protruding its anterior pair of legs and subsequently the prodorsum. This was soon followed by the complete expelsion of the body from the egg case, leaving behind the latter as empty, transparent structure.

Duration of Life Stages

The newly emerged larva was white, transluscent, wrinkled and sluggish. It remained inactive for 10-15 mintues near the egg case, which was distinguished as the hardening period. After this, the larva exhibited slow movements and started wandering in the culture cells. On detecting the preferred food item, the larva slowly started feeding. This was followed by vigourous feeding activity and gradually the larva became light golden yellow in colour. After an active feeding period of 16-22 days, the feeding activity of the larva got diminished and completely arrested. Simultaneously, its body also became turgid. This inactive phase was recorded as the I quiescent phase and it lasted for 5-6 days. Towards the end of this quiescent phase, the body of the larva became transparent with the formation of weakened area along the posterolateral region of the notogaster. Subsequently, slits developed at the weak areas, through which the last pair of legs of the moulting nymph extruded. As a result of the pressure exerted by the moulting individual, the slits got widened in both directions. The nymph slowly came out by the gradual backward movements of the body. The process of moulting was found completed within 2-4 hours and it was similar for all subsequent nymphal stages. The protonymph emerged through moulting of 1^{st} quiescent phase showed active signs of feeding on the offered leaf litter for 15-19 days. Resembling the larva, the protonymph also entered into the inactive phase (II quiescent phase) which lasted for 5-6 days. After moulting, the deutonymph came out which actively fed on the leaf litter for 18-23 days. The deutonymphal quiescence lasted for 5-6 days. The tritonymph emerged after the third moulting, voraciously fed on the leaf litter for 21-29 days, and became quiescent for 6-9 days. The 4^{th} and the final moulting resulted in the emergence of the adult. The newly emerged adult was golden yellow in colour and gradually became reddish brown within 5 days. The newly emerged adult females initiated oviposition after 23-25 days of emergence. Thus the total duration of F_1 generation of *P. baloghi* was found ranging from 141-153 days, at the temperature humidity combination of 30 $\pm$ 1^0C and 70-75% respectively.

Morphological Description of Life Stages of *P. baloghi* sp. nov.

Egg (Plate-28, Figs. 2 & 3)

Measurements: Length: 170 – 173 μm

Width : 108 – 110 μm

Freshly laid eggs were white, oval and with a smooth outer surface.

Larva (Plate-28, Fig.4; Plate-29, Figs. 1 & 2)

Measurements: Length: 243– 257 µm

Width : 163 – 167 µm

The newly emerged larva could be easily distinguished by the possession of 3 pairs of legs. The body of the larva appeared white in colour and highly wrinkled. Gradually the body colour changed to cream and towards the end of the active period, it became golden yellow in colour.

Prodorsum

Prodorsum roughly conical, with a broad base and round apex. Lamella represented by a weak ridge, the latter with a median convex projection. Prodorsal band present below and between the 2 bothridial cups. All prodorsal setae barbed, but the number of barbs very few, restricted to 3-4 and with a pointed tip. Setal base and tip devoid of barbs. Seta *ro* inserted far below the rostral apex. Bothridia (*bo*) bell shaped. Sensillus well developed with 14 branches of varying length on one side and 6-7 small barbs on the other side. Prodorsum ornamented with punctation but not reticulated as in adult.

Notogaster

Notogaster oval with wavy margins and broad anterior border. Dorsosejugal region lying just below the suture demarcated by closely set transverse wrinkles, resembling a band like structure. Notogastral bands not well developed, clearly visible only in freshly mounted specimens. Thirteen pairs of notogastral setae present. Setae c_1 and d_1 thin short and sparsely barbed. Setae e_1, f_1 and h_1 thick and serrated as shown in fig. Lyrifissure *im* visible very near to the insertion point of seta e_2. Setae h_2 and h_3 located ventrally.

Ventral region

Infracapitulum with 2 pairs of setae, *a* and *h*. Seta *a* smooth while *h* asymmetrically barbed. Epimeral setal formula 3-1-3, all setae thin and smooth, except *1b*, the latter asymmetrically barbed. Seta *3b* the longest among the smooth seta. Genital area not developed. Anal aperture with 3 pairs of smooth adanal setae their size increased. Anal plates not developed towards posteriorly. Lyrifissures *ia* and *ip* located ventrally.

Legs

Legs 3 pairs, all monodactylous.

Protonymph (Plate-28, Figs.5-8; Plate-29, Figs. 3-4)

Measurements: Length: 338 – 343 µm

Width : 197 – 201 µm

Protonymph appeared slightly larger than the larva and easily distinguished by the possession of 4 pairs of legs. The cream coloured protonymph gradually became golden yellow.

Prodorsum

Prodorsum converging anteriorly into a blunt rostrum and gradually becomes broader posteriorly. Lamellae well developed than that of the larva. Prodorsal setae bear more barbs than those of the larva and the sensillus with 15 long branches on one side and 5-6 small barbs on the other side. Prodorsum ornamented with punctations and scattered spicules.

Notogaster

Notogaster oval in shape with broad anterior end. Characteristic closely set transverse wrinkles present below the dorsosejugal suture, as in the larval stage. Notogastral bands visible only in freshly mounted specimens, most of them merged with the notogastral ornamentation. Sixteen pairs of notogastral setae present. Setae c_1, d_1 and e_1 short, thin and weakly barbed. Three pairs of neotrichial setae present at the posterior region. Notogaster ornamented with punctations and spicules.

Ventral region

Infracapitulum with 3 pairs of setae, *a, m* and *h*. Seta *a* smooth while setae *m* and *h* asymmetrically barbed. Epimeral setal formula 3-1-3-1. Setae *1b* and *3b* branched while others smooth. Genital plates developed, carrying 1 pair of smooth setae. Pre-anal plate narrow. Anal plates with 4 pairs of barbed adanal setae.

Legs

Legs 4 pairs, all monodactylous.

Deutonymph (Plate-28, Fig.9; Plate-30, Fig. 1& 2)

Measurements: Length: 400– 412 µm

Width : 244– 257 µm

The body size of deutonymph comparatively larger than that of the protonymph and the colour appeared to be golden yellow. Body ornamented with fine punctations.

Prodorsum

Prodorsum broad, terminating anteriorly as a blunt, round, rostrum. Lamellar ridge more prominent. All prodorsal setae same as that of previous stage, but slightly longer. Bothridium and sensillus (*ss*) same as that of protonymph. The transverse band between (*bo*) clearly seen than that of the protonymph.

Notogaster

Notogaster oval in shape with round posterior end. Dorsosejugal wrinkles and notogastral bands same as that of the previous stages. Notogaster with pygidial neotrichy. Twenty eight pairs of notogaster setae present. Setae c_1, d_1 and e_1 roughened. All other notogastral setae spinose. Pygidial neotrichial setae barbed. Notogaster ornamented with fine punctations and spicules.

Ventral region

Infracapitulum with 5 pairs of setae, *a*, *h*, m_1, m_2 and m_3. Seta *a* smooth, while others asymmetrically barbed. Epimeral setal formula 5-2-3-

3. Setae *1a, 1c, 2a, 3a* and *4a* smooth while *1b, 1d, 1e, 2b, 3b, 3c, 4b* and *4c*. asymmetrically branched. Genital plates bear 6 pairs of setae. Pre-anal plate narrow. Anal plates with 4 pairs of barbed adanal setae and 2 pairs of anal setae. Ventral integument ornamented with fine punctations and foveoles. Lyrifissures *ia* and *ip* located ventrally.

Legs

Legs four pairs, all monodactylous.

Tritonymph (Plate-28, Fig.10; Plate-30, Fig.3&4)

Measurements: Length: 466 – 479 μm

Width : 222 – 231 μm

Tritonymph formed the largest among the immature stages and its body easily distinguished by the light brown colouration.

Prodorsum

Prodorsum roughly triangular with broad base and more conical rostrum. Rostral apex some what wavy. Lamellar ridge well developed with the median projection more prominent. All prodorsal setae thick and spinose except at the base and tip. Rostral setae (*ro*) inserted just below the rostral apex. Prodorsal band well developed, between the bothridial cups. Bothridium and sensillus as in the previous stages. Integument of prodorsum ornamented with fine punctations and spicules.

Notogaster

Notogaster elongated with broad anterior and round posterior ends. Dorsosejugal suture well demarcated and wrinkled band like structure present as in the previous stages. Notogaster bears one complete and 4 incomplete bands. Remanants of another band also present. Setae c_1, d_1 and e_1 short and weakly barbed. Seta f_1 longer than the anterior dorso-centrals. Pygidial neotrichy present. Pygidial neotrichial setae unilateraly barbed. Submarginal and marginal setae spinose. Notogaster bears fine punctations and spicules.

Ventral region

Infracapitulum with 5 pairs of setae, resembling those of the previous stage. Epimeral setal formula 6-3-3-4. Setae *1a, 1c, 2a, 3a* and *4a* short and smooth, while others asymmetrically barbed. Genital plates divided unequally by a transverse suture. The upper part bears 5 pairs of setae and the lower part bears 2 pairs as shown in fig. Pre-anal plate narrow. Anal and adanal plates separated by a distinct ano-adanal suture. Two pairs of anal and 4 pairs of adanal setae present, all unilaterally barbed. Lyrifissures *ia* and *ip* located ventrally. Ventral integument punctate and spiculate.

Legs

Legs four pairs, all monodactylous.

Table 15: Duration of Development of Life Stages of *Papillacarus baloghi* sp. nov. at 30±1^{0}C (in days)

	Egg	Larva	I	Protonymph	II	Deutonymph	III	Tritonymph	IV	Total
			Quiescent		Quiescent		Quiescent		Quiescent	
1	14	22	5	16	5	23	6	28	6	125
2	16	21	5	15	5	18	6	28	6	120
3	14	16	6	17	5	21	6	29	8	125
4	17	16	5	16	6	23	5	21	9	118
5	15	22	6	19	5	21	5	24	6	118
6	14	20	5	15	6	18	6	27	8	119
7	14	21	5	15	6	23	5	29	6	124
8	15	18	6	19	5	23	6	27	9	128
9	17	22	5	15	6	19	5	21	9	119
10	16	16	6	19	5	23	6	26	6	118
Range	14-17	16-22	5-6	15-19	5-6	18-23	5-6	21-29	6-9	118-128

Table 16: Appearance of Notogastral Setae in the Life Stages of *Papillacarus baloghi* sp. nov.

Stage	Rows						Total number of setae	Setae appeared anew	New Neotrichal setae
	First	Second	Third	Fourth	Fifth	Sixth			
Larva	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_1, f_2	h_1, h_2, h_3	-	13	13	-
Protonymph	c_1, c_2, c_3	d_1, d	E_1, e_2	f_1, f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	20	7	4
Deutonymph							28	6	12
Tritonymph							32	4	16
Adult							30	-2	14

Table 17: Appearance of Epimeral Setae in the Life Stages of *Papillacarus baloghi* sp. nov.

Stages	Epimere				Setae appeared anew	Epimeral setal formula
	I	II	III	IV		
Larva	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	-	-	*3-1-3-0*
Protonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a*	*4a*	*3-1-3-1*
Deutonymph	*Ia, 1b, 1c, 1d, 1e*	*2a, 2b*	*3a, 3b, 3c*	*4a, 4b, 4c*	*1d,1e, 2b, 4b*	*5-2-3-3*
Tritonymph	*Ia, 1b, 1c, 1d, 1e, 1f*	*2a, 2b, 2c*	*3a, 3b, 3c*	*4a, 4b, 4c*	*1f, 2c, 4d*	*6-3-3-4*
Adult	*Ia, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i*	*2a, 2b, 2c, 2d*	*3a, 3b, 3c*	*4a, 4b, 4c*	*1g, 1h, 1i, 2d-*	*9-4-3-4*

Table 18: Appearance of Genital Setae in the life Stages of *Papillacarus baloghi* sp. nov.

Stage	Genital setae	Total No. of Setae	Setae Appearing Anew
Larva	-	-	-
Protonymph	g_1	1	1
Deutonymph	g_1 - g_6	6	5
Tritonymph	g_1 – g_7	7	1
Adult	g_1 – g_{10}	10	3

Table 19: Appearance of Adanal and Anal Setae in the Life Stages *Papillacarus baloghi* sp. nov.

Stage	Adanal Segment			Anal Segment		
	Seta	Number	Seta appeared anew	Seta	Number	Seta appeared anew
Larva	ad_1, ad_2, ad_3	3	ad_1, ad_2, ad_3	-	-	-
Protonymph	ad_1, ad_2, ad_3, ad_4	4	ad_4	-	-	-
Deutonymph	ad_1, ad_2, ad_3, ad_4	4	-	an_1, an_2	2	an_1, an_2
Tritonymph	ad_1, ad_2, ad_3, ad_4	4	-	an_1, an_2	2	an_1, an_2
Adult	ad_1, ad_2, ad_3, ad_4	4	-	an_1, an_2	2	-

4. Postembryonic Development of *Allonothrus keralensis* sp. nov.

Results of food choice test carried out in the laboratory enabled to categorize *A. keralensis* sp. nov. as a panphytophagous species with wide range of feeding habits. Voracious feeding activity culminating in reproductive success could be evident on varied food items comprising leaf litter of plants like *A. occidentale* and *A. heterophyllus,* yeast and fungi like *Curvularia geniculata*., *Pestalotia sp*, *Collectotrichus sp*. and *Phytophthora sp*. Developmental studies of the species were completed in the laboratory providing the preferred food item under controlled temperature and humidity conditions of 30 ± 1^0C and 70-75% respectively. Several progenies could be raised in the laboratory on this food, and all the progenies were comprised of only ♀ members, there by establishing parthenogenetic mode of reproduction in the species.

Oviposition

A. keralensis laid eggs either singly or in clusters of 2-6. These eggs were laid on the food substance or on the culture base or among the faecal pellets. A newly moulted adult female initiated laying of eggs within 15-18 days of its emergence.

Incubation and Hatching

Incubation period ranged from 4-5 days. During the course of incubation, the eggs became transparent and appeared as milky white at the broad end, towards the end of incubation. During hatching, a transverse slit developed and the hexapod larva came out by pushing the first pair of legs.

Duration of Life Stages

The newly emerged larva with wrinkled body remained inactive for a period of about 8-10 minutes. After this hardening period, the white coloured larva started feeding by recognizing its preferred food. Gradually, its body became swollen and after and active period of 5-6 days the larva became sluggish, inactive and entered into the 1st quiescent phase of 3-4 days duration. During the quiescent phase, the body of the larva elongated and the notogaster became swollen. Moulting was found initiated by the formation of a slit around the notogaster and the nymph came out by exerting pressure. The entire process of moulting was completed within 1½-2 hrs and after which the lower part of exuvium was seen as intact on the substratum. The processes and durations of quiescence and moulting were similar in the subsequent nymphal stages also. The newly emerged protonymph which was white in colour, after a short period of inactive phase, started various feeding on the food item for a period of 5-6 days. After a quiescent phase of 3-4 days followed by the moulting process, the deutonymph got emerged which was cream in colour with a brownish tinge on the legs and prodorsum. The feeding period of the deutonymph lasted for 6-7 days and it passed through a quiescent phase of 3-4 days. On subsequent moulting the tritonymph emerged which was golden yellow in colour with brown coloured legs and prodorsum. After an active period of

8-10 days and a quiescent period of 3-4 days, the adult individual emerged out which was light brown in colour and gradually became dark brown.

Thus the total duration development of *A. keralensis* from egg to adult was 43-47 days. The newly emerged females resumed oviposition within 15-18 days of their emergence. Hence the duration of F_1 generation of *A. keralensis* ranged from 58-65 days. The species appeared to be an asexual one, exhibiting parthenogenetic mode of reproduction. In the laboratory, only female progenies could be raised, even after repeated breeding cycles. The results of laboratory studies were in agreement with field studies also, as only female specimens could be collected during sampling from all the localities surveyed.

Morphological Description of Life Stages of *A. keralensis* sp. nov.

Egg (Plate-31, Figs. 2-3)

Measurements: Length: 190-209 μm

Width : 161 -172 μm

Freshly laid eggs appeared white in colour, oval in shape and with a rough surface. Towards the end of the incubation period, the egg colour got changed to pale brown.

Larva (Plate-31, Figs. 4 & 5; Plate-32, Figs. 1 & 2)

Measurements: Length : 294-299 μm

Width : 138-140 μm

The newly emerged larva was small in size, very sluggish and characterized by 3 pairs of legs.

Prodorsum

Prodorsum broadly triangular with a blunt rostrum. Seta *ro* phylliform, barbed and inserted slightly below the rostral apex. Seta *le* broad and fan shaped and heavily barbed. Seta *in* also fan shaped, heavily barbed and inserted near the bothridium. Bothridium rudimentary and sensillus not developed.

Notogaster

Notogaster wrinkled with wavy lateral margins. Ten pairs of barbed, fan-shaped notogastral setae of varying size present, setae c_1, d_1 and e_1 broader among the anterior pairs of setae. Among the posterior pairs of setae, h_1 the longest of all the notogastral setae, h_2 also long and inserted ventrally.

Ventral region

Infracapitulum with 2 pairs of seta, *a* and *h*, thin and smooth. Epimeral setal formula 3-1-3. Genital area not developed. Anal plates developed. Anal and adanal setae absent. Fissure *iad* located on either side, at the anterolateral borders of the anal plates.

Legs

Three pairs, all monodactylous.

Protonymph (Plate-31, Figs. 6-8, 12; Plate-32-Fig. 3 & 4)

Measurements: Length: 360 -378 µm

Width : 184-192 µm

Protonymph could be distinguished from the larva by its increased body size, presence of four pairs of legs and one pair of genital suckers on the genital plates.

Prodorsum

Prodorsum triangular with a blunt rostral apex. Seta *ro*, narrow, barbed and inserted just below the rostral margin. Seta *le* fan shaped, but narrow, barbed, longest among the prodorsal setae. Seta *in* small, fan shaped, truncated distally and barbed. Bothridium rudimentary and *ss* not developed. An arched ridge present between the interlamellar setae. Lateral ridges present on the prodorsum.

Notogaster

Notogaster elongated with round posterior end. Fifteen pairs of notogastral setae present, all fan shaped and barbed except setae ps_2 and ps_3. The latter 2 setae comparatively short and narrow and inserted ventrally. Anteriormost notogastral setae short and narrow while the posteriormost setae long and broad. The opening of lateral abdominal gland located just above the insertion of seta f_2. Setae, h_3, ps_2, and ps_3 seen ventrally.

Ventral region

Infracapitulum with 2 pairs of smooth seta, *a* and *h*. Epimeral setal formula 3-1-3-3, all setae thin and smooth. Genital plates with a single pair of thin and short seta and a pair of suckers. Anal plates developed, but without any setae. Adanal hairs, also not developed. Fissure *iad* present, anterolateral to the anal plates.

Legs

Four pairs, all monodactylous.

Deutonymph (Plate-31, Figs. 9, 10 & 12; Plate-33, Figs. 1 & 2)

Measurements: Length – 445-448 μm

Width – 234 – 238 μm

Duetonymph could be distinguished from the previous stage by its slightly bigger size and possession of 2 pairs of genital suckers.

Prodorsum

Prodorsum conical with a blunt rostral apex. Seta *ro* narrow, barbed and inserted on two prominent projections, slightly below the rostral apex. Seta *le* fan shaped and barbed. Seta *in* also fan shaped, truncate distally and barbed. Bothridium and sensillus (*ss*) present, the latter rod shaped with a slightly swollen, fusiform and roughened head. Lateral and median ridges present on the prodorsum. Interlamellar region with faint ornamentation.

Notogaster

Notogaster bears 15 pairs of setae, all fan shaped and barbed and of varying size. Posteriormost notogastrral setae longer than the anterior ones. Setae ps_2 and ps_3 ventrally inserted. The opening of lateral addominal gland conspicuous. Notogastral integument ornamented with areolae of polygonal appearance.

Ventral region

Infracapitulum with 2 pairs of setae. Epimeral setal formula 3-1-3-3, all thin and smooth. Gential plates carry 2 pairs of suckers and 4 pairs of smooth setae. Ano-adanal plates present. Anal plates carry no setae while the adanal plates carry 3 pairs of roughened setae. Ventral region heavily punctate and with scattered foveoles.

Legs

Four pairs, all monodactylous.

Tritonymph (Plate- 31, Fig.11; Plate 33, Figs. 3 & 4)

Measurements: Length: 505-516 µm

Width : 263-268 µm

Tritonymph could be easily identified by its bigger size, lightly sclerotized body and possession of three pairs of genital suckers.

Prodorsum

Prodorsum broadly triangular and with a blunt rostral apex. Lateral margins with deep furrows. Seta *ro* simple and barbed, inserted on prominent projections. Seta *le* long, club shaped and barbed. Interlamellar setae short, leaf shaped and barbed. Sensillus (*ss*) rod shaped with a swollen and roughened tip. Lateral and median ridges present, median ridge arched and seen at the interlamellar area. Prodorsal integument heavily porose. A few foveoles developed feebly.

Notogaster

Notogaster elongate, with a round posterior end bearing, 15 pairs of fan shaped and barbed setae of varying size. Posteriormost setae longer than the anterior ones. Seta ps_3 inserted ventrally. The chitinized opening of lateral abdominal gland well developed. Integument ornamented with foveoles arranged irregularly.

Ventral region

Infracapitulum bears 3 pairs of setae *a, h* and *m*. Epimeral setal formula 3-1-3-3, all setae thin and smooth. Genital plates with 8 pairs of thin and short setae. Three pairs of genital suckers present. Ano-adanal plates well developed. Two pairs of anal and 3 pairs of adanal setae present. Anal setae thin and smooth where as the adanal setae thick and barbed. Ventral plate heavily porose.

Legs

Four pairs, all monodactylous.

Table 21: Duration of Development of Life Stages of *Allonothrus keralensis* sp. nov. at 30$\pm$1^{0}C (in days)

	Egg	Larva	I Quiescent	Protonymph	II Quiescent	Deutonymph	III Quiescent	Tritonymph	IV Quiescent	Total
1	5	6	4	5	4	7	3	9	3	46
2	5	5	3	6	4	6	3	8	4	44
3	4	6	3	5	4	7	4	8	4	45
4	4	5	3	5	3	7	3	9	4	43
5	5	5	4	6	4	6	4	10	3	47
6	4	6	3	5	3	7	4	10	4	46
7	5	6	4	5	4	6	3	9	4	46
8	5	5	4	6	4	6	4	8	3	45
9	4	6	3	5	3	7	4	9	4	46
10	4	6	4	6	4	6	4	10	3	47
Range	4-5	5-6	3-4	5-6	3-4	6-7	3-4	8-10	3-4	43-47

Table 22: Appearance of Notogastral Setae in Different Stages of Development of *Allonothrus keralensis* sp. nov.

Stage	Rows						Total number of setae	Setae appeared anew
	First	Second	Third	Fourth	Fifth	Sixth		
Larva	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	-	h_1, h_2	-	10	10
Protonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	*5*
Deutonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	-
Tritonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	-
Adult	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	-

Table 23: Appearance of Epimeral Setae at Different Stages of Development of *Allonothrus keralensis* sp. nov.

Stages	Epimere				Setae appeared anew	Epimeral setal formula
	I	II	III	IV		
Larva	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	-	*7*	*3-1-3*
Protonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	*3*	*3-1-3-3*
Deutonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	-	*3-1-3-3*
Tritonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	-	*3-1-3-3*
Adult	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	-	*3-1-3-3*

Table 24: Appearance of Genital Setae at Different Stages of Development of *Allonothrus keralensis* sp. nov.

Stage	Genital setae	Total No. of Setae	Setae Appearing Anew
Larva	-	-	-
Protonymph	g_1	1	1
Deutonymph	$g_1 - g_4$	4	3
Tritonymph	$g_1 - g_8$	8	4
Adult	$g_1 - g_{15}$	15	7

Table 25: Appearance of Adanal and anal setae at different stages of Development of *Allonothrus keralensis* sp. nov.

Stage	Adanal Segment			Anal Segment		
	Seta	Number	Seta appeared anew	Seta	Number	Seta appeared anew
Larva	-	-	-	-	-	-
Protonymph	-	-	-	-	-	-
Deutonymph	ad_1, ad_2, ad_3	3	ad_1, ad_2, ad_3	-	-	-
Tritonymph	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	an_1, an_2
Adult	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	-

5. Postembryonic Development of *Archegozetes longisetosus* Aoki, 1965

Considering the extremely high feeding diversity and the outstanding role in the degradation process in all types of soil ecosystem performed by a typical Trhypochthoniid representative, *A. longisetosus*, further studies were carried out in the laboratory on its reproductive biology. Being one of the most dominant representative in all the sampling localities surveyed with wide distribution pattern and diverse feeding habits, the species was subjected to detailed laboratory feeding experiments to locate its most preferred food items. Results of the study revealed the ability of the adult and juveniles of the species to consume all the test food items like moss, yeast, mushroom, different species of fungi, leaf litter, filter paper, cotton thread, boiled rice, artificial sponge (polyurethane), and live animals like earth worm and juveniles of millipedes (Plate-34, Figs. 1-8), except the hard plastic and the fugus, *Fusarium sp*. An unusual feeding trend observed during the study was the zoophagous habit of the species, in which the adults and nymphs showed voracious feeding on live earth worm and juveniles of millipedes. Another fascinating observation made during the study was the cannibalistic behaviour exhibited by the adults and immatures of the species.

Although the adults and immatures of *A. longisetosus* could survive on artificial sponge or polyurethane, their size was found reduced compared to those reared on preferred food items. Also the duration of each stage was found prolonged when this food item was used as the test food to trace the development. Accordingly, leaf litter of *A. heterophyllus* and fungi like, *C. geniculata* and *Pestalotia sp.* were selected as the preferred food items to conduct further studies on the breeding biology and postembryonic development of the species. The entire study on the postembryonic development of *A. longisetosus* was carried out under controlled temperature and humidity conditions like 30 $\pm$ 1^{0}C and 70-75% respectively.

Oviposition

Gravid females laid eggs either singly or in clusters of 2-40. *A. longisetosus* selected hidden places for laying eggs, like small holes present on the culture base, undersurface or in the crevices of feeding substrate provided etc. A single female laid 35-52 eggs within 2 days and its life span extended for 15-30 days.

Incubation and Hatching

Incubation period ranged from 5-7 days. The eggs during the initial days of incubation appeared milky white and gradually became transparent at the animal pole. Hatching was preceded by the appearance of a weak area along the longitudinal axis of the egg. This was followed by the gradual appearance of a small slit along the weak area and the slit enlarged posteriorly, through which the larva succeeded to get emerged out by protruding it anterior part of the body. The whole process of hatching was completed within 3-4 hours.

Duration of Life Stages

The newly emerged larvae were delicate, transparent and with a wrinkled integument. They remained inactive for a few minutes and then resumed normal movements. They slowly wandered about in the culture cells in search of food. On detection of the preferred food item, the larvae slowly initiated feeding on the food items. Vigorous feeding activity could be recorded in successive days and the active feeding period of the larva extended for 3-10 days. Subsequently, the feeding activity of the larvae got reduced and they became lethargic with a swollen body. The colour of the body turned to milky white and congregated at several sites in the culture cells, there by forming small aggregates. Formation of such aggregates was found initiated by one or two members and the other members got attracted to the same site, so as to comprise 2-45 individuals in such clusters. Each aggregate containing groups of turgid, milky white, inactive stage often resembled a bunch of grapes and this was a regular feature in the culture cells. This inactive phase was recognized as the first quiescent phase, which lasted for 3-4 days. Towards the end of the quiescent phase, the notogaster developed weakened area leading to the subsequent development of slits along weakened areas, especially the postero-lateral sides of the notogaster. This was recognized as the moulting process and it took 2-3 hrs for completion. The protonymph slowly emerged out by the gradual backward movements of the body. The developmental process including the duration of active period and the quiescent phase, were similar in all stages. Finally the adult emerged out which laid eggs within 15-30 days. Thus *A. longisetosus* completed its development from egg to adult in 32-58 days.

Duration of F_1 Generation and Mode of Reproduction

The newly emerged females initiated oviposition after 15-30 days of their emergence. Thus the F_1 generation of *A. longisetosus* was found within 47-88 days. Results of repeated studies on the breeding biology of the species enabled to confer parthenogenetic mode of reproduction in the species. In no instance, male progeny was found developed and the entire population of the mite comprised of ♀ progeny. The species appeared to be purely an asexual one.

Morophological Description of Life Stages of *Archegozetes longisetosus* Aoki, 1965

Egg (Plate-35, Fig.2)

Measurements: Length – Range 189-204 μm

Width – Range 94-110 μm

Eggs appeared elliptical in shape, white in colour and with a smooth and shiny surface.

Larva (Plate-35, Figs. 3-5; Plate 36, Figs. 1& 2)

Measurements: Length: Range – 248-253 µm

Width : Range – 145-159 µm

The integument of the newly emerged larva appeared highly wrinkled with a smooth and shiny surface.

Prodorsum

Prodorsum with round anterior end and wavy lateral margin. Prodorsal setae 3 pairs, all ciliate and long. Seta *ro* 51 µm long, setiform with its smooth distal quarter unciliated. Setae *le* and *in* flagelliform measuring 77 µm and 115 µm respectively in length. Sensillus not developed. Bothridium redimentary.

Notogaster

Notogaster oval, with wavy lateral and round posterior margins. Ten pairs of flagelliform notogastral setae of varying length present, all ciliated, ciliation dense towards the distal part and basal region barren. Seta c_3 the shortest and e_1 the longest. Setae h_2 and h_3 located ventrally.

Measurements of various notogastral setae as shown below:

c_1 – 52 µm; c_2 – 103 µm c_3 – 26 µm

d_1 – 120 µm; d_2 – 129 µm, d_3 – 77 µm

e_1 – 137 µm; e_2 – 107 µm

h_1 – 94 µm; h_2 – 56 µm

Ventral region

Pedipalp 5 segmented. Rutellum with 3 blunt teeth. Infracapitulum with 2 pairs of smooth setae, *a* longer than *h*. Epimeral setal formula 2-1-2. Setae *1a, 2a* and *3a* roughened while *1b* and *3b* long and smooth. Genital area not developed. Anal region developed with 2 pairs of ciliate setae.

Legs

Three pairs, all monodactylous. Chaetotaxy of Leg I: 1-1-4-5-15. Setae of all segments ciliate. Solenidia on tarsus, tibia and genu coupled with dorsal setae. On tarsus Solenidia ω_1 thick and blunt.

Protonymph (Plate-35, Fig. 5; Plate-36, Figs. 3 & 4)

Measurements: Length: Range 324-340 µm

Width : Range 213-220 µm

Protonymph easily distinguished from the larva by its large body size, four pairs of legs, one pair of genital setae and one pair of genital suckers. The newly emerged protonymph appeared sluggish, white coloured and with wrinkled body. Gradually its body became swollen and acquired, creamy white colouration.

Prodorsum

Prodorsum broadly triangular with a blunt anterior end. Prodorsal margin laterally inflated above the level of sensillus. Seta *ro* 62µm long, erect, directed anteriorad setiform and unciliated at the distal quarter.

Lamellar and interlamellar setae flagelliform measuring 83 µm and 128 µm respectively. Bothridium bell shaped from which sprouts the setaceous sensillus (*ss*) bearing small barbs, and it measures 128 µm in length.

Notogaster

Notogaster oval with a straight anterior and round posterior ends. Setae h_3 and ps_1 appeared anew there by increasing the total number of notogastral setae from 10 to 12. All notogastral setae flagelliform and barbed throughout except at their bases. Notogastral setae vary considerably in length with c_3 being the shortest and e_1 the longest.

Measurements of various notogastral setae as given below:

c_1 – 71 µm, c_2 - 66µm; c_3 – 17 µm

d_1 – 124 µm; d_2 – 128 µm; d_3 – 88 µm

e_2 – 146 µm; e_2 – 111 µm

h_1 – 119 µm; h_2 – 71 µm; h_3 – 39 µm

ps_1 – 75 µm

Ventral region

The integument of venter smooth. Pedipalp and rutellum well developed. Pedipalpal chaetotaxy 0-1-1-2-9. Rutellum with 3 dendrites. Infracapitulum with 3 pairs of smooth setae, of which setae *m* inconspicuous. Epimeral setal formula 3-1-2-1. Setae *1a, 1c, 2a, 3a* and *4a*, roughened and setae *1b* and *3b* long and smooth. Genital area developed with 1 pair of roughened seta and 1 pair of sucker. Anal region possesses 2 pairs of barbed setae.

Legs

All legs monodactylous. Chaetotaxy of leg I. 1-1-4-5-16. Trochanter I with a tooth like structure. On tarsus I, setae (ft) (tc) and (P) smooth while others barbed. Of the two solinidia on tarsus I, ω_1 thick and blunt, while ω_2 long, thin and setaceous. ε, associated with ω_1.

Deutonymph (Plate-35, Figs. 6 & 7; Plate-37, Figs. 1 & 2)

Measurements: Length: Range 417-451µm

Width : Range 288-296 µm

Deutonymph possesses 2 pairs of genital suckers and 4 pairs of genital setae and appeared comparatively larger than the protonymph.

Prodorsum

All prodorsal setae resembled those of the previous stages except an increase in length. Seta *ro* measures 111µm. Seta *le* 178 µm and *in* 222 µm. Sensillus (*ss*) thick, measures 147µm and ends in blunt tip.

Notogaster

Notogaster bears 15 pairs of setae. Setae f_2, ps_2 and ps_3 newly added at this stage; f_2 the shortest while e_1 the longest measuring 200 µm.

Measurements of various notogastral setae as given below:

c_1 – 159 µm, c_2 – 133 µm; c_3 – 35 µm

d_1 – 215 µm; d_2 – 184 µm; d_3 – 154 µm

e_2 – 200 µm; e_2 – 175 µm

f_2 – 25 µm

h_1 – 175 µm; h_2 – 147 µm; h_3 – 114 µm

ps_1 – 154 µm

Ventral region

Rutellum and chelicerae well developed. Rutellum equipped with well developed teeth and the chelicerae chelate-dentate bearing 3-4 teeth on each digit. Pedipalp 5 segmented with a chaetotaxy 0-1-1-2-9 all setae barbed. Infracapitulum with 3 pairs of smooth setae resembling those in the previous stage. Epimeral setal formula 3-1-2-3. Setae *4b* and *4c* newly added. All setae barbed except *1b*, *3b* and *4b*. Genital area developed with 4 pairs of setae. Setae g_1 and g_2 densely barbed than others and very close to each other. Anal setae not developed. Three pairs of adanal setae present, all barbed with an increase in size posteriorly. Seta ps_3 located ventrally.

Legs

All legs monodactylous with leg chaetotaxy 1-6-5-6-17. Tarsus-1 with 3 solenidia, ω_1, ω_2 and ω_3. ω_1 thick and blunt. ε associated with ω_1.

Tritonymph (Plate-35, Fig. 8; Plate-37, Figs. 3-4)

Measurements: Length: Range 573-582 µm

Width : Range 399-406 µm

The body of tritonymph wrinkled and white in colour, immediately after moulting. The colour later changed to cream and gradually the integument became smooth. Legs developed brown colouration. The tritonymph easily distinguished from the deutonymph by the possession of three pairs of genital suckers and 6 pairs of genital setae and comparatively larger size of the body.

Prodorsum

Prodorsum broadly conical with a wavy anterior and lateral margins. Prodorsal setae 3 pairs, all flagelliform except the rostral setae (111µm), the latter setiform with smooth distal quarter. Lamellar (*le*) and interlamellar setae (*in*) measure 152 µm and 210 µm respectively. Bothridium bell-shaped and the thick, setaceous, barbed sensillus (*ss*) measures 194 µm.

Notogaster

Notogaster some what spherical bearing 15 pairs of flagellate barbed setae of varying length. Seta f_2 the shortest and setae d_2 and h_1 equally long and form the longest hairs, each measuring 167µm. Seta ps_3 located ventrally.

Measurements of various notogastral setae as given below:

c_1 – 155 µm, c_2 – 139 µm; c_3 – 56 µm

d_1 – 153 µm; d_2 – 167 µm; d_3 – 153 µm

e_1 – 155 µm; e_2 – 139 µm

f_2 – 28 µm

h_1 – 161 µm; h_2 – 133 µm; h_3 – 111 µm

ps_1 – 153 µm; ps_2 – 139 µm; ps_3 – 61 µm

Ventral region

Rutellum with 3-4 broad dendrites. Chelicerae well developed, each digit with 3-4 teeth. Pedipalp 5 segmented, with a setal formula of 0-1-1-3-9, all setae barbed. Intracapitular setae 3 pairs, all smooth. Seta *m* the smallest. Epimeral setal formula 3-1-3-3; all setae barbed except *1b, 3b* and *4b*. Genital area well developed bearing 6 pairs of setae and 3 pairs of suckers. Setae g_1-g_3 comparatively thick and densely barbed than setae g_4-g_6. Setae g_1, g_2 and g_3 inserted very close to each other while others well spaced. Anal region well developed with 2 pairs of anal and 3 pairs of adanal setae. Anal setae thin and barbed. Adanal setae densely barbed and their length decrease from ad_1 to ad_3.

Legs

All legs monodactylous. Chaetotaxy of leg I: 1-6-5-6-17. Number and nature of setae same as that of the previous stage.

Table 27: Duration of Development of Life stages of *A. longiseosus* Aoki, 1965 at 30$\underline{+}$1^{0}C (in days)

	Egg	Larva	I Quiescent	Protonymph	II Quiescent	Deutonymph	III Quiescent	Tritonymph	IV Quiescent	Total
1	5	3	3	4	3	3	3	5	4	30
2	7	5	3	6	4	4	3	7	3	40
3	5	3	3	3	3	5	4	4	3	33
4	5	4	4	7	4	5	4	5	4	42
5	5	4	4	3	3	5	4	5	3	36
6	5	4	4	4	3	5	3	7	4	39
7	7	7	4	4	4	4	3	7	4	40
8	5	4	3	3	3	4	3	4	3	32
9	6	5	4	5	4	7	3	4	4	42
10	6	4	3	5	3	4	4	4	3	36
Rank	5-7	3-7	3-4	3-7	3-4	3-7	3-4	3-7	3-4	32-42

Table 28: Appearance of Notogastral Setae at Different Stages of Development of *Archegozetes longisetosus* Aoki, 1965

Stage	Rows						Total number of setae	Setae appeared anew
	First	Second	Third	Fourth	Fifth	Sixth		
Larva	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	-	h_1, h_2	-	10	
Protonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	-	h_1, h_2, h_3	ps_1	12	h_3 – ps_1
Deutonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	f_2, ps_2, ps_3
Tritonymph	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	-
Adult	c_1, c_2, c_3	d_1, d_2, d_3	e_1, e_2	f_2	h_1, h_2, h_3	ps_1, ps_2, ps_3	15	-

Table 29: Appearance of Epimeral Setae at Different Stages of Development of *Archegozetes longisetosus* Aoki, 1965

stages	Epimere				Setae appeared anew	Epimeral setal formula
	I	II	III	IV		
Larva	*1a, 1b*	*2a*	*3a, 3b*	-	-	2-1-2
Protonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b*	*4a*	*4a*	3-1-2-1
Deutonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b*	*4b, 4b, 4c*	*4a, 4c*	3-1-2-3
Tritonymph	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	*3c*	3-1-3-3
Adult	*Ia, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b, 4c*	-	3-1-3-3

Table 30: Appearance of Genital Setae at Different Stages of Development of *Archegozetus longisetosus* Aoki, 1965

Stage	Genital setae	Total No. of Setae	Setae Appearing Anew
Larva	-	-	-
Protonymph	g_1	1	1
Deutonymph	g_1-g_4	4	3
Tritonymph	g_1-g_6	6	2
Adult	g_1-g_7	7	1

Table 31: Appearance of Adanal and anal setae at different stages of development of *Archegozetes longisetosus* Aoki, 1961

Stage	Adanal Segment			Anal Segment		
	Seta	Number	Seta appeared anew	Seta	Number	Seta appeared anew
Larva	ad_1, ad_2	2	ad_1, ad_2	-	-	-
Protonymph	ad_1, ad_2	2	-	-	-	-
Deutonymph	ad_1, ad_2, ad_3	3	ad_3	-	-	-
Tritonymph	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	an_1, an_2
Adult	ad_1, ad_2, ad_3	3	-	an_1, an_2	2	-

Chapter XII

DISCUSSION

The present investigation was undertaken with an intention to gather information on the systematic and biological aspects of a few species of primitive oribatid mites inhabiting various localities distributed in Northern Kerala. Oribatid mites are an evolutionarily old group of microarthropods, that probably has existed for atleast 380 million years (Norton *et al*., 1988) and they slowly but continuously radiated to a large number of species. Nearly 10,000 species of these mites have been described so far, but overall 1,00,000 species are expected to exist (Schatz, 2002). Their numerical abundance and species diversity are particularly noteworthy in forest soils, litter accumulated areas and virgin ecosystems. Through their extremely diverse feeding habits coupled with active vertical and horizontal migratory movements, these mites greatly influence the process of organic decomposition leading to the enhancement of soil fertility and productivity.

During the present study, a survey was conducted, collecting soil and litter samples from 6 different sites distributed over 3 districts of Kerala viz., Kozhikode, Malappuram and Wayanad. The sampling sites were varied with respect to their floral constituents based on which these could be categorized as areas of monocultivations like plantations of Rubber, Coffee, etc., litter accumulated regions, forest soils and residential areas.

The oribatid mites collected during the study, varied in their species diversity and density, according to the floral composition of each site.

Results of the survey enabled to recover quite a good diversity of oribatid species representing both primitive and advanced taxa. Only the primitive taxa were identified upto the species level, in par with the objectives of the present investigation. Thus, a total of 35 species representing 20 genera, 10 families and 8 superfamilies could be recovered through the surveys carried out during the current investigation.

In the Kozhikode district, samples collected from 3 different sites, viz., Rubber plantation (MRP), a forest area named Janakikad (JKD) and a residential area at Ayanikad (AKD) which consisted of 3 localities viz. a water logged area, litter accumulated area of mixed vegetations and a wet area at the premises of kitchen yard. In the Malappuram district, soil samples were collected from 2 sites viz. the Calicut University Campus (CUC) and a residential area at Kizhsserry (KZH). In the Wayanad district, a vast area of coffee plantation was the one and only collection site selected which was characterized by thick accumulation of coffee litter.

Among the sites surveyed, CUC exhibited extremely high diversity. The species richness and diversity of oribatid mites can better be correlated with the floral abundance of this site. Many earlier investigators (Hartenstein, 1962; Hayes 1963; Wallwork, 1976; Ramani and Haq, 1990; Hansen *et al*., 1998; Kaneko and Salamanca, 1999; Jain *et al*., 1999; Haq, 2001, 2002, 2007) observed the predominance of oribatid mites in forest floors and other areas of litter accumulation. The species diversity appeared to be the minimum in the sites MRP, KZH and COP. The low species diversity and density of oribatid mites might be a reflection of the regular human interference and less moisture content. Species diversity and density of oribatid mites decreased in the following order in the selected sites CUC> JKD> AKD> MRP> KZH> COP. This showed that accumulation of organic litter and moisture content favoured the survival and replenishment of a rich and varied oribatid population. The availability of preferred food also favoured the abundance of oribatid species in these sites. The dense accumulation of litter in the sites results in an increase in the organic content of the soil which in turn leads to an increase in the population density of oribatid mites. Ito and Aoki (1999) and Badego *et al*. (1999) suggested that orbatid population was suppressed by human activities like cultivation and application of pesticides. Wallwork (1976) reported that in agricultural lands sprayed with pesticides, population recovery of animals was slow as observed in the case of oribatid mites which have quite long life cycle.

In the present study, 35 species of primitive oribatid mites were identified belonging to 20 genera under 10 families and 8 superfamilies. The 8 superfamilies of orbatid mites recorded during the study were Mesoplophoroidea, Phthiracaroidea, Hypochthonoidea, Cosmochthonoidea, Brachychthonoidea, Lohmannoidea, Epilohmannoidea and Nothroidea.

Among the 10 families, the Lohmanniidae exhibited the highest species diversity with 6 genera and 15 species which indicated the species richness and adaptability of Lohmanniid mites. Lohmanniid representatives have been identified as potential agents in biodegradation of organic litter of higher plant origin (Luxton, 1972; Shereef, 1976; Haq, 1982, 1984, 1987, 1992, 1994, 1996; Haq and Konikkara, 1988; Ramani and Haq, 1990, 1991a, 2001; Haq, 2007). These mites greatly turn over the organic litter of higher plant origin through comminution, and transform these in to simple faecal pellets, which are more susceptible to microbial proliferation. Most of the surveyed sites were characterized by thick accumulation of leaf litter and this explains the abundance of Lohmanniid mites in the areas surveyed. Among these, *A. hammerae, A. nortoni, C. keralensis, M. unilateralis* and *P. baloghi* were erected as new to science. The genus *Allonothrus* of the family Trhypochthoniidae was represented by 3 species, of which, *A. keralensis* could be assigned as a new taxon.

The genera *Hoplophthiracarus, Cosmochthonius, Epilohmannia* and *Archegozetes* were found each represented by 2 species. The genera *Apoplophora, Atropacarus, Rhysotritia, Eohypochthonius, Malacoangelia, Sphaerochthonius, Brachychthonius, Malaconothrus* and *Trimalaconothrus* were represented by a single species each, of which *A. (H). sensillatus*, *E. payyoliensis* and *M. hygricola* were erected as new to science. Thus, as a result of the survey conducted during the present study, 7 species i.e., 20% of the total collection, belonging to 8 genera, 4 families and 4 superfamilies were enabled to assign as new to science.

Of the 35 species collected, *A. longisetosus* appeared as a widely distributed species as it was recovered from almost all the sites. The population density of this species also appeared to be comparatively high in all the sites, suggesting its wide nutritional range. This species was already distinguished as a pantropical species (Palmer and Norton, 1991) based on its wide pattern of distribution. Many earlier workers (Schuster, 1956; Hartensten, 1962; Woodring, 1963; Shereef, 1971; Luxton, 1972, Haq and Prabhoo, 1976; Haq, 1982, 1994, 1996a, Maraun *et al*., 1998a) reported that oribatid mites exhibit a wide variety of nutritional habits. *A. longisetosus* was already established as a panphytophagous (Haq and Prabhoo, 1976, Haq, 1982) species with extremely diverse choice of diet. This explains its distribution and numerical abundance in most of the sites surveyed during the present study.

Natural ecosystem supplements a diversity of food stuffs to the oribatid mites and which in turn leads to the development a variety of behavioural and feeding responses among them. Analysis of feeding preference in the natural habitat is an extremely difficult task and the most probable alternative is to conduct food choice test under laboratory condition. During the present study also food choice test was conducted which enabled the categorization of mites into macrophytophagous (feeding on wood, root and leaf litter), microphytophagous (feeding on fungi, algae and pollen) and non specialized feeders (feeding on dead organic materials as well as on fungi, lichens and pollen). Shuster (1956) classified oribatid mites as macrophytophagous, microphytophagous and non-specialized feeders based on their feeding responses. A similar grouping was presented by Wallwork (1958) and modified by Luxton (1966, 1972). Haq (1982) categorized 10 species of oribatid mites as microphytophagous, macrophytophagous, and panphytophagous.

Results of laboratory feeding experiments revealed that the macrophytophagous lohmanniid mite, *P. baloghi* preferred the moist and decayed leaf litter and fed on the soft mesophyll tissue, leaving behind the midribs and veins. Such leaf skeletorizing habit was already established in other lohmanniid members also (Haq, 2007). Hartenstein (1962) established that leaf feeding mites preferred parenchymatous tissue of decaying leaves. Harding and Stuttard (1974) also discussed the inability of microarthropods to utilize dry litter as food. Ramani and Haq (2001) noted the association of *Lohmannia* sp. and *H. rimosus* with moist litter accumulations.

Results of food choice test disclosed the extremely dynamic food selection in the pantropical oribatid species, *A. longisetosus* which fed on a variety of food items comprising fungi, yeast, mushroom, filter paper, cotton thread, artificial sponge, live animals like earth worm and juveniles of millipedes. The species apart from its saprophagous feeding habit, exhibited zoophagous and even cannibalistic habits also, which were so far unreported among members of the genus *Archegozetes* and the family Trhypochthoniidae. As a result of this eurytyptic feeding habit, populations of a particular species may be able to survive on varied habitats (Luxton, 1972; Harding and Stuttard, 1974; Behan and Hill, 1978). The role of *A. longisetosus* in the break down of leaf litter, algae, filter paper etc. was already reported (Haq, 1976, 1982; Norton & Smirz and Norton, 2004. However, the zoophagous trend of this species and the prevalence of cannibalism are rather new findings.

During the present study, *A. longisetosus* was found to feed and breed on artificial sponge (polyurethane). Although the adults and immatures of *A. longisetosus* could survive on artificial sponge, their size got reduced when compared to those reared on preferred food items. Also the duration of each stage was found prolonged on this diet. This suggests that polyurethane though supports development does not constitute the preferred diet. The species though rejected hard plastic, its positive response towards the polyurethane was a good sign as it sheds light on the possibilities of utilizing this species in the degradation of even nondegradable substances for subsequent incorporation in to soil. This is particularly important as plastic pollution has become one of the major environmental issues currently.

A. longisetosus appeared as a generalist, with innate potential to feed and breed on a wide variety of food substances in the soil ecosystem. The species thus aids in the comminution of organic substances of both plant and animal origin, thereby hastening the process of organic decomposition and nutrient turnover in the soil ecosystem.

During the present work, 5 species were considered for detailed studies on postembryonic development viz. *E. payyoliensis*, *M. hygricola, P. baloghi, A. keralensis* and *A. longisetosus*. All the above species were found to exhibit their own developmental pattern. The average durations of development of the above 5 species were 68, 134, 123, 45 and 45 days respectively. The macrophytophagous mites viz. *M. hygricola* and *P. baloghi* required sufficiently more time to complete their life cycle. This prolonged developmental period could result in the minimum number of annual generations in the natural ecosystem. The microphytophagous and panphytophagous species viz., *E. payyoliensis*, *A. keralensis* and *A. longisetosus* were found to complete their development within short period. Because of the shorter developmental period, these species probably could lead to more number of annual generations in the field. This must be the reason for the occurrence of comparatively high population density of these species in the field. However, this generalization cannot be taken into consideration under field condition, where these mites are exposed to a complex of biotic and abiotic factors, some of which may be detrimental like the predation, parasitism etc. which exert a negative impact on the population.

In the present study, *A. longisetosus* was the largest species among the 5 species selected for developmental studies. But this species had the shortest duration for development when compared to the smallest species, *M. hygricola* which took more time to complete its development. This observation was contrary to the earlier findings (Wallwork, 1970; Butcher, *et al*., 1971) that smaller species possess short duration of development.

The breeding habits of oribatid mites generally vary with respect to the variations of species. Certain species lay eggs in the secluded habitats while others lay them exposed. In the present study, different methods for protection of eggs have been observed among the 5 species. *A. longisetosus* selected hidden places for laying eggs, like the small holes present on the culture base, undersurface or in the crevices of feeding substrates provided etc. In *M. hygricola*, the eggs were found buried on the culture medium. Arlian and Woolley (1970) found that females of *L. cidarus* deposited eggs either singly or in clusters in a hole in the substratum or food material or hidden under debris, food or fungus. According to Haq and Ramani (1984) *P. bengalensis* laid single eggs in the culture cells as well as on leaf fragments. Shereef and Haq (1992) observed that the females of *G. triquetra* inserted the ovipositor in the fungal cushion and deposited eggs in batches. The habit of laying of eggs may ensure protection to eggs from predators and desiccation under field condition. The habit of laying of eggs on or in the vicinity of food would be of great advantage to immatures, particularly to the newly emerged larvae, to get easy accessibility of food materials.

Oribatid mites display varied patterns of oviposition and seldom the same species reveals this difference even under controlled laboratory conditions. Among the 5 species studied during the current investigation, *A. longisetosus* and *A. keralensis* laid eggs either singly or in clusters, whereas the other 3 species viz. *P. baloghi*, *E. payyoliensis* and *M. hygricola* always laid single eggs. According to Rockett and Woodring (1966) the nature of oviposition depended on seasons. Contradictory to this, in the present study, there was no such seasonal variation observed in the species studied. However, laying of aggregated eggs was already observed in *A. longisetosus* (Haq, 1982; Heethoff *et al*., 2007). The phenomenon of aggregation among nymphal stages prior to moulting was also reported, which was suspected to be mediated through some pheromones (Haq, 1982).

A prelarval stage was observed in *A. longisetosus* and *P. baloghi*. The occurrence of prelarval stage was reported in many species of oribatid mites by many authors (Grandjean, 1956; Sengbusch and Sengbusch, 1970; Webb, 1997, Schuster, 1988, Heethoff *et al*., 2007).

The periods of incubation in *P. baloghi*, *E. payyoliensis* and *M. hygricola* were 14-17, 15-16, 14-18 days respectively which appeared to be comparatively higher than that of *A. keralensis* (4-5 days) and *A. longisetosus* (5-7 days). Shereef (1976) reported that incubation period in *P. aciculatus* was 12 days and in *L. egypticus* it was 18 days. Shereef and Haq (1992) found that incubation period in *G. triquetra* was 8-10 days. *O. terrebrantis* was found to have shorter incubation period of 5-6 days as reported by Sumangala and Haq (1995). Haq and Ramani (1984) reported that *P. bengalensis* had an average incubation period of 4.1 days. Generally, the incubation period and subsequent duration of life stages are comparatively greater in members of primitive taxa of oribatids than those of higher taxa.

Durations of active stages and quiescent stages of all the species showed marked variation during the current study. In *P. baloghi* the duration of the last quiescent stage was found much prolonged. This prolongation may be due to the greater morphological changes occurred before the final moulting. In *M. hygricola* and *E. payyoliensis*, during moulting, the slit formation occurred at the anterolateral regions of the body. Whereas in *P. baloghi* and *A. longisetosus*, slits were formed at the posterolateral regions. A different type of moulting was observed in *A. keralensis*, in which the slits were formed around the notogaster and the remnants of the ventral half of the exuvium were found retained on the substratum. Arlian and Woolley (1970) found an inverted 'T' shaped slit during ecdysis in *L. cidarus* whereas a small break was observed at the anterolateral region in *L. ornatissimus* by Haq (1978). Alphonsa and Haq (2006) observed the formation of a postero-lateral slit during moulting in *H. davisi*.

During the course of development, an increase in size was noticed in all the 5 the species, from larva to adult. Such progressive increase in the body size was noticed by Arlian and Woolley (1970) in *L. cidarus*, by Haq (1978) in *L. ornatissimus* and *A. longisetosus*, by Seniczak (1978) in *Achipteria coleoptrata* by Ramani and Haq (1988) in *Uracrobates indicus* and by Alphonsa and Haq (2006) in *H. davisi*. Increase in size during development is a natural rule met with in all animal groups, including oribatid mites. However, a reduction in size is also observed during the transition from tritonymph to adult in many species of *Scheloribates, Paralamellobates, Hydrozetes* etc. Such a regressive trend in size has been reported earlier (Seniczak *et al*., 2007; Seniczak and Seniczak, 2008) among higher oribatid species.

A detailed study on the morphology of the 5 species, showed an increase in the total number of notogastral, epimeral, genital, anal and adanal setae from larva to adult. A regression of 2 pairs of notogasral neotrichial setae was noticed in the adult stage of *P. baloghi*. Such a regression of notogastral setae in the adult stage was known among higher oribatids (Ramani and Haq, 1988; Seniczak and Seniczak, 2008).

In all the 5 species, the larva was always a hexapod devoid of genital plates and suckers. This is true for all groups of mites including oribatid mites. Such hexapod larvae bearing no genital plates were already mentioned in various species of oribatid mites (Arlian and Woolley, 1969; Clement and Haq, 1984; Ramani and Haq, 1988; Alphonsa and Haq, 2006; Seniczak and Seniczak, 2008). The hexapod nature of larvae in Acari is a clear indication of its phylogenetic relationship with other groups of arthropods, especially with insects as viewed by Wallwork (1963).

Another important observation was the variation in the number of claws among immatures and adults. The adults and immatures of all the species except *A. keralensis* were monodactylous. In the latter species, the immatures were monodactylous and the adults became tridactylous. Such a transition from monodactyly to tridactyly was previously observed in *L. cidarus* by Arlian and Woolley (1969) and the present observation also supports this.

A good fraction of oribatid mites is reported to adopt parthenogenesis as the mode of reproduction (Seniczak and Seniczak, 2008). Occurrence of parthenogenesis is reported to be atleast ten times greater in oribatid mites when compared to other taxa of metazoans (*Norton et al.*, 1993; Heethoff *et al.,* 2007). All the 5 species included in the study viz. *E. payyoliensis*, *M. hygricola*, *P. baloghi*, *A. keralensis* and *A. longisetosus* exhibited a parthenogentic mode of reproduction since in no instance, male progeney was found developed and the entire population of the mites comprised of only females. This was proved by the results of field sampling also. Parthenogenesis as a major mode of reproduction in oribatid mites, especially among members of primitive taxa was already stressed (Palmer and Norton, 1992, 1990, Norton, *et al*., 1993, Heethoff *et al*., 2007). A few taxa of higher oribatid mites also adopted this mode of asexual reproduction.

Being very fragile and delicate members with some sort of sluggish habits, the adoption of parthenogenetic mode of reproduction by laying large number of eggs would be advantageous to the members of primitive taxa. This would supercede the adverse impacts of natural predation and climatic condition prevailing in the respective microhabitats. Additionally, the prolonged life cycle of primitive taxa when compared to the higher taxa also necessitates the species to adopt a parthenogentic trend for the maintenance of population density.

Chapter XIII

SUMMARY

Soil ecosystem constitutes the fundamental substrate for all living things, including the microbes, plants and animals. Soil acts as the reservoir for all nutrient elements in a trapped condition. For the continuation of the biogeochemical cycles, the organic litter should be degraded and this is a function of a complex type of interaction between the microbes and the various faunal groups. Oribatid mites constitute the major share of the biotic components of the soil ecosystem by virtue of their numerical abundance and species diversity. The original home of these mites constitutes the decaying vegetation and other organic components of the soil and they represent one of the main groups of arthropods which are actively involved in the decomposer food web. They are the engineers of soil structure, indicators of the health of soil systems and major inteactors with nematodes and microbes in decomposition. However, despite the multitude of roles played by these mites in the ecosystem, much of the faunal diversity of oribatid mites still remains as an unexplored entity as far as India, particularly Kerala is concerned. This is mainly because of the lack of knowledge on this group of mites and their highly cryptic nature coupled with the great difficulties in their extraction, processing and identification. The present attempt is to fill up the above lacuna, to a certain extend and includes the collection, identification and description of oribatid mites, particularly the primitive oribatid taxa. Further, detailed studies on the breeding biology of a few dominant representatives of local importance are also included so as to gather knowledge on the relative roles of these species in their soil ecosystem.

The first part of the thesis provides information on the systematic aspects of oribatid mites and it includes the results of a general survey conducted on the primitive oribatid mites harbouring varied soil ecosystems like the forest soils, litter accumulated areas, areas of mixed vegetation and isolated pockets of originally rich soils of North Kerala. For the survey, soil and litter samples were collected from 6 different sites with varied floral composition. The collected samples were subjected to extraction through modified Berlese-Tullgren funnel apparatus to separate the mites. The mites were collected in preserved condition for taxonomic studies and in live condition for biological studies. Preserved specimens were dehydrated in alcohol series and cleared in 1:1 mixture of lactic acid and ethanol, mounted in Hoyer's/Polyvinyl alcohol media and identified following appropriate keys and relevant literature and confirmed with the help of concerned experts. Drawings of the various species were made with the help of a Camera lucida attached to a Meopta research microscope.

The results of the survey yielded 35 species of primitive oribatid mites belonging to 20 genera recognized under 10 families and 8 superfamilies. Of these, the family Lohmanniidae contributed the maximum generic composition with 6 genera and 25 species, followed by Trhypochthoniidae with 2 genera and 4 species, Phthiracaridae with 2 genera and 3 species, Hypochthoniidae and Malaconothridae with 2 genera and 2 species each Cosmochthoniidae and Epilohmaniidae each with a single genus and 2 species, Apoplophoridae, Sphaerochtoniidae and Brachychthoniidae each with a single genus and single species. The data showing the sitewise distribution were tabulated and presented.

In the systematic part of the thesis, detailed morphological descriptions of 19 species of primitive oribatid mites were included along with appropriate figures. The above 19 species were found representing 16 genera, 8 families and 7 superfamilies. Of these, 7 species representing 7 genera, 4 families and 4 superfamilies appeared to be new to science. All relevant morphological structures of taxonomic importance of the various species were represented through drawings, supplemented by detailed descriptions.

In the second part of the thesis, results of detailed studies on the feeding and breeding biology of 5 selected common species were presented. The species selected for biological studies were *E. payyoliensis, M. hygricola, P. baloghi, A. keralensis* and *A. longisetosus*. The feeding responses of the above 5 species to a variety of food items were assessed in the laboratory by conducting food choice tests. Based on their feeding responses, they could be grouped under the macrophytophagous and panphytophagous feeding categories. Extensive studies were carried out on the feeding response of *A. longisetosus*, by offering a variety of food items like different species of fungi, leafy/woody litter, filter paper, cotton thread, boiled rice, live animals like earth work etc. The adults and juveniles of this species exhibited extremely diverse feeding habits, devouring actively all the above food items. Another fascinating observation made during the study was the potential of the above species to devour artificial sponge or polyurethane. The above species though rejected hard plastic, was able to complete its development on artificial sponge, with extended periods of life stages. Apart from its saprophagous feeding habit the species, exhibited predatory and even cannibalistic behaviour particularly among the immature stages. An interesting phenomenon of aggregation was also found exhibited by the immature stages of this species, prior to the initiation of quiescent phases. All the remaining four species were found to show limited range of nutritional habits, confining their diet to leafy/woody elements of litter.

The biology of part of the thesis also comprised the results of developmental studies of selected species. Population density of any organism depends greatly on its reproductive potential and survival rate. In order to understand the reproductive behaviour of oribatid mites, the postembryonic development of the above 5 species viz., *E. payyoliensis*, *M. hygricola*, *P. baloghi*, *A. keralensis* and *A. longisetosus* were carried out. Live adults were reared in special culture cells containing Plaster of paris-Charcoal base by offering them their most preferred food items. Observations were made on oviposition, hatching, active and quiescent phases, moulting, duration of individual instars, durations of F_1 generation, etc. Morphological details of each stage were studied and presented through illustrations and drawings. In general, all the species studied passed through five different active phases. The egg after incubation hatched out into a hexapod larva, followed by protonymph, deutonymph, tritonymph and adult. Each active stage was followed by an inactive quiescent phase which subsequently moulted into the next phase. The duration of development varied with respect to variations in individual species. The above 5 species, viz., *E. payyoliensis, M. hygricola, P. blaoghi, A. keralensis* and *A. logisetosus* completed their life cycle with an average of 68, 135, 123, 45, 45 days respectively. The study further showed that macrophytophagous species like *M. hygricola* and *P. baloghi* required comparatively longer time to complete their life cycle than the panphytophagous species, *E. payyoliensis*, *A. keralensis* and *A. longisetosus*. The study also revealed that, different species of oribatid mites followed the same pattern of development with species specific variations.

Thus, the present study helped to identify and contribute 7 new species belonging to 7 genera and 4 families to science. The results of feeding studies brought out the biodegradative potential of 5 species of primitive oribatid mites, on a variety of food items. One of the most interesting observation made during the study was the potential of *A. longisetosus* to feed and survive on the artificial sponge, a quiet undegradable synthetic material (Polyurethane). This opens new vistas to explore more on the potential of this species to degrade materials like plastic, which has become one of the chief polluting agent now a days. The study also revealed the unusual feeding trend of *A. longisetosus* including predation and even cannibalism among the immatures. Further, the results of developmental studies revealed the morphological details of the immature stages and duration of the various life stages, total duration of development etc., providing a clue to the number of possible generations in the field. The prevalence of parthenogenetic mode of reproduction also could be established in all the 5 species studied.

BIBLIOGRAPHY

Alberti,G.,Fernandez, N.A. and G . Kummel. 1989. Spermatophores and spermatozoa of Oribatid mites (Acari : Oribatida).Part II. Functional and systematical considerations. *Zoologisches Institutes.1 (Morphologie/Okologie)der Universit at Heidelberg*,pp.1-18.

Alberti, G., Seniczak, A. and S. Seniczak. 2003. The digestive system and fat body of an early-derivative oribatid mite, *Archegozetes longisetosus* Aoki (Acari: Oribatida, Trhypochthoniidae). *Acarologia*, **43**(1):151-222.

Alphonsa, X. and M.A. Haq. 2005. Oriculture- a novel method of organic farming. *Agrobiose News Letter,* **4**: 29-30.

Alphonsa, X. and M.A. Haq. 2006. Reproductive biology and life history stages of *Haplacarus davisi* A. Xavier *et al.*, 2005 (Acari: Oribatei). *Zoo's Print Journal*, **21** (6): 2272-2276.

Alphonsa, X. and M.A. Haq. 2007.A study on the feeding habits and gnathal appendages in oribatid mites (Acarina: Cryptostigmata).

Zoo's Print Journal, **22**(5): 2671-2674

Alphonsa, X., Haq, M.A. and N. Ramani. 2005. Description of two new species of *Haplacarus* (Acari: Oribatei) from Malabar, Kerala, India. *Zoo's Print Journal*, **20**(8): 1948-1951.

Andre, H.M. and D.J. Voegtlin. 1981. Some observations on the biology of *Camisia carolli* (Acari: Oribatida). *Acarologia*, **22**(1): 81-89.

Aoki, J.I. 1958a. Zwei *Heminothrus*-arten aus Japan (Acarina-Oribatei). *Annot. Zool. Jap.*, **31**(2): 121-125.

Aoki, J.I. 1958b. Einige phthiracarideu aus utsukushighara mittel Japan (Acarina-Oribatei). *Annot. Zool. Jap.*, **31** (3): 171-175.

Aoki, J.I. 1961a Beschreibungen, von neun oribatiden Japans. *Jap. J. Appl. Ent. Zool.*, **5**(1): 64-69.

Aoki, J.I. 1961b. On six new oribatids from Japan. *Jap. J. Sanit. Zool.*, **12**(4): 233-238.

Aoki, J.I. 1961c. Notes on the oribatid mites. *Bull Biogeogr. Soc. Jap.*, **22**(6): 75-80.

Aoki, J.I. 1965a. Oribatiden (Acarina) of Thailands. *Nature and Life in S.E. Asia.*, **4**: 129-193.

Aoki, J.I. 1965b. Notes on the species of the genus *Epilohmannia* from the Hawaiian Islands (Acari: Oribatei). *Pacific Insects.*, **7**(2): 309-315.

Aoki, J.I. 1966a. Studies on the oribatid mites of Japan II. *Trichthonius simplex* sp. nov. *Bull. Nat. Sci. Mus. Tokyo.*, **9** (1):1-7.

Aoki, J.I. 1966b. A new species of soil mite, *Malaconothrus japonicus* from Central Japan (Cryptostigmata:Malaconothridae). *Ann. Zool. Jap.*, **39**(3): 169-172.

Aoki, J.I. 1969. Eine neue unter art der Bodenmilben aus Fujisan (Acari: Euphthiracaridae). *Acta. Arachnol.*, **22**(2): 27-30.

Aoki, J.I. 1971. Soil Mites (Oribatids) climbing trees. *Proc. 3rd Internat. Cong. Acar. Prague.*, 59-65.

Aoki, J.I. 1973. Oribatid mites from Iriomote Jima, the Southernmost Island of Japan (1). *Mem. Nat. Sci. Mus. Tokyo*., **6**: 585-602.

Aoki, J.I. 1977. Three species of the genus *Eohypochthonius* from Japan (Acari: Oribatei). *Acarologia*, **19** (1):117-122.

Aoki, J.I. 1980. A revision of the oribatid mites of Japan 4. *Annot. Zool. Jap*., **53**(2): 124-136.

Aoki, J.I. and T. Fujikawa. 1969. Description of a new species of the genus *Hafenferefia* Jacot (Acari : Cryptostigmata). Taxonomic notes on oribatid mites of Hokkaido 1. *Annot. Zool. Jap*., **42**(4): 216-219.

Arlian, L.G. and Woolley, T.A. 1969. Life stages of *Liacars cidarus* (Acari: Crptostigmata, Liacaridae) *J. Kansas. Entomol. Soc*., **42**: 512-524.

Arlian, L.G. and Woolley, T.A. 1970. Observations on the Biology of *Liacarus cidarus* (Acari: Cryptostigmata, Liacaridae). *J. Kansas. Entomol. Soc*. **43**(3): 298-301.

Ayyildiz, N. and M. Luxton. 1990. The genus *Cosmochthonius* Berlese, 1910 (Oribatida: Cosmochthoniidae). *Acarologia*, **31**(3): 279-284.

Badamdorj, B.Y. 2000. Oribatid mite of the genus *Epilohmannia* (Acari: Oribatida: Epilohmanniidae) from Japan and Mongolia. *Systematic and Applied Acarology*, **5**: 187-206.

Badejo, M.A., Makinde, A.M. ad N.M. Straalen. 1999. The oribatid mite fauna of soil under different vegetation cover in Ile Ife Nigeria. *Tropical Ecology*, **40**(22): 275-280.

Badejo, M.A., Woas, S. and L. Beck. 2002a. Description of six species of Nothroid mites from Nigeria and Brazil (Acari: Oribatida: Nothroidea), Genus, Wroclaw, **13**(4): 505-548.

Badejo, M.A., Woas, S. and L. Beck. 2002b. Resdescription of *Archegozetes magnus* (Sellnick, 1925) (Trhypochthonioidea) from Brazil and description of two new species of nanhermaniid mites: *Bicyrthermannia nigeriana* and *Masthermannia seropedica* (Nanhermannioidea) (Acari: Oribatida). Genus, Wroclaw, **14**(1): 125-149.

Baker, E.W. and G.W. Wharton, 1952. An introduction to Acarology, Macmillan Co. New York.

Balogh, J. 1958. Oribatides nouvelles de, Agrique tropicale. *Rev. Zool. Bot. Afr.*, **58**(1-2): 1-34.

Balogh, J. 1960. Oribates (Acari) nouveaux d Angolae et du Congo Belge (2 eme serie). *Publ. Cult. Co. Diam. Ang. Lisboa.*, **51**: 13-50.

Balogh, J. 1961. An outline of the family Lohmanniidae Berl. 1916. (Acari: Oribatei). *Acta. Zool. Acad. Sci. Hung.*, **7**: 19-44.

Balogh, J. 1962a. Some new Lohmanniidae from Peru (Acari:Oribatei). *Opusc. Zool. Budapest*, **4**: 59-61.

Balogh, J. 1962b. Recherches sur la faunae Endogee de Madagascar VII. Oribates (Acariens). *Nouveaux. Naturalista. Malagache*, **13**: 1-6.

Balogh, J. 1965. A synopsis of the world oribatid (Acari) genera. *Acta Zool. Hung.*, **11**: 5-99.

Balogh, J. 1972. The oribatid genera of the world. Akademiai Kiado, Budapest, 188pp+71pls.

Balogh, J. and P. Balogh. 1987. New outline of the family Lohmanniidae Berlese, 1916 (Acari: Oribatida). *Acta. Zool. Acad. Sci. Hung.,* **33** (3-4): 327-398.

Balogh, J. and P. Balogh. 1988. Oribatid mites of the Neotropical region II. *Akademiai kiado 'es Nyomda Vallalat, Budapest, Hung*., **3**: 1-333.

Balogh, J. and P. Balogh. 1990. Oribatid mites of the Neotropical region III. Elsevier Science publ., B.V., Amsterdam, 333pp.

Balogh, J. and S. Mahunka. 1969. The zoological results of the Hungarian soil zoological expeditions to South America II. (Acari: Oribatida) from the material of the second expedition. II. *Opusc. Zool*. Budapest., **9** (1): 31-39.

Balogh, J. and S. Mahunka. 1979. New taxa on the system of the oribatida (Acari). *Ann. Hist. Nat. Mus. Natt. Hung*., **71**: 279-290.

Balogh, J. and S. Mahunka. 1981. New data on the oribatid fauna of the Neogea (Acari) V. *Acta. Zool. Acad. Sci. Hung.*, **27** (1-2): 49-102.

Balogh, J. and S. Mahunka. 1983. Primitive oribatids of the Palaearctic region. Elsevier Science Publishers B.V. Amsterdam. The Netherlands, 226, pp+133 pls.

Baran, S. and N. Ayyildiz. 2000. Systematic studies on *Rhysotritia ardua* (C.L. Koch) (Acari, Oribatida) in Erzincan and Erzurum Plains. *Turk J. Zool.*, **24**: 231-236.

Baumler, W. 1970. Zur Morphologie, Biologi and Okologie von *Hermannia gibba* (C.L. Koch) (Acarina: Oribatei) unter Berucksichtigung einiger Begleitarten, Teil, II. *Zeit. Angew. Ent.*, **66**: 337-362.

Bayartogtokh, B. 2000. Oribatid mites of the genus *Epilohmannia* (Acari:Oribatida:Epilohmanniidae) from Japan and Mangolia. *Syst. Appl. Acarol*., **5**: 187-206.

Bayoumi, B.M. 1979. New data on the oribaid fauna of Egypt (Acari: Oribatida). *Folia. Entomol. Hung.*, **32**(2): 9-12.

Bayoumi, B. M. and M. S. Alkhaufa. 1986. Three new oribatid mites (Acari: Oribatei) from Saudi Arabia. *Bull. Soc. Amis. Sci. Lett. Poznan. Ser. D. Sci. Biol.*, **25**: 119-126.

Behan Pelletier, V.M. and S.B. Hill. 1978. Feeding habits and spore dispersal of oribatid mites in the North American Arctic. *Rev. Ecol. Biol. Soc.*, **15**: 497-516.

Behan Pelltier, V.M. and S.B. Hill. 1983. Feeding habits of sixteen species of oribatei (Acari) from an acid peat bog, Genamey, Ireland. *Rev. Ecol. Biol.*, **20**(2): 221-267.

Behan Pelltier, V.M. and M.G. Paoletti. 1999. Oribatid mite biodiversity of agroecosystem, role of bioindication. *Agriculture, Ecosystem and Environment*,**74**(1-3): 411-423.

Berlese, A. 1896. *Angella murcioides. Berl. n. sp. AMSI.*, **78** (7): 26

Berlese, A. 1923. *Centuria sesta di Acari nuovi. Redia.*, **15**: 237-262.

Bernini. F and A. M. Avanzati. 1987. Notulae oribatologicae XLI. Some new *Stegnacarus* species belonging to the Magnus group (Acarida, Oribatida). *Internal. J. Acarol.*, **13**(3): 165-176.

Bernini. F and A. M. Avanzati. 1988. Taxonomic revision of *Steganacarus* (*Steganacarus) magnus* (Nicolet, 1855) (Acarida, Oribatida). *Journal of Natural History*, 22(2) : 435-464.

Bernini, F., Manicaradi, G. and A.M. Avanzati. 1986. Notulae Oribatologicae-XXXVIII. On the first European records of an *Eohypochthonius* species in Italy (Acarida, Oribatida). *Internat. J. Acarol.* **12**(3): 115-122.

Berthet, P.L. and G. Gerad. 1965. A statistical study of microdistribution of oribatei (Acari) Part I. The distribution pattern. *Oikos*, **16**: 214-227.

Bhattacharya, S.K. 1962. Laboratory studies on the feeding and life cycles of soil inhabiting mites. *Pedobiologia*, **1**: 291-298.

Bhattacharya, T., and R. Banerjee. 1979. Some Cryptostigmatid mites (Acari:Oribatei) from Birbhum district, West Bengal, India. *Indian J. Acarol.*, **4**(1): 19-24.

Bhattacharya, T. Bhadhuri, A. K. and D. N. Raychaudhuri. 1974. Soil oribatid mites of Santiniketan, Birbhum, West Bengal, (Acarina: Lohmanniidae). *Oriental insects.*, **8** (2): 281-289.

Bhattacharya, T., Halder G. and D. Ghosh. 1986. Scanning electron microscopic studies of *Annectacarus longisetosus* (Acari: Lohmanniidae). *Entomon*, **11**(4): 295-297.

Block, W. 1965. The life histories of *Platynothrus peltifer* (Koch, 1839) and *Damaeus clavipes* (Hermann 1804) (Acarina-cryptostigmata) in soils of Pennine Moorland. *Acarologia*, **7**: 735-743.

Block, W. 1966. Seasonal fluctuations and distribution of mite populations in moorland soils, with a note on biomass. *J. Anim. Ecol.*, **35**: 487-503.

Block, W. and P. Convey. 1995. The biology, the cycle and ecophysiology of the Antarctic mite Alaskozetes antarticae. *J. Zool. Lond.*, **236**: 431-449.

Bolen, E.G. and B. McDaniel. 1989. *Neoepilohmannia*. A new genus of the family *Epilohmannidae* (Oribatida: Epilohmannoidea). *Internal. J. Acarol.*, **15**(2): 103-106.

Bulanova, Zachvatkina E.M. 1960. New representatives of primitive oribatid mites from USSR. Perlohmannoidea, Grandjean, 1958 (Acariformes:Oribatei). *Zool. Zh.*, **39**: 1835-1848.

Butcher, J.W., Snider, R. and R.J. Snider. 1971. Bioecology of edaphic collembolan and Acarina. *Ann. Rev. Ent.*, **16**: 249-288.

Cancela Da Fonseca, J.P. 1969. La Spermatophore of *Damaeus guadrihastatus proc. 2nd Int. Cong. Acarology Sutton. Bonington*. 227-232.

Cancela Da Fonseca, J.P. 1970. De la systematique a lecologie. Quelques problems. *Acarologia*, **12**: 23-24.

Cancela Da Fonseca, J.P. 1975. Notes oribatologiques.*Acarologia*,**17** (2) :320-330.

Canestrini, G. 1897. Nuovi Acaroidei dell N. Guinea. *Term. Fuz.*, **20**: 461-474.

Chakrabarti, D.K. and A.K. Bhaduri. 1972. New records of the soil oribatid mites (Acari: Oribatei) from the district of Nadia and 24 Parganas, West Bengal. *Sci. and Cult.*, **38**: 499-500.

Chakrabarti, D.K. and A.R. Talukdar. 1979. A new species of *Malaconothrus* and a few new records from other genera of soil oribatid mites (Acari) from the district of Cachar Assam. *Sci. and Cult.*, **45**(2): 79-81.

Chakrabarti, D.K., Bhaduri, A.K. and D. N. Raychaudhuri. 1972. One new species and new subspecies of oribatid mites (Acari: Oribatei) from West Bengal, India. *Acta. Arachnol.*, **24**: 86-90.

Chakrabarti, D.K, Bhaduri, A.K. and D. N. Raychaudhuri. 1977a. A new species and a few records of soil oribatid mites (Acari: Oribatei) from West Bengal. *Sci. and Cul.*, **43**(4): 179-180.

Chakrabarti, D.K, Kundu, B.K. and B.K. Mondal. 1979. A new genus *Sigmonothrus* (Oribatei:Camisiidae) from Darjeeling, West Bengal. *Indian J. Acarol.*, **3** (2): 58-66.

Chinone, S. 1974. Further contribution to the knowledge of the family *Brachychthoniidae* from Japan. *Bull. Biogeogr. Soc. Jap.*, **30**(1): 1-29.

Cleat, N.O. 1952. Growth in the laboratory of economically important oribatid mites. *Nature,* **169**: 280-281.

Clement, A. and M.A. Haq. 1984. Biology of *Pelokylla malabarica* Clement and Haq, 1982 (Acari: Oribatei). In: D.A. Grifiths and C.E. Bowmann (Eds.) *Acarology VI,* Ellis Horwood Ltd., Chichester, England, pp. 847-854.

Clement A. and M. A. Haq. 1991. Two new species of oribatid mites (Acari: Oribatei) from Kerala. In: G. K. Veeresh, D. Rajagopal and C.A. Virakthamath (Eds.) *Advances in management and conservation* of *soil fauna*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 733-739.

Coetzee, L. 2001a. New species of the family Lohmaniidae (Acari: Oribatida) from South Africa. *Navorsinge van Die Nasionale Museum Bloemfontein*, **17**: 53-67.

Coetzee, L. 2001b. Lohmanniidae species (Acari, Oribatida) from the Holocene deposits at Florisbad, South Africa. *Navorsinge Van Die Nasionale Museum Bloemfontein*, **17**(5): 126-132.

Cordo, H.A. and C.J. De Loach.1975 Ovipositional specificity and feeding habits of the waterhyacinth mite, *Orthogalumna terebrantis*,in Argentina. *Environmental Entemology,* 4 :561-565.

Corpuz-Raros, L.A. 1979a. Philippine Oribatei (Acarina) I: Preliminary list of species and descriptions of 40 new species. *Philipp. Agric.*, **62**(1): 82*pp*

Corpuz-Raros, L.A. 1979b. Philippine Oribatei (Acarina) II: Family Lohmanniidae, Kalikasan. *Philipp. J. Biol.*, **8**(3): 315-334.

Csiszar, J. 1961. New oribatids from Indonesian soils (Acari). *Acta. Zool. Hung.*, **7**: 345-366.

Del Fosse, E.S., Cromroy, H.L. and D.H. Habeck. 1975. Determination of the feeding mechanism of the waterhyacinth mite. *Hyacinth control Journal*, **13**: 53-55.

Dinsdale, D. 1974. Feeding activity of a phthiracarid mite (Aracnida: Acari). *J. Zool., London.*, **174**: 15-21.

Edsberg, E. and S. Hagvar. 1999. Vertical distribution, abundance and biology of oribatid mites (Acari) developing inside decomposing spruce needles in a podosol soil profile. Pedobiologia, **43** (5): 413-421

Ewing, H.E. 1910. New acarina from India. *Trans Acad. Sci. St. Louis.*, **19**: 113-121.

Feider, Z. and M. Calugar. 1969. Chaetotaxie picioarelor la specilte genuriler *Phthiracarus* si *Hoplophthiracarus* (Oribates) din Romania (Chaetotaxy of the legs of some species of Romanian acarines belonging to the genera *Phthiracarus* and *Hoplophthiracarus*) (Oribates). *An Stint Univ. Ali Cuza Lasi Sect. 11(A) Biol.*, **15** (1): 75-79.

Fernandez, N. 1981. Contribution a la connaissance de la faune oribatologique d' Argentine III. Spermatophore d' Epilohmannia maurii. *Acarologia*, **22**(2): 239-242.

Forsslund, K.H. 1938. Beitrage zur kenntnis der Einwirkung der boden bewohnenden tiere auf die zerseityungdes Bodensl uber die Nahrungeiniger Hornmilben (oribatiden). *Medr. St. Skogsforsoksanst.*, **31**: 99-107.

Fujikawa, T. 1988. Fluctuation of oribatid mites in Nayoro nature farming field during ten years.*Edaphologia*, **39** :29-37

Fujikawa, T. 2003. Thirteen new species from the Shirakami- Sanchi World Heritage Area, Nippon (Acari: Oribatida). *Acarologia*, **43**(4): 369-392.

Gasdorf, E.C. and C.J. Goodnight. 1963. Studies on the ecology of soil arachnids. *Ecology*, **44**: 261-268.

Ghosh, A.K. and A. K. Bhaduri. 1979. Studies on the oribatid mites (Acari: Oribatei) of Nagaland, India. *Indian J. Acarol.*, **3** (2): 51-57.

Gordeeva, E., Niemi, R. and A.D. Petrova-Nikitina. 1998. A new genus and species, *Tauroplophora aureonatata*, from the Crimea, Ukraine, and a new species, *Cryptoplophora asiatica* from Turkmenistan (Acari, Oribatida, Protoplophoridae). *Acarologia*, **39**(2): 185-190.

Grandjean, F. 1933. Etude sur les development des oribates. *Bull. Soc. Zool*. France, **58**:30-61.

Grandjean, F. 1934a. La notations des polis gastronotiques at des polis dorsaux du prodosoma chezles oribatid (Acariens). *Bull. Soc. Zool. France.*, **59**: 12-44.

Grandjean, F. 1934b. Oribates de I Afrique du Nord (2e Se rie). *Bull. Soc. Hist. Nat. Afrique du Nord.*, **25**: 235-252.

Grandjean, F. 1938. Les segments post. Larvales de L' hysterosoma chez les oribates (Acarines). *Bull. Soc. Zool. France.*, **64**: 273-284.

Grandjean, F. 1939. Les segments post-larvales de L'hysterosoma Chez les oribates (Acariens). *Bull. Soc. Zool. France.*, **64**: 273-284.

Grandjean, F. 1949. Formules anales, gastronotiques, genitales de development numberique des pols chez les oribates. *Bull. Soc. Zool.*, France. **74**: 201-225.

Grandjean, P. 1950a. Observations ethologique sur *Camisia segnis* et *Platynothrus peltifer*. *Bull. Mus. Hist. Nat. Paris*, **2**(22): 224-231.

Grandjean, F. 1950b. Etude sur les Lohmanniidae (Oribates: Acariens). *Arch. De. Zool. Exp. Et. Gen.*, **87 (**2): 95-162.

Grandjean, F. 1954 . Essai de classification des Oribates (Acariens).*Bulletin de la Societe Zoologique de France*, **78**: 421-446.

Grandjean, F. 1956a. Caracteres chitineux de l'ovipositeur, en strucutre normale chez les oribates (Acariens). *Archives de zoologie experimentale et generale, Paris*, **93**: 96-106.

Grandjean, F. 1956b. Observations sur les oribaes (34 e serie) *Bull. Mus. Nat. Hist. Naturella, Paris.*, **28**: 205-212.

Grandjean, F. 1969. Considerations sur le classement des oribates lour division en 6 groups majeurs. (Considerations on the classification of the oribates: Their division into 6 major groups). *Acarologia*, **11**(1): 127-153.

Greaves, R.C. 1960. Ecological observations on the insects and other inhabitants of woody shelf fungi in the Chicago area. *Ann. Entomol. Soc. America*. **53**: 61-78.

Haller, G. 1884. Bescheribung, einiger heuen milben. *Arch. F. Naturg*., **50**: 217-236.

Hammer, M. 1958. Investigations on the oribatid fauna of the Andes Mountain. I. The Argentine and Bolivia. *Biol. Skr. Dan. Vid. Selsk*., **13**(2): 1-96.

Hammer, M. 1962. Investigations on the oribatid fauna of the Andes Mountain iii. Chile. *Biol. Skr. Dan. Vid. Selsk*., **13**(2): 1-96.

Hammer, M. 1973. Oribatids from Tongatapu and Eua. The Tonga Islands from Upolu, Western Samoa. *Biol. Skr. Dan. Vid. Selsk.*, **20**(3): 1-70.

Hammer, M. 1980. Investigations on the oribatid fauna of Java. *Biol. Skr. Dan. Vid. Selsk*., **22**(9): 1-79.

Hansen, R.A., Coleman, D.C., Curry, J.P., Bolgee, T. and G. Purvis. 1998. Litter complexity and composition are determinants of the diversity and species composition of oribatid mites (Acari: Oribatida) in litter bags. - Soil organisms and soil resource management. Proc. Internat. Colloquium. *Soil Zoology*, Dublin, **9**, (1-3): 17-23.

Haq, M.A. 1976. Observations on the feeding habits of oribatid mites. Prof. K.K. Nayar. Comm. Symposium. Dept. of Zoology, University of Kerala.

Haq, M.A. 1978a. Breeding biology of oribatid mites. *Soil Biology & Ecology in India*, *U.A.S. Tech. Series*, **22**: 145-151.

Haq, M.A. 1978b. Some aspects of the taxonomy of oribatid mites from the soils of Kerala. *Soil Biology and Ecology in India*. *U.A.S. Tech. Series*, **22**: 117-134.

Haq, M.A. 1982a. Feeding habits of ten species of oribatid mites (Acari: Oribatei) from the soils of Malabar, South India, *Indian J. Acarology*, **6**: 39-50.

Haq, M.A. 1982b. Pheromonal regulation of aggregation and moulting in *A. longisetosus* (Acari: Oribatei). *Calicut Univ. Research Journal*, Special Conference Number, May 19.

Haq, M.A. 1984. The role of microbes in the nutrition of a lohmannid mite (Acari: Oribatei). In: D.A. Grifiths and C.E. Bowman (Eds.) Acarology, VI (2) Ellis Horwood Ltd., Chichester, England: pp. 819-825.

Haq, M.A. 1987. Biodegradation of cellulose in the gut of *Heptacarus hirsustus* Wallwork, 1964 (Acari, Oribatei). In: B.R. Striganova (Ed.) *Soil fauna and soil fertility*, Moscow, Nauka: pp. 93-98.

Haq, M.A. 1989. Some interesting aspects of oribatid behaviour. In: B.H. Patel (Ed.) *The Behaviour*, *Proc.Nat.Symp.Anim.Behav.,* Sir P.P. Institute of Science, Bhavnagar, pp. 18-26.

Haq, M.A. 1992. Beneficial aspects of oribatid mites. In: M.A. Haq and N. Ramani(Eds.) *Man, mites and environment*, Anjengo publications, Calicut: 128-138.

Haq, M.A. 1994. Role of oribatid mites in soil eosystems. In: S.C. Bhandari and L.C. Somany (Eds.) *Ecol. Biol. Soil organisms*, Agrotech Publishing Academy, Udaipur. pp. 143-177.

Haq, M.A. 1996a. Nutritional diversity of oribatid mites in relation to soil fertility. *Journal of Karnataka University Science*, Special Issue, 76-96.

Haq, M.A. 1996b. Biodiversity of acarine biocontrol agents. In: Dunston P. Ambrose (Ed.) *Biological and cultural control of insect pests, an Indian scenario*, pp. 107-120.

Haq, M.A. 2001. Oribatid mite strategies in relation to enviornment. *Entomon*, **26**: 305-309.

Haq, M.A. 2007. Biodegradation and Productivity in tropical ecosystem by oribatid mites. *Acarology XI: Proceedings of the International Congress*. Moralos-Malacara, J.B., Behan-Pelletier, V., Uckermann, E., Perez, T.M., Estrada-Venegas, E.G. and Badii, M. (Eds). Institute de Biologia and Facultad de Ciencias, Universidae Nacional Autonoma de Mexico, Sociedad Latinoamericana de Acarologia, Mexico ISBN 978-970-32-4451-5.

Haq, M.A. and A. Clement. 1980. A comparative study of the duration of life cycles of four species of oribatid mites (Acari: Oribatei) from the soils of Kerala, India. *Indian J. Acarol*., **5**: 56-61.

Haq, M.A. and A. Clement. 1981. Spermatophore deposition and transfer in *Pelokylla malabarica* (Acari: oribatei) . *Entomon*, **6**(2): 135-141.

Haq, M.A. and A. Clement. 1995. Two new species of lohmanniid mites (Acari, Oribatei) from Malabar, India. *Indian J. Acarol*., **13**(1&2): 23-28.

Haq, M.A. and M. Jaikumar. 1993. Lohmanniid mites (Acari, Oribatiei) from Kerala, India I. A new species of *Meristacarus* Grandjean, 1934. *Acarologia*, **34**(4): 387-393.

Haq, M.A. and I.D. Konikkara. 1988. Microbial association in xylophagous oribatids. In: G.P. ChannaBasavanna and C.A. Virakthamath (Eds.). *Progress in Acarology* (1), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi: pp. 483-489.

Haq, M.A. and N.R. Prabhoo. 1976. Observations on the feeding habits of oribatid mites from the soils of Kerala (Acarina: Cryptostigmata)-Panphytophages. *Entomon*, **1** (2): 133-137.

Haq, M.A. and N. Ramani. 1984. Postembryonic development of *Paralamellobates bengalensis* Bhaduri et Chaudhuri, 1968 (Acari: Oribatei) parasitic on *Dioscorea alata*. In : D.A. Griffiths and C.E. Bowman (Eds.) *Acarology*, **VI** (2), Ellis Horwood Ltd., Chichester, England, pp. 819-825.

Haq, M.A. and N. Ramani. 1987. Biosystematics of oribatid mites in relation to nutrition . Workshop on biosystematics of insects of importance in agriculture, medicine and forestry, Entomological Research Institute, Loyola College, Madras, p. 35-36.

Haq, M.A. and N. Ramani. 1997. Oribatid mites from Lakshadweep-1. A new speices of *Lepidacarus* Csizar, 1961 (Acari: Lohmanniidae). *Entomon*, **22**(2): 119-123.

Haq, M.A. and E.A.M. Shereef. 1992. Postembryonic development of species of *Galumna* Von Heyden (Acari: Oribatei). *Proc. IV Kerala Science Congress*, Thrissur: 155-160.

Haq, M.A. and X. Alphonsa. 2005. Four new species of phthiracarid mites (Acari: Oribatei) from Malabar, Kerala, India. *Zoos Print Journal*, **20**(11): 2062-2071.

Haq, M.A., Mubarak, K.V.A and N. Ramani. 1983. New lohmanniid mites (Acari: Oribatei) from Kerala, India. *Indian J.Acarol.*, **8**: 87-94.

Harding, D.J.L and R. A. Stuttard. 1974. Microarthropods. In: G.H. Dickinson and C.J.P. Pough (Eds.) Biology of plant litter decomposition, Vol **2** Academic Press, London. pp.489-532.

Hartenstein, R. 1962. Soil Oribatei 1.Feeding specificity among forest soil oribatei(Acarina). *Annals of Entomological Society of America*, 55: 202-206.

Hartenstein, R. 1962a. Soil Oribatei II: *Bebla kingi* new species (Acarina: Belbidae) and a study of its life history. *Ann. Entomol. Soc. Amer.*, **55**(5): 357-361.

Hartenstein, R. 1962b. Soil Oribatei IV: Observations on *Ceratozetes gracillis* (Acarina: Ceretozetidae). *Ann. Entomol. Soc. Amer.*, **55**(5): 583-586.

Hartenstein, R. 1962c. Soil Oribatei V. Investigations on *Platynothrus peltifer* (Acarina: Camisiidae). *Annals Entomol. Soc. Amer.,* **55**(6): 709-713.

Hartenstein, R. 1962d. Soil oribatei, VII. Decomposition of conifer needles and deciduous leaf petioles by *Stegnacarus diaphanum* (Acarina: Phthiracaridae). *Ann. Entomol. Soc. Amer.*, **55**: 713-716.

Hayes, A.J. 1963. Studies on the feeding preferences of some phthiracarid mites(Acari: oribatei*). Ent. Exp. Appl.*, **6**: 241-256.

Heethoff, M., Laumann, M. and P. Bergmann. 2007a. Adding to the reproductive biology of the parthenogenetic oribatid mite, *Archegozetes longisetosus* (Acari, Oribatida, Trypochthoniidae). *Turk. J. Zool.*, **31**: 9pp**.**

Heethoff, M., Domes, K., Laumann, M., Maraun, M., Norton, R.A. and S. Scheu. 2007b. High genetic divergences indicate ancient separation of parthenogenetic lineages of the oribatid mite *Platynothrus peltifier* (Acari, Oribatidae). *J. Evolutionary. Biol.*, **20**: 392-402.

Hu, S.H. and J.I. Aoki. 1993. Oribatid mites from tropical forests of Yunnan province in China. I. Family Lohmanniidae. *Proc. Japan. Soc. Syst. Zool.*, **49**:25-29.

Irmler, U. and Ptadenhauer, J. 1996. Succession of litter population by soil fauna (Oribatida, Collembola) in different forest types. *Verhandlangen –dev-Gesellschaft-fur-okologie*, **26**: 275-282.

Ito, Y. and Aoki, J.I. 1999. Species diversity of soil inhabiting oribatid mites in Yanbaru, the northern part of Okinawa, Honto and the effects of undergrowth removal on it. *Pedobiologia*, **43**(2): 110-119.

Jacot, A.P. 1930. Moss mites as spore bearers. *Mycologia.*, **22**: 94-95.

Jacot, A.P. 1933. Aparity among the oribatidae. *Can. Ent.*, **65**: 263-4.

Jacot, A.P. 1937. North American moss mites. *J. New York Entomol. Soc.*, **45**: 353-375.

Jacot, A. P. 1938. More box mites of the North Eastern United States. New York, *Ent. Soc.*, **46**: 371-374.

Jacot, A.P. 1939. 'Reduction of spruce and fir litter by minute animals'. *J. For.*, **37**: 858-860.

Jacot, M. 1965. Studies on the life cycle of *Hermannia scabra* (C.L. Koch) 1879 (Acarina, oribatei). *Oikos*, **16**: 17-19.

Jaikumar, M., Haq, M. A. and N. Ramani. 1994. Lohmanniid mites from Kerala, India IV. A new species of *Annectacarus* Grandjean, 1950. *Acarologia*, **35** (1): 75-82.

Jain, K.L., Manju, S., Dinesh, D., Mamta, S., Singh, M., Dogra, D. and M. Singh. 1999. Quantification of oribatid fauna and the physico chemical characteristics of soils in some local forest plantations. *Environment and Ecology*, **17**(2): 400-404.

Jalil, M. 1965. The life cycle of *Hermannia scabra* (C.L. Koch, 1879)(Acarina:Oribatei). *Oikos*, 16: 16-19.

Jalil, M. 1972. A note on the life cycle of *Platynothrus peltifer*. *J. Kans. Entomol. Soc.* **45**(3): 307-311.

Judson, M. 1991. Description of the first African representative of the genus *Javacarus* (Acari, Lohmanniidae) from Cameroon. *J. Afr. Zool.*, **105** (4): 347-354.

Kaneko, N. 1989. Life histories of four oribatid mite species in a mull type soil in cool temperate forest in Japan. *Pedobiologia*, **33**(2): 117-126.

Kaneko, N. and E.F. Salamanca. 1999. Mixed leaf effects on decomposition rates and soil microarthropods communities in an Oak pine stand in Japan. *Ecological research*, **14**(2): 131-138.

Kardar, M.A.H. 1972. A new species of Lohmanniidae (Acarina: Oribatei) from India. *Oriental insects,* **6**: 61-64.

Kunst, M. 1959. Bulgarische oribatiden (Acarina) III. *Acta. Univ. Carol. Biol.*,

1: 51-74.

Kuriki, G. 2000. A review of ecological studies on oribatid m ites in Sphagnum mines. *Japanese Journal of Ecology*, **50**: 141-153.

Lebrun, P. 1964. Quelques aspects de la phenologie des populations ol′ oribatides (Acari: Oribatei) dans la sol forestier en Moyenne-Belgique. *Bull. Acad. r. Belg*. **50**: 370-392.

Lebrun, P. 1969. Ecologie et biologie de *Nothrus palustris* (C.L. Koch) (Acari, oribatei) Densite et structure de la population. *Oikos*, **20**: 34-40.

Lebrun, P. 1970. Ecologie et biologie de *Nothrus palustris* (C.L. Koch, 1839) 3. Note cycle de vie, *Acarologia,* **12**: 193-207.

Lebrun, P. G. Van Impe, D. Desaint Georges Gridelet, G. Wauthy and H.M. Andre, 1991. The life strategies of mites. In : R. Schuster and P.W. Murphy (Eds.) The Acari: Reproduction, Development and life history strategies, Chapman and Hall, London, pp. 3-22.

Li, Y.R., Li. L.S and H.N. Chen. 1991. A new species of *Papillacarus* from Chonging China (Oribatida:Lohmannida). *Acta. Entomol. Sinica*., **34** (4): 496-498.

Lions, J. C. 1967. La prelarve de *Rhysotritia ardua* (C.L. Koch, 1836) (Acarien, Oribatei). *Acarologia*, **9**: 273- 283.

Lions, J. C. 1973. Quelques prelarves nouvelles d′ oribates. *Acarologia*, **15**: 356-370.

Luxton, M. 1966. Laboratory studies on salt marsh Acarina with notes on their behaviour. *Acarologia*, **8**: 163-175.

Luxton, M. 1972. Studies on the oribatid mites of a Danish beech wood soil 1. Nutritional biology. *Pedobiologia*, **12**: 434-463.

Luxton, M. 1975. Studies on the oribatid mites of a Danish beech wood soil II. Biomass, calorimetry and respirometry. *Pedobiologia*, Ed. **15**(8): 161-200.

Luxton, M. 1979. Food and energy processing by oribatid mites. *Rev. Ecol. Biol. Sol.*, **16**: 103-111.

Luxton, M. 1981. Studies on the oribatid mites of a Danish beech wood soil VII. Energy budgets. *Pedobiologia.*, **22**: 77-111.

Luxton, M. 1985. Cryptostigmata (Arachnida: Acari) A concise review. *Fauna New Zealand*, **7**: 3-99.

Luxton, M. 1987. New mites of the family Crotoniidae (Acari: Cryptostigmata) from Northern Queensland. *Acarologia.*, **28**(4): 381-388.

Mahunka, S. 1973. Zwei neue Lohmanniiden. Arten. Aus Korea. *Folia Ent. Hung.*, **26**: 49-56.

Mahunka, S. 1977. Neue and interessante milben aus dem Genefer XX, Contribution to the oribatid fauna of South East Asia (Acari: Oribatida). *Revue Suisse de Zoologie*, **84**: 247-274.

Mahunka, S. 1980. Oribatids from Tunisian Soils (Acari:Oribatida): 1. *Folia Ent. Hung.*, **33** (1): 123-134.

Mahunka, S. 1981. Oribatids, Acari, From Mongolia. *Archoribatida* species, oribatiden (Acari). *Ann. Hist. Nat. Mus. Natl. Hung. Budap.*, **73**: 297-303.

Mahunka, S. 1982a. New and interesting mites from the Geneva Museum (Switzerland): Oribatida: Americana: 5 Costa Rica. *Arch. Sci*. Geneva, **35** (2): 179-194.

Mahunka, S. 1990. Notes and remarks on oribatid taxa (Acari) I: *Annals Hist. Nat. Mus. Natn. Hung*., **82**: 191-250.

Mahunka, S. 1995. New oribatids (Acari:Oribatida) from Thailand. *Acta. Zool. Acad. Sci. Hung*., **41**: 137-145.

Mahunka, S. 2000. Oribatids from Hong Kong II (Acari: Oribatida: Euphthiracaridae) Acarologiea Genavensia. *Archives. des. Sci. Geneva*., **53**(1): 43-48.

Mahunka, S. and L. Zombori. 1985. The variability of some morphological features in oribatid mites. *Folia Entomol. Hung*., **46** (1): 115-128.

Maraun, M.2001. Molecular analysis of sexual and asexual oribatid mites (Oribatida, Acari) : Evolutionary and phylogenetic implications. *Proc. Of 10th Workshop Marie Curie Fellows*, London.

Maraun, M., Heethoff,M., Schereider, K., Scheu, S., Weigmann, Cianciolo,J., Thomas, R.H. and R.A. Norton.2004. Molecular phylogeny of oribatid mites(Oribatida, Acari) :Evidences for multiple radiations opf parthenogenetic lineages. *Experimental and Applied Acarology*, **33**:183-201.

Maruan, M., Migge, S. and S. Scheu. 1998a. Food preferences in oribatid mites (Oribatida) Abhandlungen Und-Berichte- Des- Naturkunda museums. *Gorlitz*, **70**(2): 198-199.

Marie, J.P., Minnot and R.A. Norton.1997. Obligate thelytoky in oribatid mites. No evidence for *Wolbachia* inducement. The Canadian Entomologist, 129:691-698.

Mc Daniel, B. and E.G. Bolen. 1983. A new species of *Epilohmannia* from Texas and new distribution records for *Epilohmannia pallida* Wallwork (Oribatida: Epilohmanniidae). Indian J. Acarol., **9**(1): 37-41.

Mc Daniel, B., Norton, R. A. and E. G. Bolen. 1979. Mites of the family Lohmanniidae (Acari:Oribatei) from Texas. *Proc. Entom. Soc. Washington*, **81**(4): 621-629.

Michael, A.D. 1884. *British Oribatidae. 1*. Ray Society, London.

Michael, A.D. 1888. British Oribatidae 2. Ray Society, London.

Michael, A. D. 1898. Oribatidae. *Das Tierreich. Berlin.*, **3**: 1-93.

Misra, B., Bhaduri A. K. and D. Raychaudhuri. 1982. Oribatid mites of Manipur, India, Family Phthiracaridae. *Indian J. Acarol.*, **1** (2): 73-78.

Mitchell, M.J.1977. Life history strategies of oribatid mites. In: Dindal, D.L(Ed.) Biology of oribatid mites, SUNY CESF, Syracuse, New York, pp. 65-69.

Mitchell, M.J. 1979. Energetics of oribatid mites in an aspen woodland soil. *Pedobiologia*, 17: 305-319.

Mondal, B.K. and D.K. Chakrabarti. 1983. A new species and new records of soil oribatid mites (Acari: Oribati) from forest and tea soils in Darjeeling, India. *Indian J. Acarol.*, **7**: 79-84.

Moreno Twose, A.I. and M.L. Moraza Zoorilla.1994. *Epilohmannia norberti sp. n* and *Rhysotritia riezuae sp. n.*, Two new species of Macropylides (Acari, Oribatida) from Spain. *Acarologia*, **35**(4): 381-397.

Murphy,P.W., and M. Jalil, 1964. Some observations on the genus *Tectocepheus*. *Acarologia*, **6**: 187- 197.

Nannelli, R. and F. Bernini. 1984. Postembryonic development of *Cepheus peggazzanoae* Bernini and Nanelli (Acarida:Oribatida):Morphological and ecological aspects. In: D.A. Griffiths and C.E. Bowmann (Eds.) Acarology VI , (2), Ellis Horwood Ltd., England, pp. 855-859.

Niedbala, W. 1980. Two new Phthiracaridae (Acari: Oribatidae) originating in Poland. *Bull. Acad. Pol. Sci. Ser. Sci. Biol.*, **28**(12): 699-706.

Niedbala, W. 1981. *Steganacarus absimilus*, new species (Acari: Oribatida: Phthiracaridae) from North America. *Bull. Acad. Pol. Sci. Ser. Sci. Biol.*, **29**(787): 323-326.

Niedbala, W. 1982a. Phthiracaridae (Acari: Oribatida) new from Central America. *Redia*, **65**: 97-118.

Niedbala, W. 1982b. Three new species of genus *Hoplophorella* (Acari: Oribatida: Phthiracaridae) of Kenya. *Bull. Soc. Amis. Sci. Biol.* **22**: 127-142.

Niedbala, W. 1982c. Three Phthiracaridae (Acari: Oribatei) original to Nepal. *Folia Entomol. Hung.*, **43**(1): 95-110.

Niedbala, W. 1983a. New Phthiracaridae of Uganda (Acari: Oribatida). *Folia Entomol. Hung.*, **44** (1): 109-124.

Niedbala, W. 1983b. Three new Phthiracaridae (Acari: Oribatida) from the Soviet Far East (USSR). *Bull. Soc. Amis. Sci. Lett. Poznan. Scr. Sci. Biol*. **23**(0): 153-170.

Niedbala, W. 1983c. Two new Phthiracaridae (Acari: Oribatida) from the Georgian SSR (USSR). *Bull. Soc. Amis. Sci. Lett. Poznan Ser. Sci. Biol.*, **23**(0): 171-182.

Niedbala, W. 1983d. The new Phthiracaridae (Acari: Oribatida) of the Caucasus (USSR). *Ann. Zool. Warsaw,* **37** (1-3): 1-62.

Niedbala, W. 1983e. Two new Phthiracaridae (Acari: Oribatida) of the mountains of Kazakr SSR and the Kirgiz SSR (USSR). *Ann. Zool. Warsaw*, **37**(1-3): 63-70.

Niedbala, W. 1984. New species of Phthiracaridae (Acari: Oribatida) from India. *Ann. Zool. Warsaw*, **36**(29): 549-565.

Niedbala, W. 1985. Essai critique sur *Mesoplophora* (Acari: Oribatida: Mesoplophoridae). *Ann. Zool. Warsaw*, **30**(7): 93-117.

Niedbala, W. 1986a. *Hoplophthiracarus inelegans* sp. n. (Acari: Oribatida: Phthiracaridae) De Costa Rica. *Bull. De. La. Soc. Des. Amis. Des. Sci. et. Des. Letters De Poznan*, **25**: 115-117.

Niedbala, W. 1986b. Catalogue des Phthiracaridae (Acari), Clef pour la determination des especes et descriptions d' especes novelles. *Ann. Zool. Warsaw*, **9**(15): 310-370.

Niedbala, W. 1986c. System des Phthiracaridae (Oribatida: Euptyctima). *Acarologia*, **27**(1): 61-84.

Niedbala, W. 1988a. Systematics of Phthiracaridae (Acari: Oribatida) In: G. P. Channabasvanna and C. A. Viraktamath and C. A. Viraktamath (Eds.) Progress in Acarology , **1,** Oxford and IBH Publ. Co. Pvt. Ltd., India, pp. 287-288.

Niedbala, W. 1988b. Systematics of Phthiracaridae (Acari: Oribatida). In:, G. P. Channabasavanna and C. A. Viraktamath (Eds.) Progress in Acarology , **1**, Oxford and IBH Publ. Co. Pvt. Ltd., India, **1**: 288-290.

Niedbala, W. 1991. Preliminary hypothesis of biogeography of Phthiracaridae (Acari: Oribatida). In: Modern Acarology: F. Dusbabek and V. Bukva (Eds.), Academia, Prague and SPB Academic Publ., The Hague, **2**: 219-232.

Niedbala, W. 1993. Three Euphthiracaroid mites (Acari, Oribatida, Euphthiracaroidea) from Africa. *Acarologia*, **34**(3): 265-271.

Niedbala, W. 2000. The ptyctimous mite fauna of the oriental and Australian regions and their centres of origin (Acari: Oribatida). *Genus, Supplement, Wroclaw*, 1-493.

Niedbala, W. 2004. Supplement to the knowledge of ptyctimous mites of oriental region (Acari, Oribatida). *Genus, Wroclaw*, **15**(3): 391-423.

Norton R.A. 1977. A review of F. Grandjean's System of Leg Chaetotaxy in the oribatei and its application to the Damaeidae. Extracted from: Biology of oribatid mites (D.L. Dindal, ed.). *SUNY College of* Environmental Science and Forestry, Syracuse, NY, 122 pp.

Norton, R.A. 1979. Notes on synonymies, recombinations and lectotype designations in Nathan Banks Species of *Nothrus* (Acari: Oribatei). *Proc. Ent. Soc. Wash.*, **81**(4): 645-649.

Norton, R.A. 2003. *Nothrolohmannia baloghi* sp. n. (Acari: Oribatida). From Rainforest in Papua New Guinea, and reevaluation of Nothrolohmanniidae. *Acta Zoologica Academiae Scientiarum Hungaricae*, **49**(1): 25-42.

Norton, R. A. and L. J. Metz. 1980. Neohypochthoniidae (Acari: Oribatei), a new mite family from the Eastern United States. *Ann. Ent. America*, **73**(1): 54-62.

Norton, R. A. and Z. Olszanowski. 1989. A new *Holonothrus* (Oribatida: Crotoniidae) from Zaire with notes on the distribution of Crotoniid mites. *J. Afr. Zool.*, 405-412.

Norton, R. A., Metz, L. J. and G. D. Sharma. 1978. Observation on *Epilohmannoides* Jacot 1936 (Acarina: Oribatei) with the description of a new species. *J. Georgia Ent. Soc.*, **13**(2): 134-148.

Norton, R.A., Williams, D.D., Hogg, I.D., and S.C. Palmer. 1988. Biology of oribatid mites, *Mucronorthus nasilis* (Acari: Oribatida: Trhypochthoniidae) from small cold water spring brook in eastern Canada. *Can. J. Zool.*, **66**: 622-629.

Norton, R.A. Ketheley, J.B., Johnston, D.E. and B.M. Oconnor. 1993. Phylogenetic perspectives on genetic systems and reproductive modes of mites. In: D.L. Wrensch and M.A. Ebbert (Eds.) Evolution and diversity of sex ration in insects and mites. Chapman & Hall, New York and London: pp. 8-99.

Okhubo, N. 1979. A new species of the genus *Epilohmannoides* (Acarina: *Oribatida*) from Japan. *Annot. Zool. Jap.*, **52**(4): 261-265.

Olszanowski, Z. 1997. On the genus *Holonothrus* (Acari: Oribatida) in the Australian Region. *Acarologia*, **38**(4): 385-402.

Palmer, S.C. and R.A. Norton. 1990. Further experimental proof of Thelytokus Parthenogenesis in oribatid mites (Acari: Oribatida: Desmonomata). *Experimental and Applied Acarology*, **8**: 149-159.

Palmer, S.C. and R.A. Norton. 1991. The distribution mechanisms and evolutionary significance of parthenogenesis in oribatid mites. In : Schuster, R. and P.W. Murphy (Eds.)The Acari: Reproduction, Development and Life history strategies, Chapman and Hall, London, pp. 107-136.

Palmer, S.C. and R.A. Norton. 1992. Genetic diversity in Thelytokus Oribatid Mites (Acari, Acariformes: Desmonomata). *Biochemical Systematics and Ecology*, **20**(3): 219-231.

Parry, B. W. 1979. A revision of the British species of *Phthiracarus* Perty, 1841 (Cryptostigmata: Euptyctima). *Bull. Br. Mus. (Nat. Hist.) Zool.*, **35**: 323-363.

Pauly, F. 1952. Die Coupla der Oribatiden (Moosmilben) *Natrwissenschaften*, **24**: 572-573.

Pauly, F. 1956. Zur Biologie einiger Belbiden und Zur Funktion ihrer Pseudostigmaticschen, Organe. *Zool. Jahrb.* (*Syst*), **84**: 275-328.

Pearse, N. D. R. 1906. On some Oribatidae from the Sikkim Himalaya. *J. Roy. Mier. Soc.*, 269-273.

Penttinen, R. and E. Gordeeva. 2003. *Cosmochthonius zanini* sp. n. (Acari, Oribatida, Cosmochthoniidae) from the eastern mediterranea. *Vestnik Zoologii*, **37**(5): 77-83.

Perez-inigo, C. 1968. Les Lohmanniidae d' Espagne (Acari: Oribatei) (The Lohmanniidae of Spain (Acari: Oribatei)). *Eos. Rev. Respan. Entomol.,* **43** (1-2): 157-170.

Perez-inigo, C. 1989. Premiere decouverte du genre *Vepracarus* en Afrique Continentle (Acari: Oribatei: Lohmanniidae). *Revue Zool. Afr. J. Afr. Zool.*, **103**: 389-393.

Perez-Inigo, C. and M. Sarasola. 1998. Soil Oribatid mites (Acari, Oribatei) from Uruguay (II). Some species from the lake Merin Basin. *Acarologia*, **39**: 149-154.

Perkins, B.D., 1971. Preliminary studies on a strain of the water hyacinth mite from Argentina. *2nd Int.Symp.on Biol.Control of weeds*, Rome, Italy.

Piffl, E. 1963. *Heptacarus notoneotrichus* cine neue. Hornmilbe aus Aegypten (Oribatei: Lohmanniidae). *Any. Ost. Akad. Wiss*., **100**: 24-37.

Piffl, E. 1966. *Heptacarus supertrichus* nov. spec. cine neue. Lohmanniden art. (Oribatei: Acari) aus dem Irak. *Any. Ost. Akad. Wiss*., **103**: 162-169.

Prasad, V. 1974. Important families of Indian Cryptostigmata. All India summer institute in Acarology, June, 17- July, 13. Dept. of Entomology, U.A.S., Bangalore, pp. 48-52.

Ramani, N. and M.A. Haq. 1984. Oribatid mites (Acari) associated with *Eapatorium odoratum*. *Indian J. Acarol*., **8**(2): 95-99.

Ramani, N. and M.A. Haq. 1987a. Temperature as a regulative factor in the development of *Scheloribates decarinatus* Aoki, 1983 (Acari: Oribatei). In: Aspects of Behaviour (Ismail, S.A. and Alawdeen, S.S., eds). pp. 92-97, Dept. of Zoology, The New College, Madras, India.

Ramani, N. and M.A. Haq. 1987b. Biology of *Scheloribates decarinatus* Aoiki, 1984(Acari: Oribatei), an inhabitant of *Chromolaena odorata*. *Journal of Soil Biology and Ecology*, **7**(1): 27-35.

Ramani, N. and M.A. Haq. 1988. Developmental studies of *Uracrobates indicus* (Acari: Oribatei) inhabiting *Mangifera indica*. In: G.P. Channabasavanna and C.A. Viraktamath (Eds.). Progress in Acarology, **1**: 483-489, Oxford and IBH Publishing Company, Pvt. Ltd., India.

Ramani, N. and M.A. Haq. 1991. Potential of *Meristacarus degradatus* and *Xylobates rhombiodes* (Acari: Oribatei) in the degradation of higher plant materials. In: O. Pushabek and V. Bukva Modern (Eds.) Acarology. Academia, Prague and SPB, pp. 411-415.

Ramani, N. and M. A. Haq. 1992. Oribatid mites from coconut palm – 3. A new species of *Afronothrus* (Acari: Oribatei: Trhypochthoniidae) from Kerala, India. *Acarologia*, **33**: 207-212.

Ramani, N. and M.A. Haq. 1999. Role of oribatid mites in biodegradation and soil fertility. *Proc. II Kerala Science Congress*, Thiruvanantha-puram: 26-27.

Ramani, N. and M.A. Haq. 2001. Feeding habits of the Indian oribatid mites *Hoplophthiracarus rimosus* and *Lohmannia* n. sp. and their role in decomposition. In R.B. Halliday, D.E. Walter, H.C. Proctor, R.A. Norton and M.J. Colloff (Eds.). *Acarology:Proceedings of the 10th International Congress*, Melbourne; CSIRO publishing, pp. 262-265.

Rhode, C.J. 1955. Studies on Arthropods from a moss habitat with special emphasis on the life history of three oribatid mites. *Diss. Abs.*, 15 Northwestern University, pp. 56-64.

Rhode, C.J. 1956. A modification of the plaster - charcoal techniques for rearing of mites and other small arthropods. *Ecology*, **37**: 843-844.

Rockett, C.L. and J.P. Woodring. 1966. Biological investigations on a new species of *Ceratozetes* and of *Pergalumna* (Acarina: Cryptostigmata) *Acarologia*, **8**: 511-520.

Saha, S. and A.K. Sanyal, 1996. Two new species of the genus *Malaconothrus* (Acari:Oribatei) collected in Vizcaya. *Entomon*, **21**(1): 105-107.

Sankaran, T. 1976. Possibilities of biological control of the aquatic weeds, *Eichhornia crassipes* and *Salvinia auriculata*, India. In: Proc. Ref. Seminar on Noxious Aquatic vegetation, The Hague, pp. 323- 330.

Sanyal, A.K. 1982. Description of two new species and one new record of Cryptostigmatid mites (Acari: Oribatei) from Maharashtra, India. *J. Bombay Nat. Hist. Soc.*, **81**: 151-155.

Sanyal, A. K. and A. K. Bhaduri. 1981. *Hoplophorella sunderbanensis* new species (Acari: Oribatei) from West Bengal, India. *Indian J. Acarol.*, **6**: 33-38.

Sanyal, A.K. and A.K. Bhaduri. 1982. A new species of the genus *Hoplophorella* (Acari: Oribatei) from West Bengal, India. *Indian J. Acarol.*, **6**: 35-38.

Sanyal, A. K. and A. K. Bhaduri. 1983. A new species of the genus *Trichthonius* (Acarina: Oribatei) from India. *Acarologia*, **24**(2):219-221.

Sanyal, A. K. and A. K. Bhaduri. 1988. The present state of knowledge of Oribatid (Acari) taxonomy in India. In: progress in Acarology, G.P. Channa Basavanna and C. A. Viraktamath (Eds.), Oxford and IBH Publ. Co. Pvt. Ltd., India, **1**: 295-300.

Sanyal, A. K. and D. Sengupta. 1990. A new species of the genus *Sphaerochthonius* (Acari: Oribatei) from West Bengal, India. *Acarologia*, 31(3): 288-295.

Sarkar, S. 1983. New representatives of oribatid mites (Acari: Oribatei) from soil of Tripura, India. *Orient. Zool.*, **3**: 91-98.

Sarkar, S. 1985. A new species of the genus *Archegozetes* Grandjean, 1931 (Acari: Oribatei) from Tripura, India. *Utter Pradesh. J. Zool.*, **5**(1): 82-85.

Sarkar, S. and L. S. Subias. 1982. Some new macropylid Oribates (Acarida) from India. *Eos. Rev. Esp. Entomol.*, **58**(1-4):311-318.

Sarkar, S. and L. S. Subias. 1984. New Lohmanniids (Acarida: Oribatida) from India. *Oriental Insects.*, **18**: 25-30.

Schatz, A. 1979. Nutrition biology of oribatid mites (Acari) in high alpine areas of Tyrol (obergurgh). *Ber. Naturwiss, Med. Ver. Innsbruck*, **66**: 7-20.

Schatz, H. 1993. The genus *Lohmannia* (Acari: Oribatida: Lohmanniidae) in the Galapagos Islands. *Acarologia*, **34**: 69-84.

Schatz, H. 1994a. New records of the genus *Torpacarus* (Acari: Oribatida Lohmanniidae) from the Galapagos Islands and Central America. *Acarologia*, **35**(2): 167-180.

Schatz, H. 1994b. Lohmanniidae(Acari:Oribatida)from the Galapagos Islands, The Cocos Island and Central America. *Acarologia*, 35 : 267-287.

Schatz, 2002. Die Oribatiden Literatur and die beschriebenen Oribatidenarten (1758-2001) Eine Analyse Abhandlungen und Berichte des Naturkundemuseums . *Gorlitz*, **74:** 37-45.

Schenker, R. 1983. Effects of temperature acclimation on cold hardiness of alpine microarthropods. *Rev.Ecol.Biol.Soil.*, **20**: 37-47.

Schenker, R. 1984. Special and seasonal distribution patterns of oribatid mites (Acari:Oribatei) in a forest soil ecosystem. *Pedobiologia*, **27**: 133-149.

Schneider, K. and M. Maraun. 2005. Feeding preferences among dark pigmented fungi (Dematiacea) indicate trophic niche differentiation of oribatid mites. *Pedobiologia*, **49**: 61-67.

Schneider, K., Renker, C., Scheu, S. and M. Maraun. 2004. Feeding biology of oribatid mites: a mini review. *Phytophaga*, **14**: 247-256.

Schubart, H. 1970. *Ameronothrus schusteri* n. sp., cine neu oribatidae von der kueste Jugoslawiens (Arachnida: Acari). (*Ameronothrus schuusteri*) n. sp., new oribatids from the cost of Yugoslavia (Arachnida: Acari)). *Sensckenberb Biol.*, **51**(5-6): 425-432.

Schulte, G. 1976. Zur Nahrungbioloie der terrestrischen and marinen milbefamilie Ameronothridae (Acari:Oribatei). *Pedobiologia*, **16**: 332-352.

Schuster, R. 1956. Der Anteil der Oribatiden an den Zersetzungsvorgangen in Boden. *Zeitschrift fur Morphologie and Okologie der Tiere*, **45**:1-33.

Schuster, R. 1962. Nachweis eines Paarungszeremoniells bei den Hornmillben. *Naturw.*, **21**: 502-503.

Schuster, R. 1988. Untersuchungen zur Epizootiologie der Monieziose des Schafes in der DDR, unter besconderer. Berucksichtigung Zwischenwirte. *Monatsh.Vet.*, **43**: 233-235.

Schuster, R., Coetzee, L. and J.F. Putterill.2000. Oribatid mites (Acari:Oribatida) as intermediate hosts of tapeworms of the family Anoplocephalidae(Cestoda) and the transmission of Moniezia expansa cysticercoids in South Africa. *Ondersteport J. Vet. Res.*, **67**: 49-55.

Sellnick, M. 1928. Formenknesis. Hornmilbe, Oribatei. In: Tierwelt Mitteleuropas, 3. P. Brohmer, P. Ehromanu and G. Ulmer (Eds.) Quella and Meyer, Leipzig, 1-42.

Sellnick, M. 1959. Acarina from South Eastern Polynesia II (Oribatidae). Bernic P. Bishhop Museum. Occasional papers, **22**(9): 129-133.

Sengbusch, H.G. 1954. Studies on the life history of three oribatid mites with observations on other species. *Ann. Entomol. Soc. Amer.*, **47**: 646-667.

Sengbusch, H.G. 1958. Zuchtversuche mit oribatiden (Acarina) *Naturwiss.*, **45**: (20): 498-499.

Sengbusch, H.G. 1961. A study of spermatophores and sperm transfer in the Oribatei(Acarina). *J. Parasitol.*, 47: 43-44.

Sengbusch, H.G. 1963. Methods recommended for the preparation and culture of oribatei. *Advances in Acarology,* **1**: 181-190.

Sengbusch, H. G. 1982a. Micronesian Oribatei I. A. new species of *Haplacarus* from Yap. (Acari: Lohmanniidae). *Pac. Ins.*, **24**(1): 25-30.

Sengbusch, H. G. 1982b. Micronesian Oribatei II. A new species of *Javacarus* from Ponape (Acari: Oribatei: Lohmanniidae). *Pac. Ins.*, **24**: 164-170.

Sengbusch, H. G. 1984a. Micronesian Oribatei III. A new species of *Lohmannia* from Saipan (Acari: Oribatei: Lohmanniidae) *Int. J. Entomol.*, **28**(1-2): 136-142.

Sengbusch, H. G. 1984b. Micronesian Oribatei IV. A new species of *Annectacarus* from Truk and Saipan (Acari: Oribatida: Lohmanniidae). *Int. J. of Entomol*, **26**(4): 354-361.

Sengbusch, H.G. and C.H. Sengbusch. 1970. Post-embryonic development of *Oppia nitens* (Acarina Oribatei). *J. New York Entomol. Soc.*, **78**: 207-214.

Sengupta, D., Sanyal, A. K. and S. Chakrabarthi. 1997. List of oribatid (Acari: Oribatei) mites from the Indian Himalaya along with some notes. *Hexapoda.*, **8**(1): 19-35.

Seniczak, S. 1972. A method of cultivation of soil mites in glass cultivation tubes with asbestos bottoms. *Pol. Journ. Soil. Sci.*, **5**: 127-132.

Seniczak, S. 1978. The morphology of juvenile forms of soil mites of the family Achipteridae (Acari: Oribatei) 1. *Annals Zoologici.*, **34**(5): 89-99.

Seniczak, S. 1980. The morphology of juvenile stages of moss mites of the subfamily Trichoribatinae (Acari: Oribatei) 1. *Annales Zoologici*, **35**(8): 83-92.

Seniczak, S. 1988. The morphology of juvenile stages of moss mites of the family Pelopidae Ewing (Acarina: Oribatida), 11. *Annales Zoologici*, 41: 383-393.

Seniczak, S. 1989a. The morphology of juvenile stages of moss mites of the subfamily Sphaerozetinae (Acarida:Oribatei) 1. *Annales Zoologici,* **42**(10) : 225-235.

Seniczak, S. 1989b. The morphology of juvenile stages of moss mites of the subfamily Sphaerozetinae (Acarida:Oribatei) 11. *Annales Zoologici,* **42**(11) : 237-248.

Seniczak, S., Solnoy, T. and A. Seniczak. 2008. Systematic status of *Hydrozetes octosetosus* Willmann, 1932 (Acari: Oribatida: Hydrozetidae) in the light of ontogenetic and ecological studies. *Journal of Natural History*, **41**: 2081-2098.

Seniczak, A. and S. Seniczak. 2008. Setal variability of *Hydrozetes lemnae* and *H. thienemanni* (Acari: Oribatida: Hydrozetidae). *Biologia*, **63**(5): 677-683.

Shereef, G.M. 1970. Observations on the feeding, reproduction and faeces obtained from oribatids fed on different species of *Penicillium* and *Aspergillus*. *IV Vol. Int. de zool. du. sol.*, 1970 Dijon France.

Shereef, G.M. 1971. The comparison studies of life cycle of oribatid mites in U.S.S.R. Ph.D. Thesis, Moscow, 1971.

Shereef, G. M. 1976a. Biological studies and descriptions of life stages of two species: *Papillacarus aciculatus* Kunst. and *Lohmannia egypticus* Elbadry and Nasr (Oribatei Lohmanniidae) in Egypt. *Acarologia*, **28**(2): 351-359.

Shereef, G.M. 1976b. Biology of two oribatid species in Giza region. *Acarologia*, **18**(1): 170-173.

Shiji, M.T., Haq, M.A. and N. Ramani, 2007. Two new species of Lohmanniid mites (Acari:Oribatei) from Kerala, India. *Systematic and Applied Acarology*, **12**:229-236.

Sitnikova, L.G. 1959. Life cycles of some oribatei and methods of their cultivation. *Zool. Inst. Acad. Sci. USSR* (*Leningard*), **38**(11): 1663-1673.

Smriz, J. 1994. Survival of *Scutovertex minutus* (Koch) (Acari:Oribatida) under differing humidity conditions. *Pedobiologia*, **38**: 448-454.

Smriz. J. and R.A. Norton. 2004. Food selection and internal processing in *Archegozetes longisetosus* (Acari: Oribatida). *Peodobiologia*, 48: 111-120.

Spain, A. and M. Luxton. 1971. Catalog and bibliography of the acari of the New Zealand Sub-region. *Pacific Insects Monographs*, **25**: 179-226.

Stary, J. 1998. *Torpacarus* species (Acari: Oribatida: Lohmanniidae) from Cuba. *Acta. Zool. Soc. Bohemicae*., **62**(1): 57-68.

Strenzke, K. 1949. Zur fortflanxung der Moosmilben, *microkosmas*. **38**: 177-180.

Sumangala, K. and M.A. Haq. 1995. Reproductive strategies of *Orthogalumna terebrantis*. Wallwork (Acari: Oribatida) , a biocontrol agent of water hyacinth. In: Dunston P. Ambrose (Ed.) *Biological and cultural control of insect pests, an Indian Scenario.* Adeline Publishers, Tirunelveli, pp. 150-154.

Susmitha, S. and A.K. Sanyal. 1996. Two new species of the genus *Malaconothrus* (Acari: Oribatei) from Tripura, India. *Entomon*, **21**(1): 105-109.

Suzuki, K.1977. Ontogenetic development of *Perlohmannia gigantica* (Aoki, 1960). 1. Morphology of larval stase (Acari:Cryptostigmata). *Acta Arachnologica,* 27(sp.): 95-107.

Szczykutowicz, A.S. and Z. Olszanowski. 2006. New species of *Allonothrus* from Costa Rica (Acari: Oribatida: Trhypochthoniidae). Genus, Wroclaw, **17**(1): 133-139.

Szywilewska A., Olszanowski Z. and R.A. Norton. 2005. New oribatid mite of the genus Crotonia (Acari: Oribatida: Crotoniidae) from Chile. *Annales Zoologici* (Warszawa), **55**(3): 449-452.

Taberly, G. 1951. Demonstration de la parthenogenesa chez *Tryhypochthonius tectorum* Berlese (Acarien, oribata) *Compt. Rend*., **233**: 1226-1228.

Taberly, G. 1953. Sur'Ethologie et la development post embryonnacre de *Trhypochthonius tectorum* (Acarina, Oribatei). *Bull. Soc. Zool., France*, **77**(5-6): 330-341.

Taberly, G. 1957. Observations sur les spermatophores at leur transport cez les oribates (Acariens). *Bull. Soc. Zool. France*, **82**: 139-145.

Taberly, G. 1987. Recherches Sur La Parthenogenese thelytoque de deux especes. d'acariens oribates: *Trhypochthonius tectorum* (Berlese) et *Platynothrus peltifer* (Koch). II. Etude anatomique. Histologique et cytologique des femelles parthenogenetiques. *Acarologia*, **28**(2): 285-293.

Taberly, G. 1988. Recherches Sur La Parthenogenese thelytoque de deux especes. d'acariens oribates: *Trhypochthonius tectorum* (Berlese) et *Platynothrus peltifer* (Koch) IV. Observations sur les males atavique. *Acarologia*, **29**: 95-107.

Tadros, M.S. 1973. The feeding specificity among soil oribatids (Acarina) in the Arab Republic of Egypt. *Bull. Zool. Soc. Egypt.*, **25**: 69-74.

Talukdar, A.R. and D.K. Chakrabarti, 1985. New species and records of primitive oribatid mites (Acari: Oribatei) from Assam. *Indian J. Acar.*, **9**: 29-36.

Trave, J. 1970. The immature stages of the genus *Neoribates* (Parakalummidae, Oribates). *Acarologia*, **12** (1): 208-215.

Trave, J. 1992. La Chaetotaxic du Palpe Des Nothroides (Dribates) *Acarologia*, **33**(4): 377-385.

Trave, J. and Z. Olszanowski. 1991. La Chaetotaxic Pedieuse des crotoniidae (Oribates, Nothroides). *Acarologia*, **32**(4): 399-413.

Travenicek, M. 1979. Spermatophores of some oribatids of the family Liacaridae (Acarina: Oribatei) *Uestu. Cesk. Spol. Zool.*, **43**: 223-239.

Tullgren, A. 1918. Ein Schreinfacher Ausleseppparatt Aur terricole Tierformen 2. *Angew. Ent.*, **4**: 149-150.

Van der Hammen, L.1952. The Oribatei (Acari) of the Netherlands. *Journal of Zoologische Verhandelingen*, 17(1): 1-139.

Van der Hammen, L.1955. Notes on the Oribatei(Acari) of Dutch New Guinea III. The development of Archegozetes magna (Selln.) and Allonothrus schuilingi (Van der Hammen). *Proc. Kon. Ned.Ak.Wet.,* **58**: 195-205.

Van der Hammen, L. 1977a. A. Berlese; collected Acarological papers previously published in Redia, 1903-1923. Dr. W. Junk bv. Publ., The Hague, Lochem, **1:** 1-15.

Van der Hammen, L. 1977b. A. Berlese; collected Acarological papers previously published in Redia, 1903-1923. Dr. W. Junk bv. Publ., The Hague, Lochem, **11:**(16).

Van der Hammen, L. 1977c. A. Berlese; collected Acarological papers previously published in Redia, 1903-1923. Dr. W. Junk bv. Publ., The Hague, Lochem, **111:**(17).

Van der Hammen, L. 1977d. A. Berlese; collected Acarological papers previously published in Redia, 1903-1923. Dr. W. Junk bv. Publ., The Hague, Lochem, **5:**(19-31).

Vizthum, M. 1923. Acarina, Schulze Biologie der Tiere Deutschlends, 21.

Waitzbaur, J. 1983. Licht Und Elekroskopische Untersuchungen der spermiogenese Und Spermatophore von *Hermana gibba* (Oribatidae, Acari). *Acarologia*, **3** : 322-341.

Wallwork, J.A. 1958. Notes on the feeding behaviour of some forest soil Acarina. *Oikos*, **9**: 260-271.

Wallwork, J.A. 1960a. Observations on the behaviour of some oribatid mites in experimentally controlled temperature gradients. *Proc. Zool. Soc. Lond*. **135**: 619-629.

Wallwork, J.A. 1960b. Some oribatei from Ghana III. Two new species of the genus *Allonothrus* (Van Der Hammen). *Acarologia*, **2**: 568-574.

Wallwork, J. A. 1961. Some Oribtei from Ghana V. Two members of the family Trhypochthoniidae, including a description of a new genus. *Acarologia*., **3**: 322-341.

Wallwork, J.A. 1962a. Some Oribatei from Glana X. The family Lohmanniidae. *Acarologia*, **4**(3): 457-487.

Wallwork, J. A. 1962b. Notes on the taxonomy and distribution of oribatid mites (Acari: Oribatei) from Ghana. *Ann. Mag. Nat. Hist*., **4**:678-681.

Wallwork, J.A. 1963. Evolutionary trends in morphological characters in tropical oribatids. In: J. Naegele (Ed.) Advances in Acarology, Comstock Publishing Associates, Cornell University Press, pp. 379-391.

Wallwork, J. A. 1964. Some oribatei (Acari: Cryptostigmata) from Tchad (1st series). *Rev. Zool. Bot. Aft*., **70**(3-4): 353-385.

Wallwok, J.A. 1967. Acari. In: A. Burges. and F. Raw (Eds.) *Soil Biology* , Academic Press, London and New York, pp. 363-395.

Wallwork, 1970. Ecology of soil animals. Mc. Graw Hill, London, New York: 283pp.

Wallwork, J.A. 1976. The distribution and diversity of soil fauna. Academic press. 355pp.

Walter, D.E. and H.C. Proctor. 1999. Mites: Ecology Evolution and Behaviour. *CAB International, Oxon. UK.*, 322pp.

Wang, Hu Fu and R.A. Norton. 1988. New records of Crotonoidea from China, with description of a new species of *Allonothrus* (Acari: Oribatida). *Acta Zootaxonomica sinica*, **13**(3): 261-273.

Wauthy, G. and A. Fain. 1991. Observations on the legs of *Trimalaconothrus maniculatus* Fain and Lambrechts, 1987 (Acari, Oribatida) Part I. Larva Leg IV of Nymphs and fundamental phanerotaxy. *Acarologia*, **32**(4): 415-433.

Webb, N.R. 1969. The respiratory metabolism of *Nothrus silvestris* Nicolet. *Oikos.*, **20**(2): 294-299.

Webb, N.R. 1977. Observations on *Stegnacarus magnus*, general biology and life cycle. *Acarologia*, **19**(4): 686-696.

Webb, N.R. 1979. Observations on *Stegnacarus magnus* differences between instars. *Acarologia*, **20**(1): 138:146.

Weigmann, G. 1975. Vorkommen von *Ameronothrus* (Acari: Oribatei) in Litoral Sudafrikas Veroff. *Inst. Meeresforsch. Bremerh.*, **15**: 65-67.

Weigmann, G. 2001. The body segmentation of oribatid mites from a phylogenetic perspective. In Halliday, R.B., Walter, D.E., Proctor, H.C., Norton, R.A. and Colloff, M (Eds.) *Acarology:Proceedings of the 10th International Congress*, Melbourne; CSIRO, pp. 43-49.

Weigmann, G. and G. Schulle, 1977. The evolution of the family Ameronothridae (Acari: Oribatei) 1. Morphological aspects. *Acarologia*, **19**(1): 161-166.

West, C. 1982. Life histories of 3 species of subantarctic oribatid mites. *Pedobiologia*, **23** (1): 59-67.

Woodring, J.P. 1963. The nutrition and biology of saprophytic Sarcoptiformes. In: J. Naegele comstok (Ed.) Advances in Acarology **1**, Comstock Publishing Associates, Cornell, University Press, pp. 89-111.

Woodring, J.P. 1970. Comparative morphology, homologies and functions of the male system in oribatid mites (Arachnida:Acari). *Journal of Morphology*, 132(4): 425-431.

Woolley, T.A. 1960. Some interesting aspects of oribatid ecology (Acarina). *Annals of the Entomological Society of America*, **53**: 251-253.

Woolley, T. A. 1966. New oribatid mites from Central America (Acari: Cryptostigmata). *Proc. Ent. Soc. Washn.*, 68-334.

Woolley, T.A. 1967. The infracapitulum. A possible index of oribatid relationship. *Int. Congr. Acarol.*, **2**: 209-221.

Yamamoto, Y. 1996. Two new oribatid mites of the family Malaconothridae in Wakayama Prefecture, Central Japan (Acari: Oribatei). *Acta Arachnol.*, **45**(2): 119-124.

Yamamoto, Y. 1997. Two new oribatid mites of the genus *Trimalaconothrus* found from a *Sphagnum* Bog at Akai, North East, Japan. (Acari: Oribatei: Malaconothridae). *Edaphologia*, **58**: 35-40.

Yamamoto, Y. and J. I. Aoki. 1971. The fauna of the lava caves around Mt. Fujisan VII. Malaconothridae (Acari: Cryptostigmata). *Bull. Nat. Sci. Mus.*, **14**(4): 570-585.

Yamamoto, Y. and J.I. Aoki. 1997. A new oribatid mite of the genus *Malaconothrus* from Iriomote Island, South West Japan (Acari: Oribatei: Malaconothridae). *J. Acarol. Soc. Jpn.*, **6**(1): 43-47.

Yamamoto, Y. and L. Coetzee. 2004. The *Trimalaconothrus* species from South Africa (Acari: Oribatida: Malaconothridae). *Acta Arachnologica*, **53**(1): 13-25.

Yamamoto, Y., Aoki, J.I., Wang, X.Z., and S.H. Hu. 1993. Oribatid mites from subtropical forests of Wu-Yan-Ling, East China (1) Two new species of the family Malaconothridae (Acari: Oribatei). *Edaphologia*, **49**: 25-31.

Yamamoto, Y., Kuriki, G. and J.I. Aoki. 1993. Three Oribatid Mites of the Genus *Trimalaconothrus* found from a Bog in the North Eastern Part of Japan (Acari: Oribatei: Malaconothridae). *Edaphologia*, **50**: 23-30.

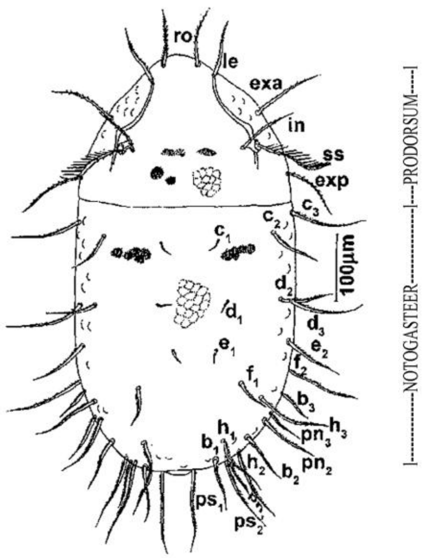
Zinkler, D. 1971. Carbohydrasen streube wohnender collembolan und oribatiden, 329-334. In: IV Colloquium Pedobiologiae, Dijon. France.

Zinkler, D. 1972. Carbohydrases in litter oribatid mites. *Vesh. dt. Zool. Ges.*, **65**: 149-153.

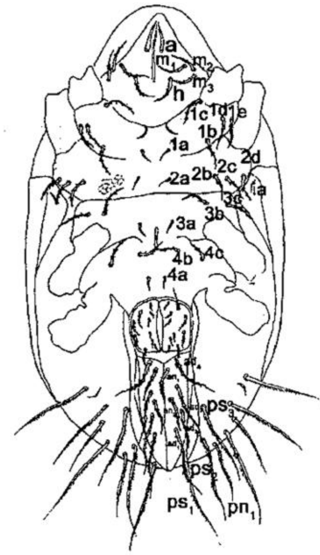
PLATE 1

PLATE 2

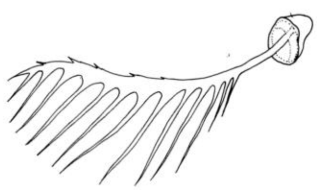
PLATE 3



1

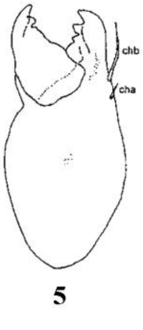


3

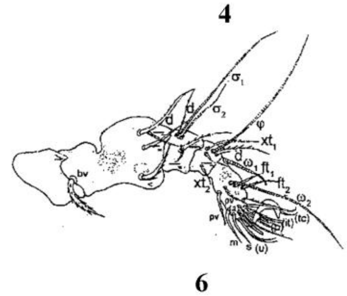


2

4

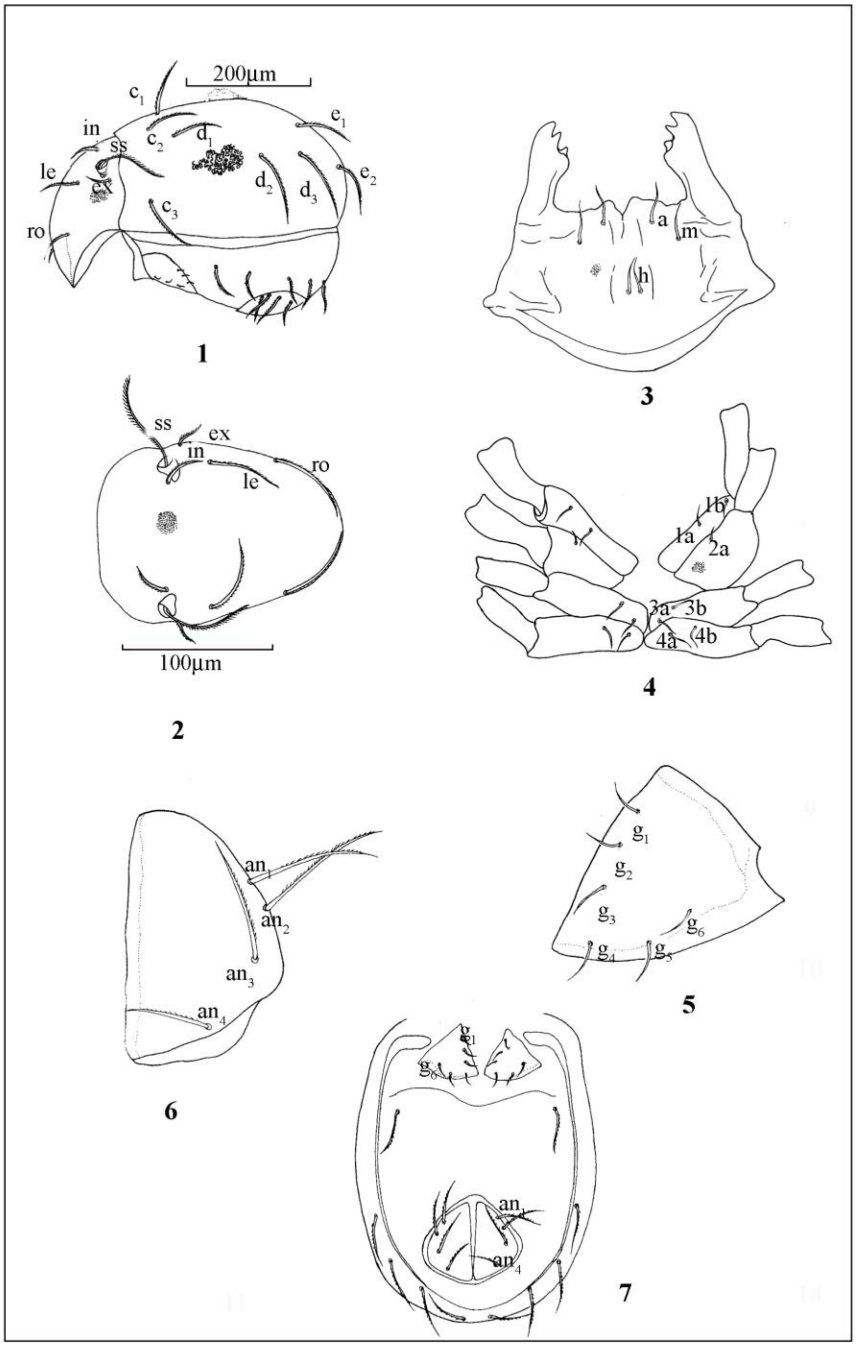


5



6

PLATE 4



200μm
c1
c2
c3
d1
d2
d3
e1
e2
in
ss
le
ex
ro
1
a
m
h
3
ss
ex
in
le
ro
100μm
2
1b
1a
2a
3a
3b
4a
4b
4
an1
an2
an3
an4
6
g1
g2
g3
g4
g5
g6
5
g1
g6
an1
an4
7

PLATE 5

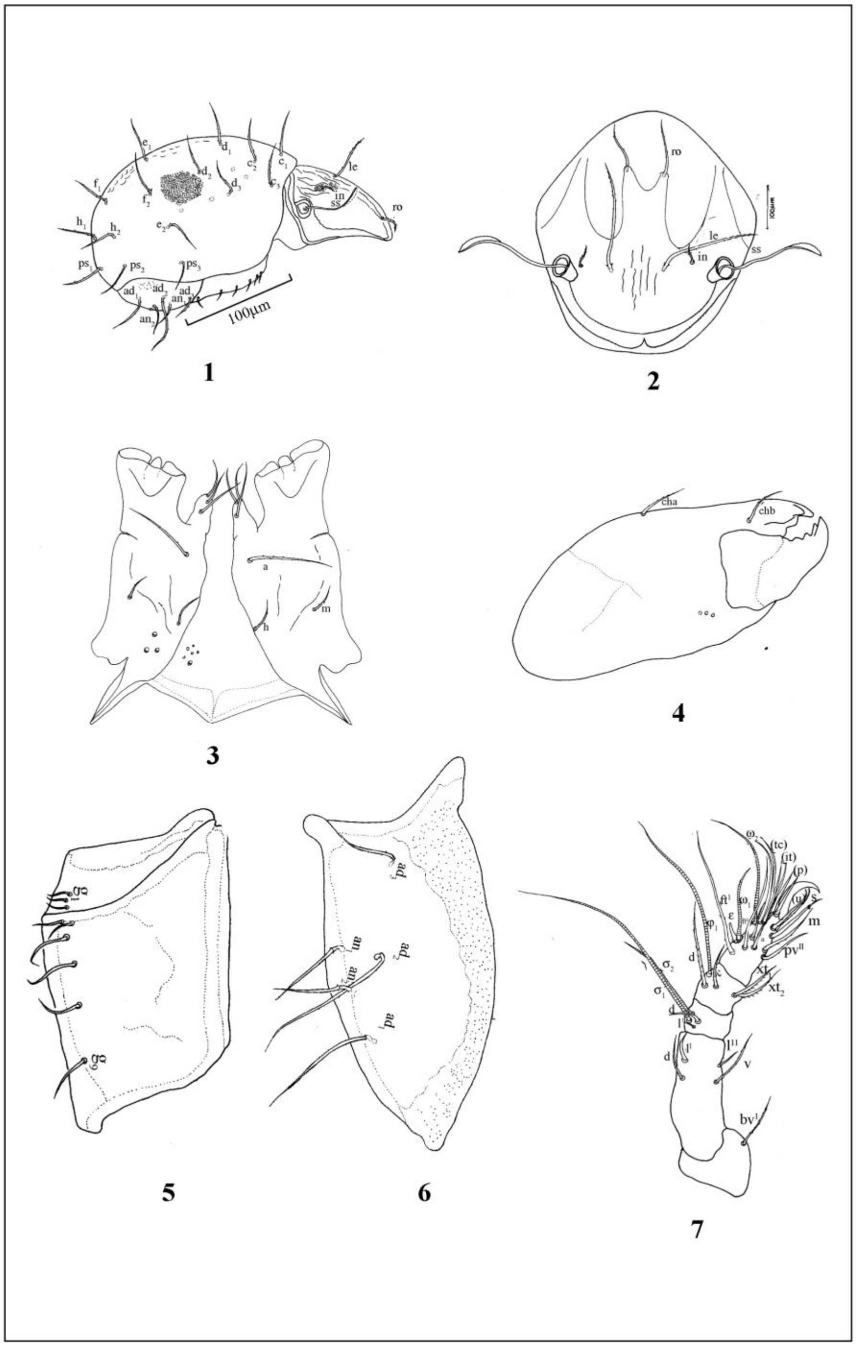
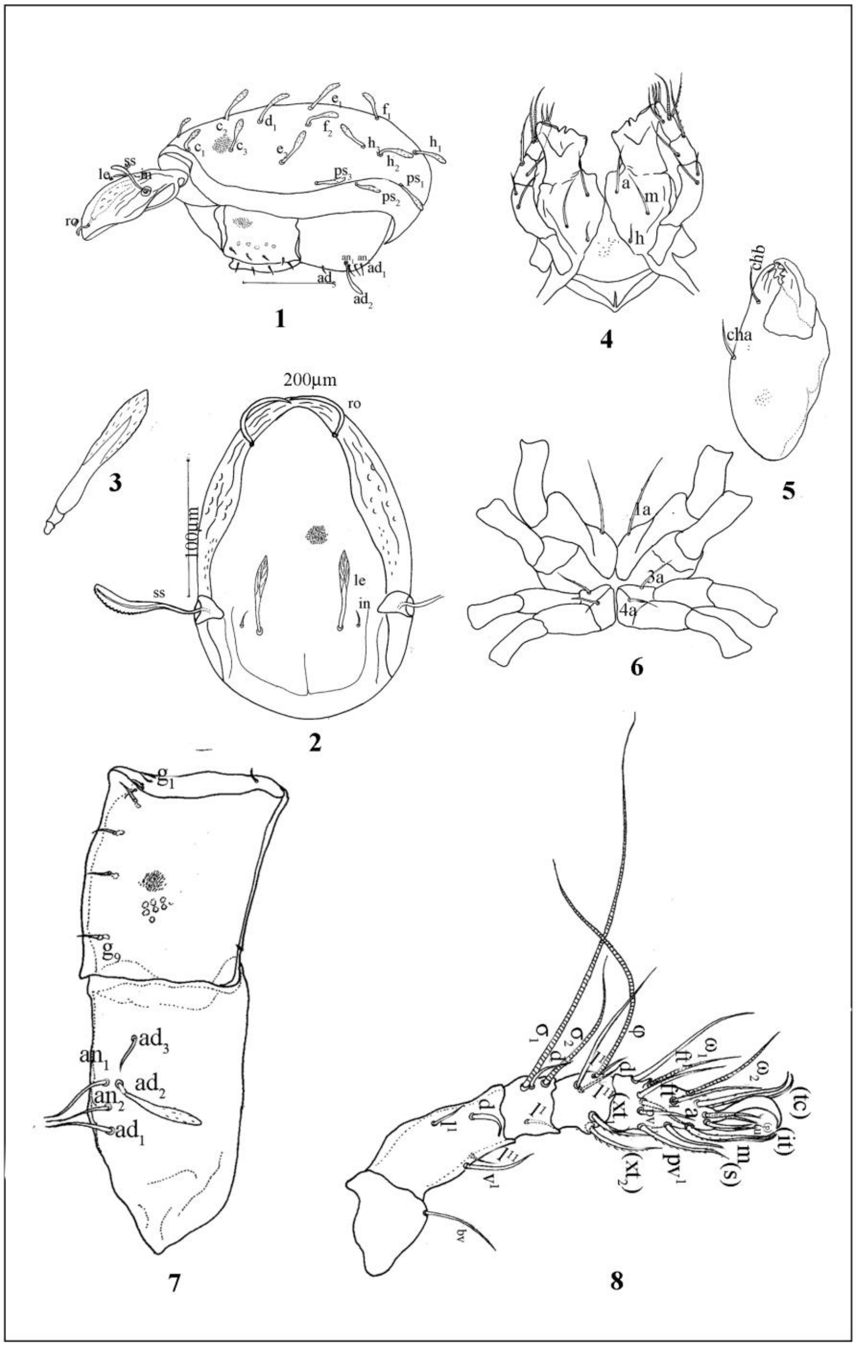
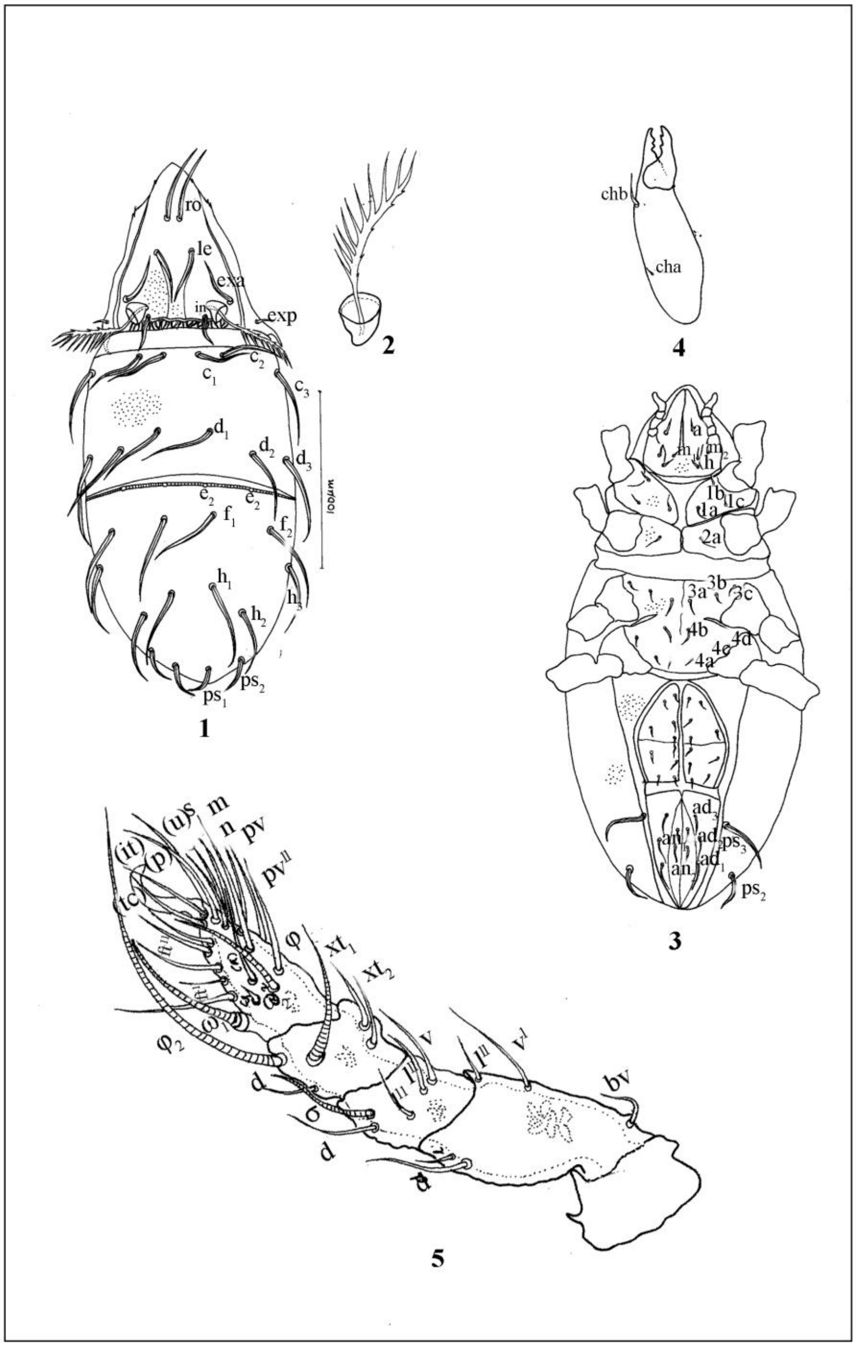


PLATE 6



1
2
3
4
5
6
7
8
200µm
100µm
ro
ss
le
in
c_1
c_2
c_3
d_1
e_1
e_2
f_1
f_2
h_1
h_2
h_3
ps_1
ps_2
ps_3
ad_1
ad_2
ad_3
an
a
m
h
chb
cha
1a
3a
4a
g_1
g_9
an_1
an_2
σ_1
σ_2
φ
ω_1
ω_2
ft
(tc)
(it)
m
(s)
pv^1
(xt_1)
(xt_2)
bv

PLATE 7



ro
le
exa
in
exp
c1
c2
c3
d1
d2
d3
e2
f1
f2
h1
h2
h3
ps1
ps2
1
2
chb
cha
4
a
m1
m2
h
1b
1c
da
2a
3a
3b
3c
4b
4c
4d
4a
ad3
ad2
ad1
an1
an2
ps3
ps2
3
(it)
(p)
(u)
s
m
n
pv
tc
φ
xt1
xt2
v
bv
d
φ2
5

PLATE 8

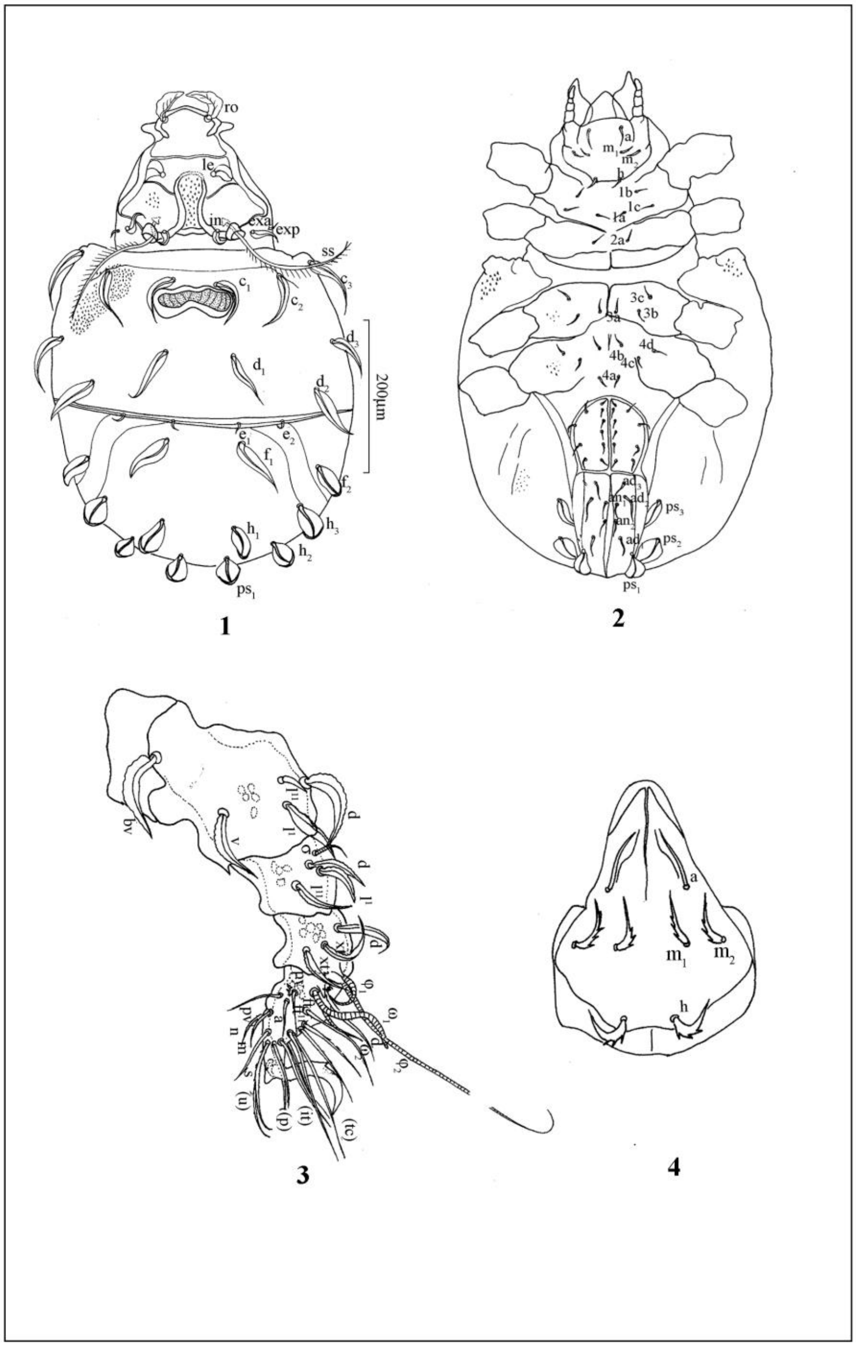
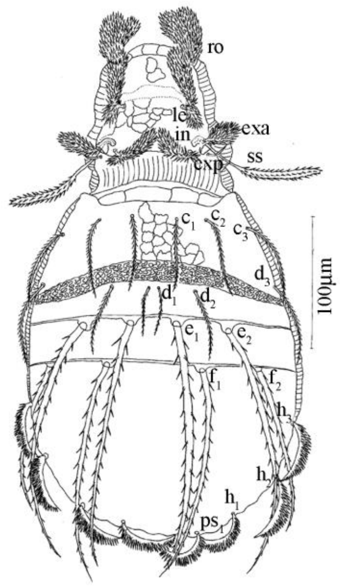

ro
le
in
exa
exp
ss
c1
c2
c3
d1
d2
d3
200µm
e1
e2
f1
f2
h1
h2
h3
ps1
1
a
m1
m2
h
1b
1c
1a
2a
3c
3b
3a
4b
4d
4c
4a
ad3
ad2
ad1
an1
an2
ps3
ps2
ps1
2
bv
v
l'
l''
d
σ
φ1
ω1
ω2
φ2
3
a
m1
m2
h
4

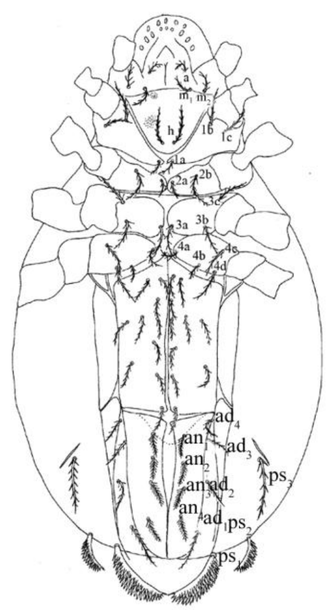
PLATE 9

1



ro
lc
in
exa
exp
ss
c1
c2
c3
d3
d1
d2
100µm
e1
e2
f1
f2
h3
h2
h1
ps1

2



a
m1
m2
h
1b
1c
1a
2a
2b
3c
3a
3b
4a
4b
4c
4d
ad4
an1
ad3
an2
an3
ad2
ps3
an4
ad1
ps2
ps1

PLATE 10

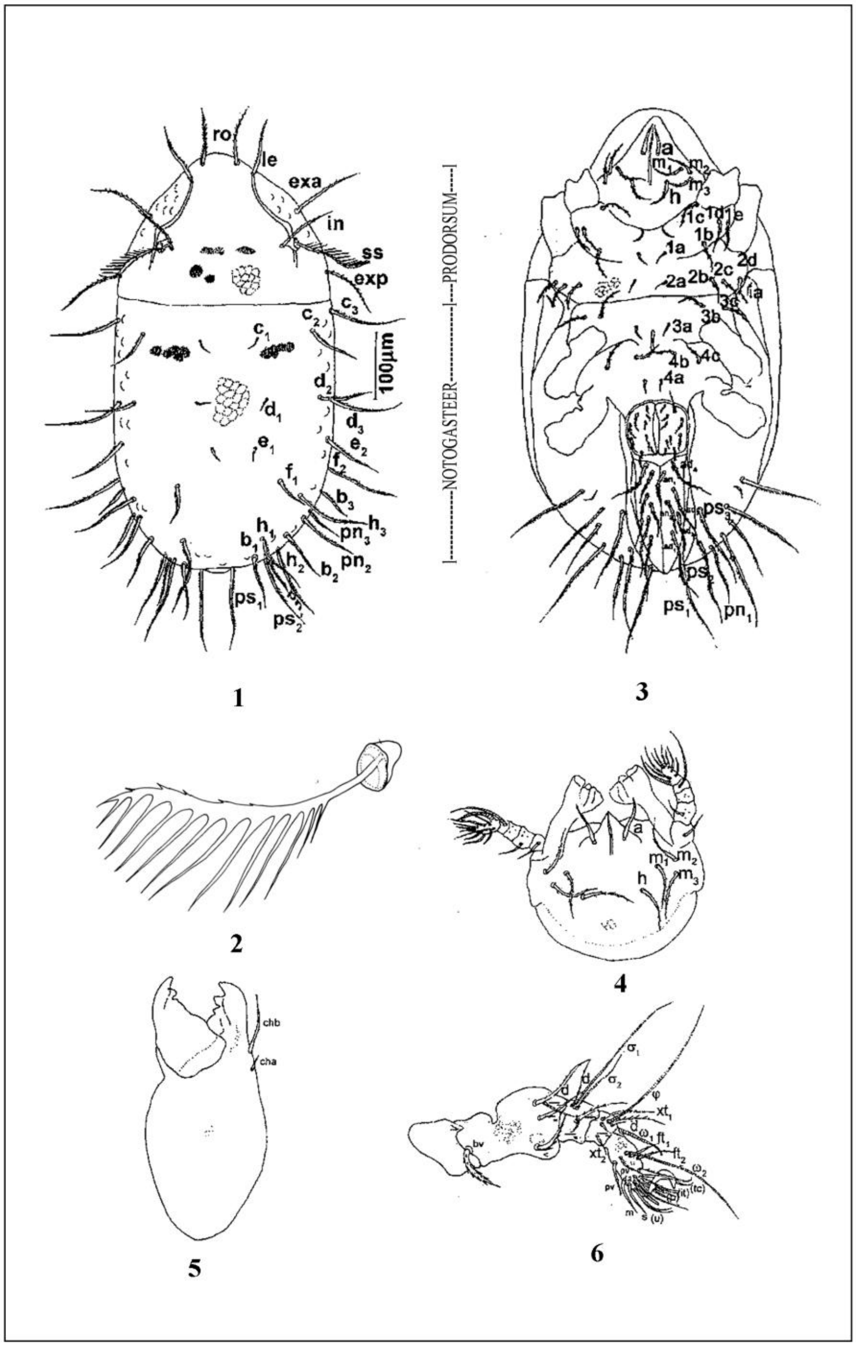
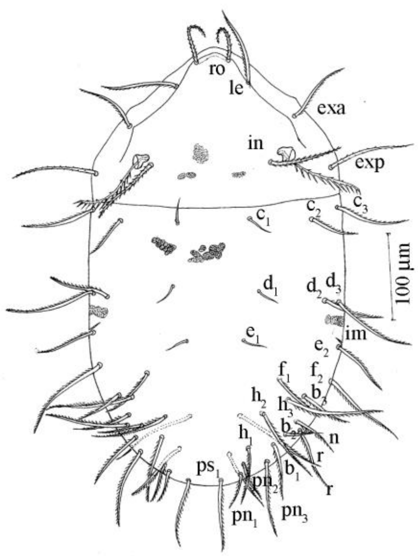
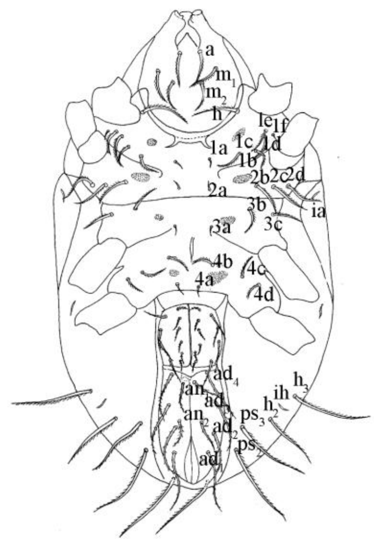

ro
le
exa
in
ss
exp
c_1
c_2
c_3
100µm
d_1
d_2
d_3
e_1
e_2
f_1
f_2
b_1
b_2
b_3
h_1
h_2
h_3
pn_1
pn_2
pn_3
ps_1
ps_2
ps_3
NOTOGASTEER
PRODORSUM
a
m_1
m_2
m_3
h
1a
1b
1c
1d
1e
2a
2b
2c
2d
3a
3b
3c
4a
4b
4c
1
2
3
4
5
6
chb
cha
σ_1
σ_2
φ
xt_1
xt_2
ω_1
ω_2
ft_1
ft_2
bv

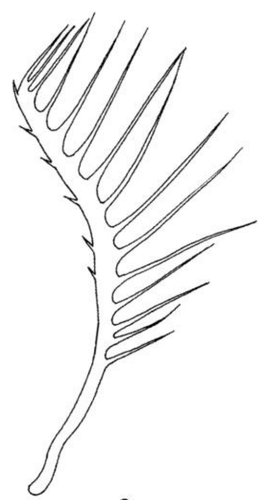
PLATE 11



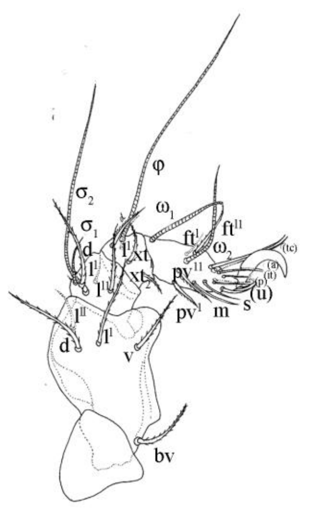
1



2



3



4

PLATE 12

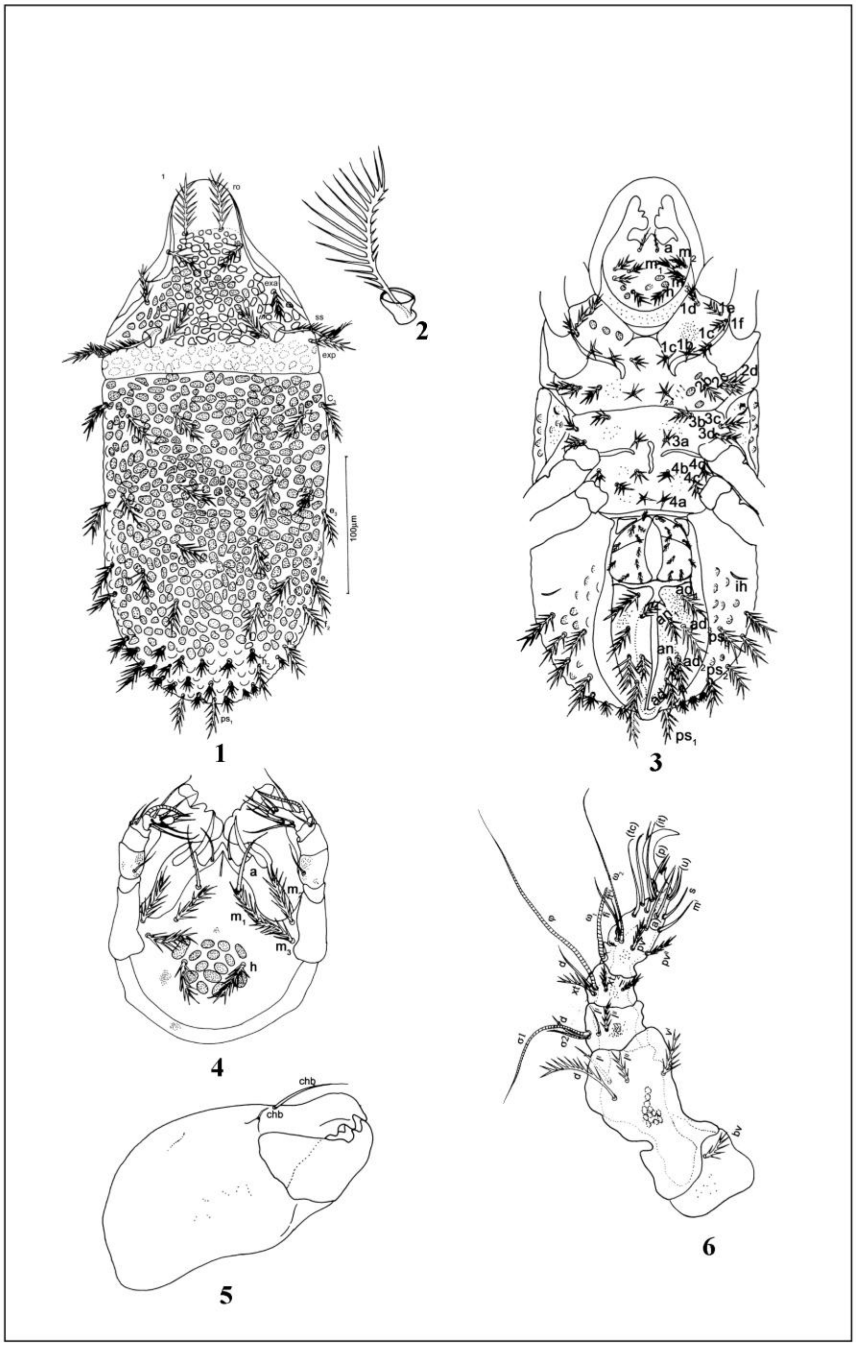
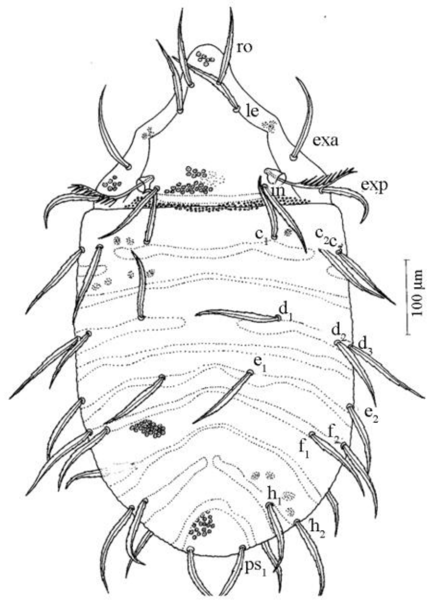


PLATE 13

1


ro
le
exa
exp
in
c1
c2
c3
100 µm
d1
d2
d3
e1
e2
f1
f2
h1
h2
ps1

2

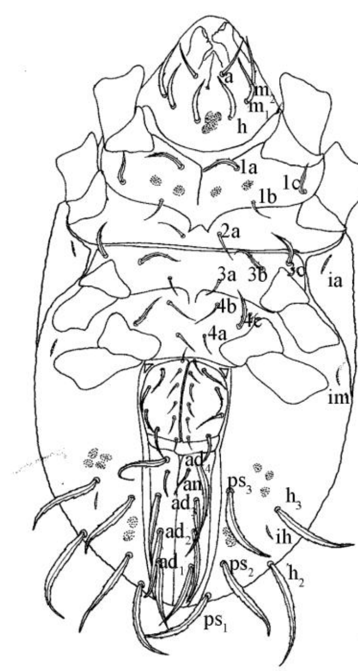
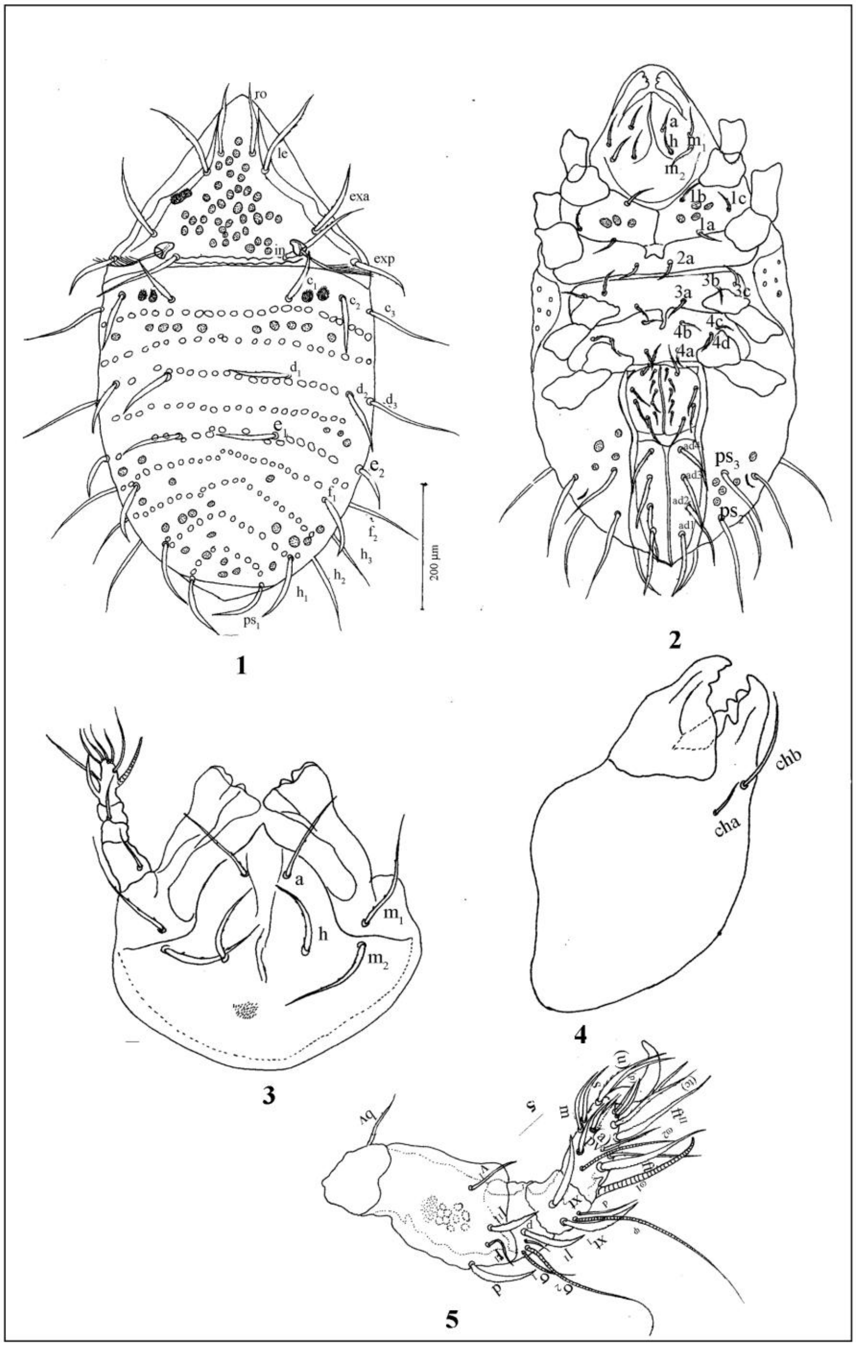

a
m2
m1
h
1a
1c
1b
2a
3a
3b
3c
ia
4b
4c
4a
im
ad4
an
ad
ps3
h3
ad2
ih
ad1
ps2
h2
ps1

PLATE 14



ro
le
exa
in
exp
c_1
c_2
c_3
d_1
d_2
d_3
e_1
e_2
f_1
f_2
h_3
h_2
h_1
ps_1
200 µm
1
a
h
m_1
m_2
1b
1c
1a
2a
3a
3b
3c
4b
4c
4d
4a
ad4
ad3
ad2
ad1
ps_3
ps_2
2
a
h
m_1
m_2
3
chb
cha
4
5

PLATE 15

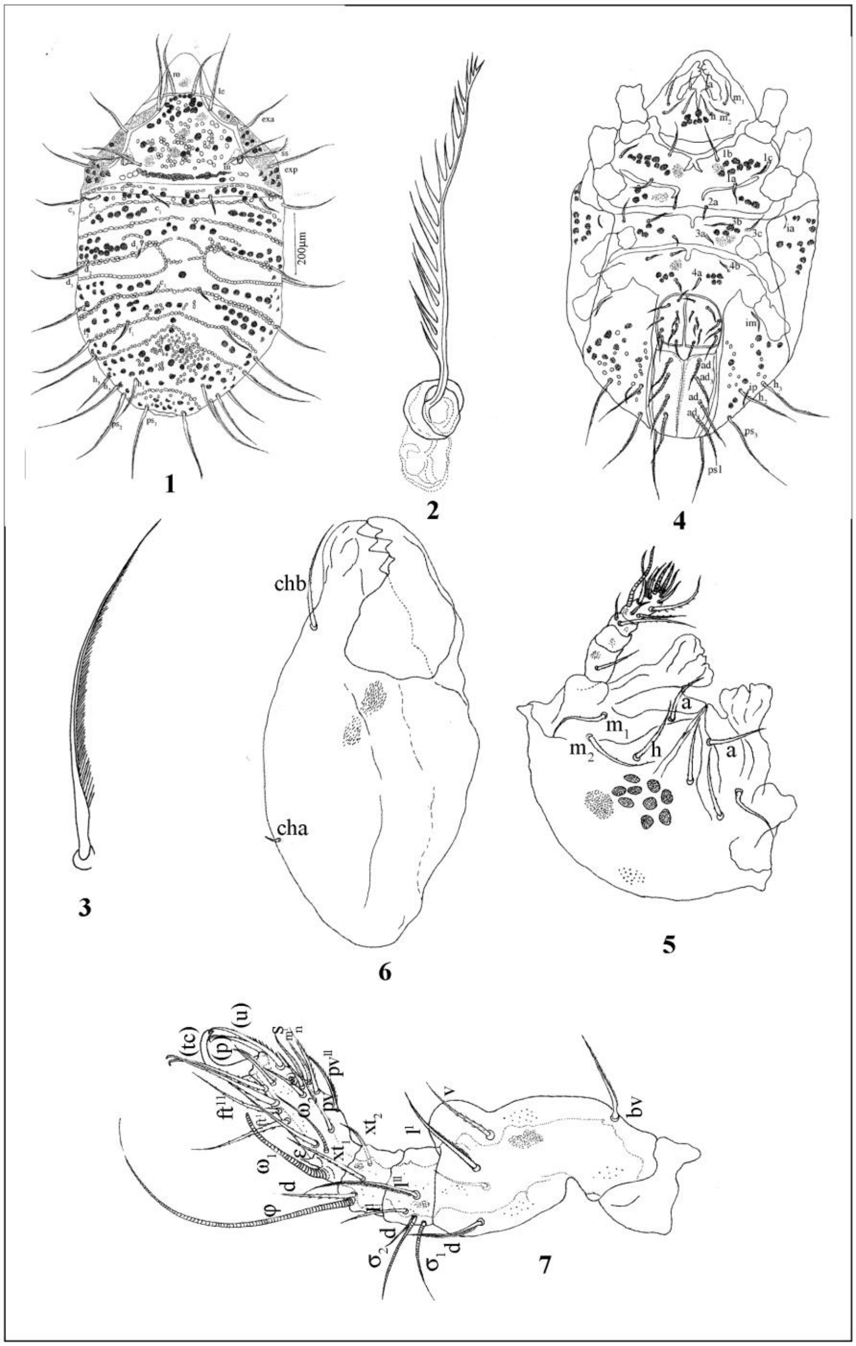


PLATE 16

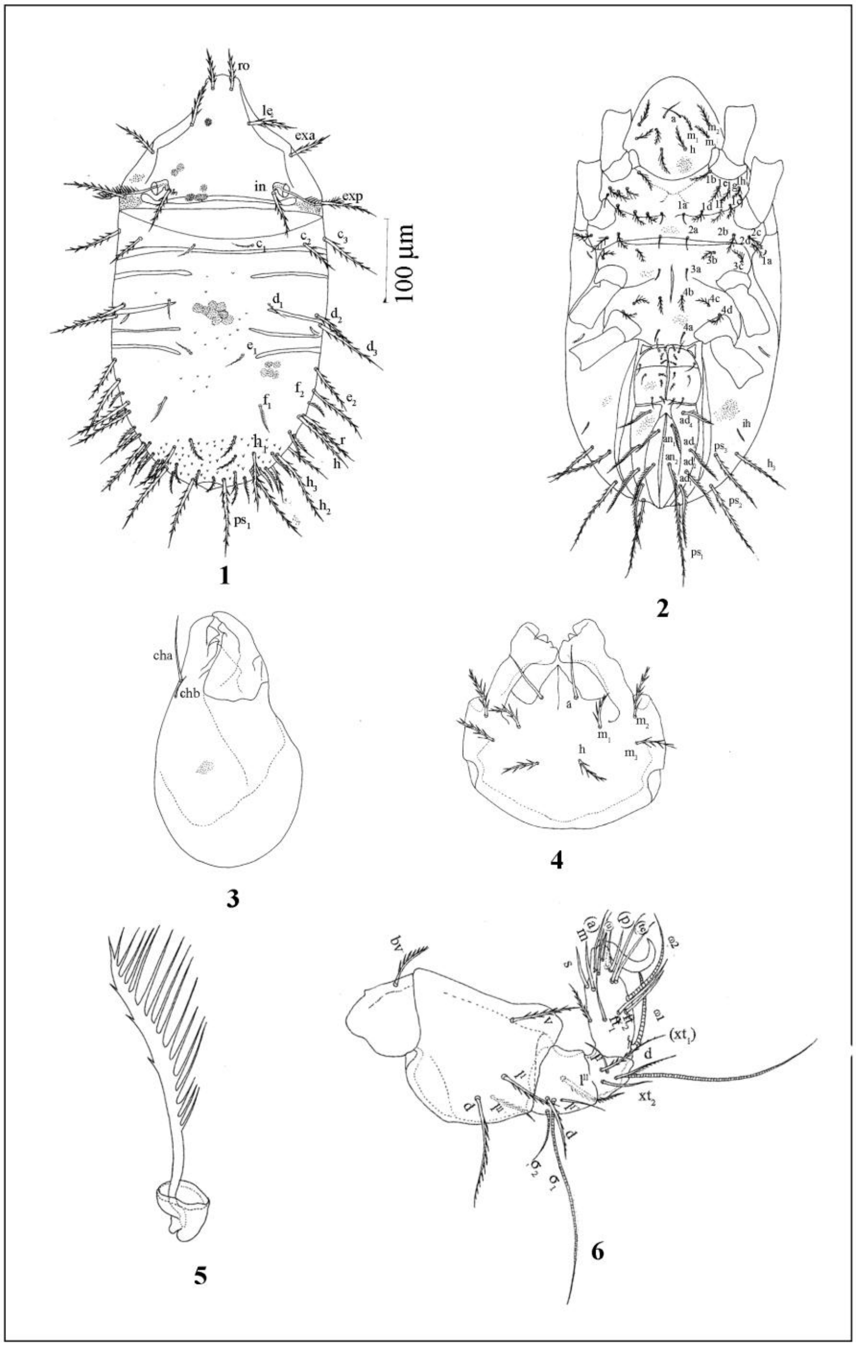
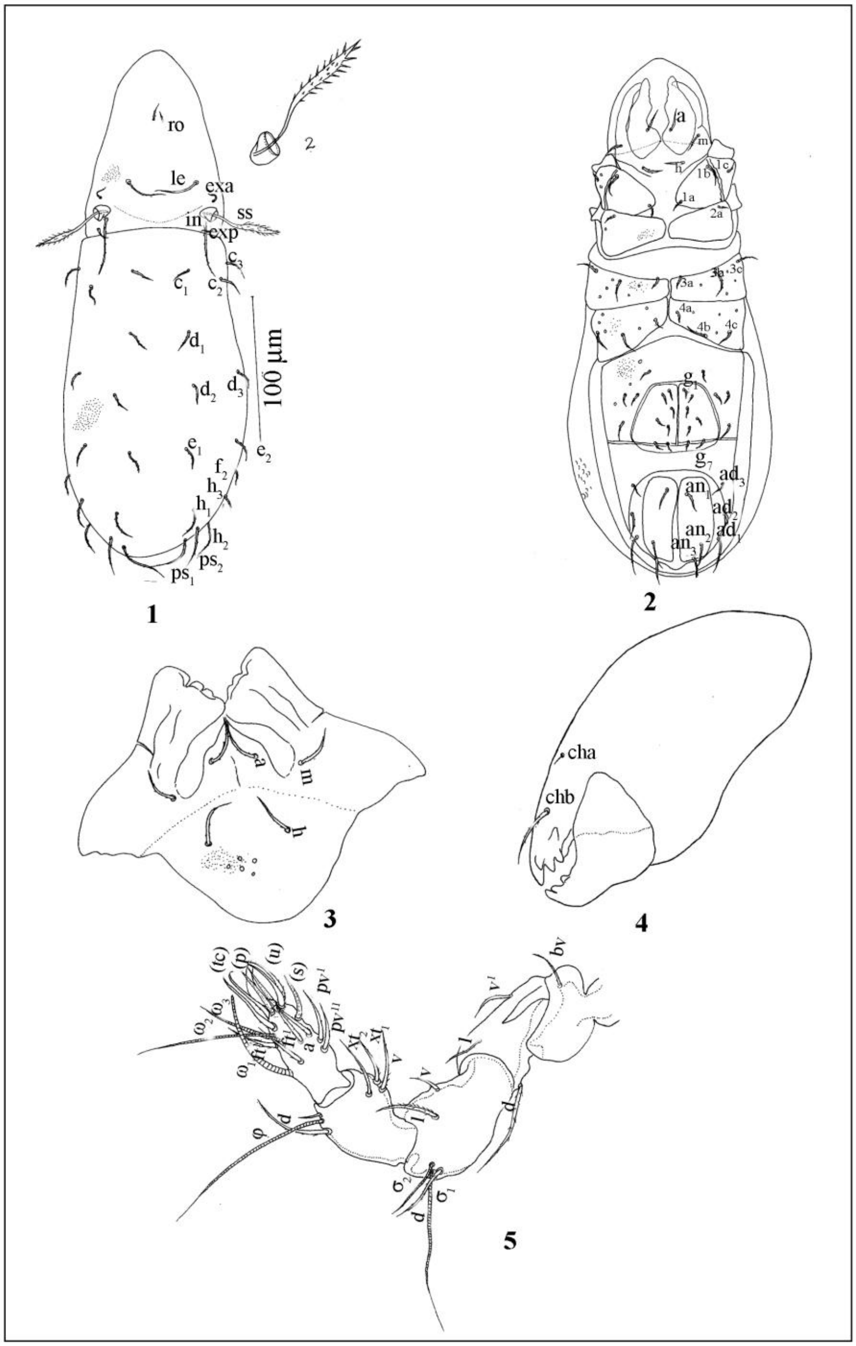


PLATE 17



ro
le
exa
in
ss
exp
c3
c1
c2
100 µm
d1
d2
d3
e1
e2
f2
h3
h1
h2
ps2
ps1
1
a
m
h
1c
1b
1a
2a
3b
3c
3a
4a
4b
4c
g1
g7
ad3
an1
ad2
an2
ad1
an3
2
a
m
h
3
cha
chb
4
(tc)
(p)
(u)
(s)
pv
bv
v
l
d
φ
σ2
σ1
ω1
ω2
5

PLATE 18

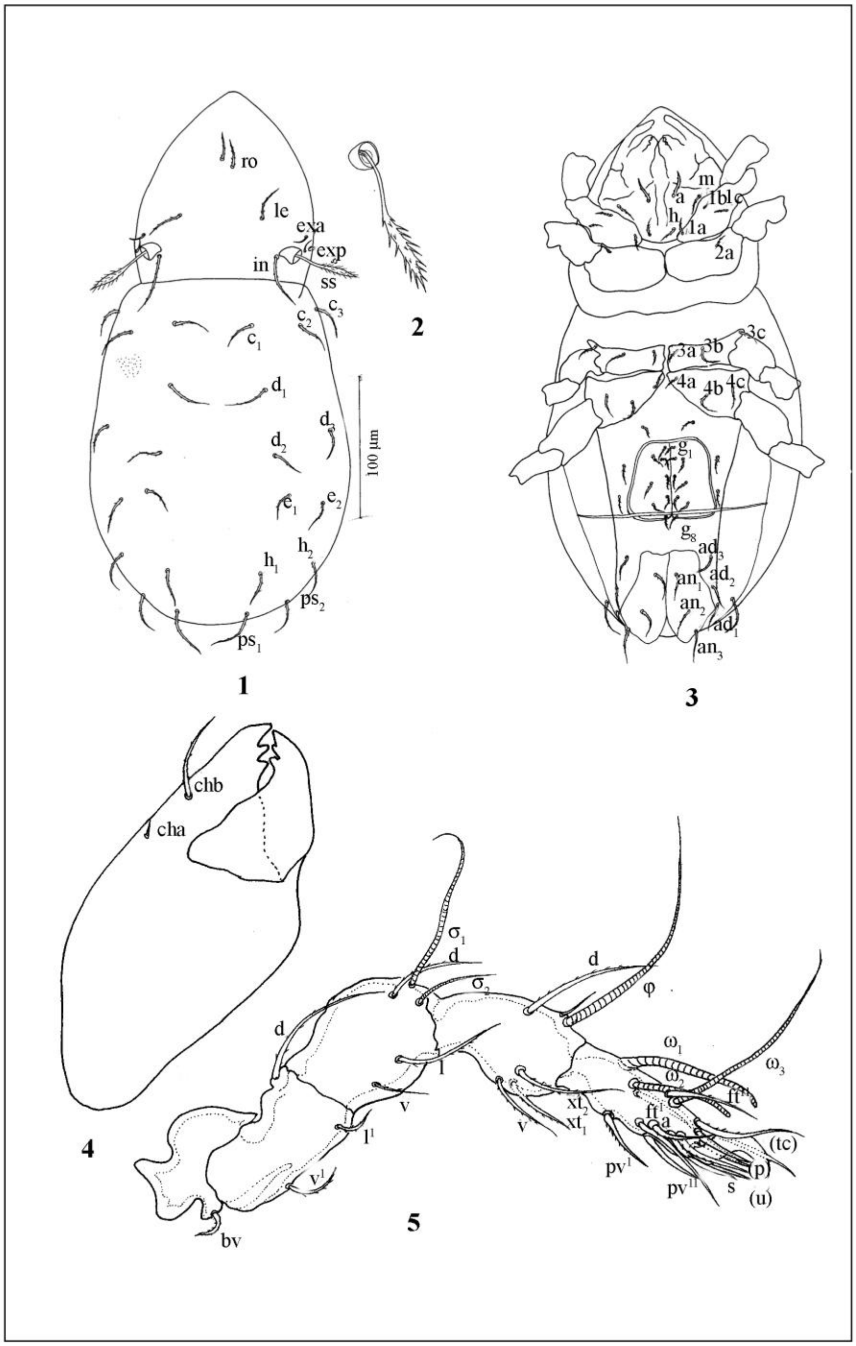
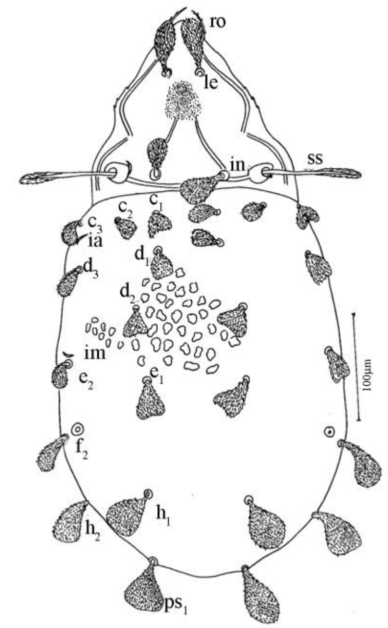
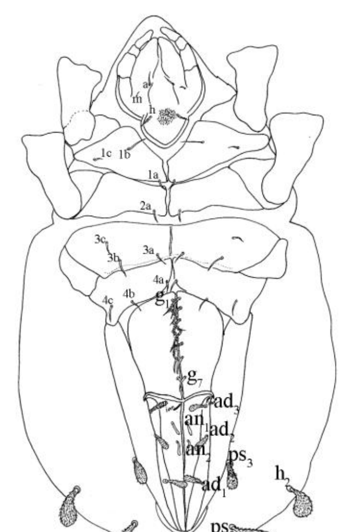

ro
le
exa
exp
in
ss
c_1
c_2
c_3
d_1
d_2
d_3
e_1
e_2
h_1
h_2
ps_1
ps_2
100 µm
1
2
m
a
1b
1c
h
1a
2a
3a
3b
3c
4a
4b
4c
g_1
g_8
ad_3
ad_2
ad_1
an_1
an_2
an_3
3
chb
cha
4
σ_1
d
σ_2
d
l
v
l^1
v^1
bv
d
φ
v
xt_2
xt_1
ω_1
ω_2
ω_3
ft^{11}
ft^1
a
(tc)
(p)
pv^1
pv^{11}
s
(u)
5

PLATE 19



ro
le
ss
in
c_1
c_2
c_3
ia
d_1
d_2
d_3
im
e_1
e_2
f_2
h_1
h_2
ps_1
100µm

1



a
m
h
1c
1b
1a
2a
3c
3b
3a
4a
4c
4b
g_1
g_7
ad_3
an_1
ad_2
an_2
ps_3
h_2
ad_1
ps_2

2

PLATE 20

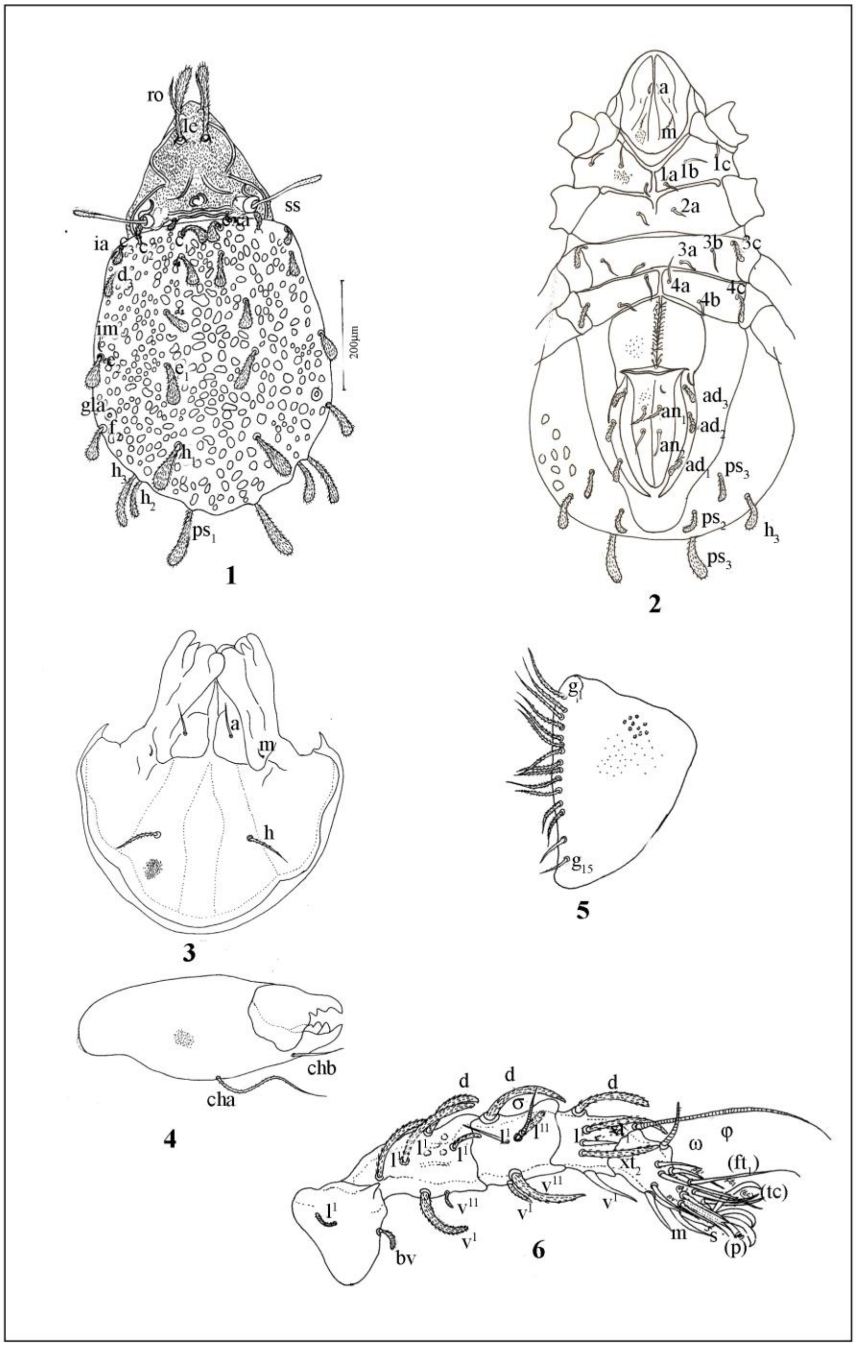
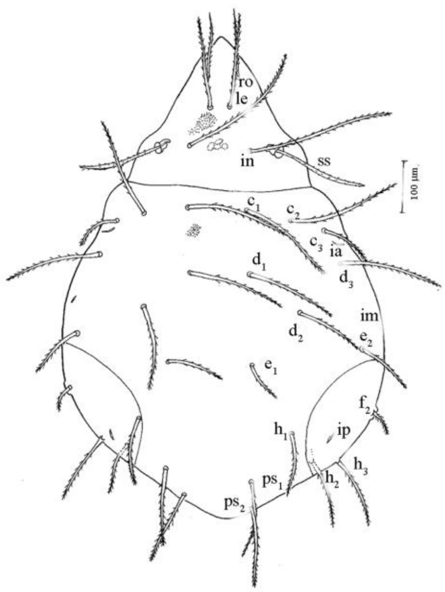
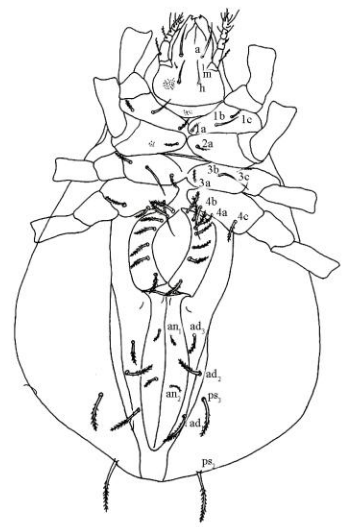

ro
lc
ss
ia
xa
im
gla
200µm
1
a
m
1a
1b
1c
2a
3a
3b
3c
4a
4b
4c
ad$_3$
ad$_2$
ad$_1$
an$_1$
ps$_3$
ps$_2$
h$_3$
2
a
m
h
3
g$_1$
g$_{15}$
5
chb
cha
4
d
σ
ω
φ
(ft$_1$)
(tc)
bv
m
s
(p)
6

PLATE 21



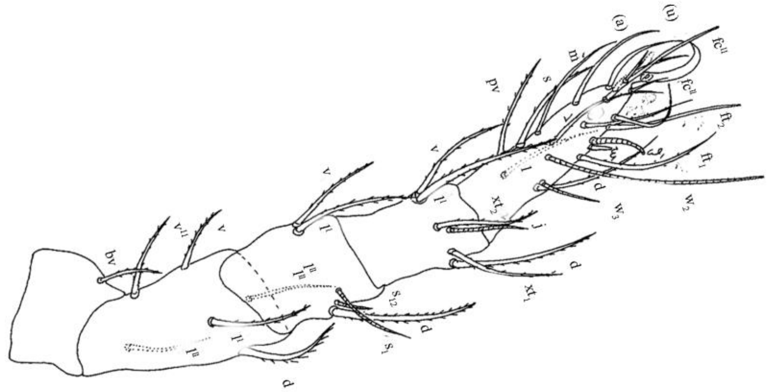
ro
le
in
ss
100 µm
c_1
c_2
c_3
ia
d_1
d_3
im
d_2
e_2
e_1
f_2
h_1
ip
h_3
ps_1
h_2
ps_2

1



a
m
h
1b
1c
1a
2a
3b
3c
3a
4b
4a
4c
an_1
ad_1
ad_2
an_2
ps_3
ad_3
ps_2

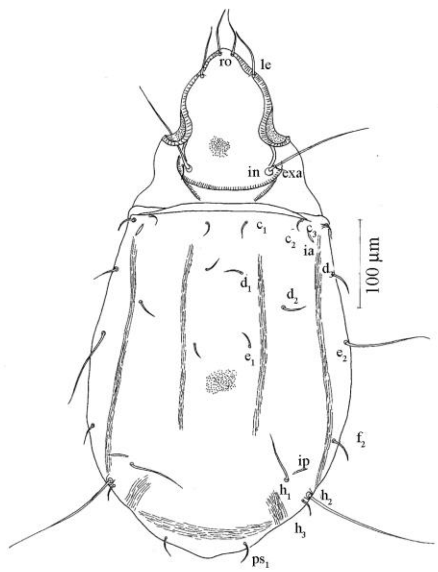
2



(a)
(u)
fc_{II}
fc_{II}
pv
s
ft_2
ft_1
w_2
w_3
xt_2
xt_1
bv
v
S_{12}
S_1
d

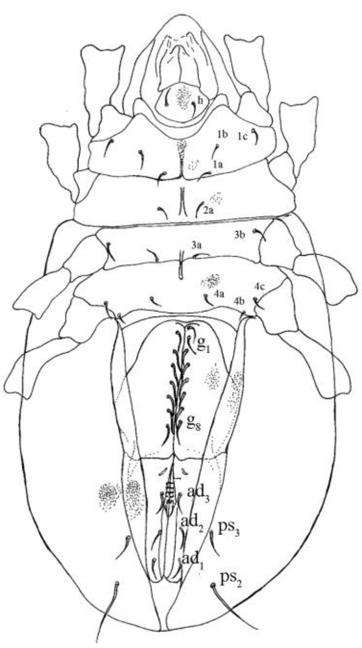
3

PLATE 22



ro
le
in
exa
c_1
c_2
c_3
ia
100 μm
d_1
d_2
d_3
e_1
e_2
f_2
ip
h_1
h_2
h_3
ps_1

1



h
1b
1c
1a
2a
3a
3b
4a
4b
4c
g_1
g_8
ad_3
ad_2
ad_1
ps_3
ps_2

2

PLATE 34

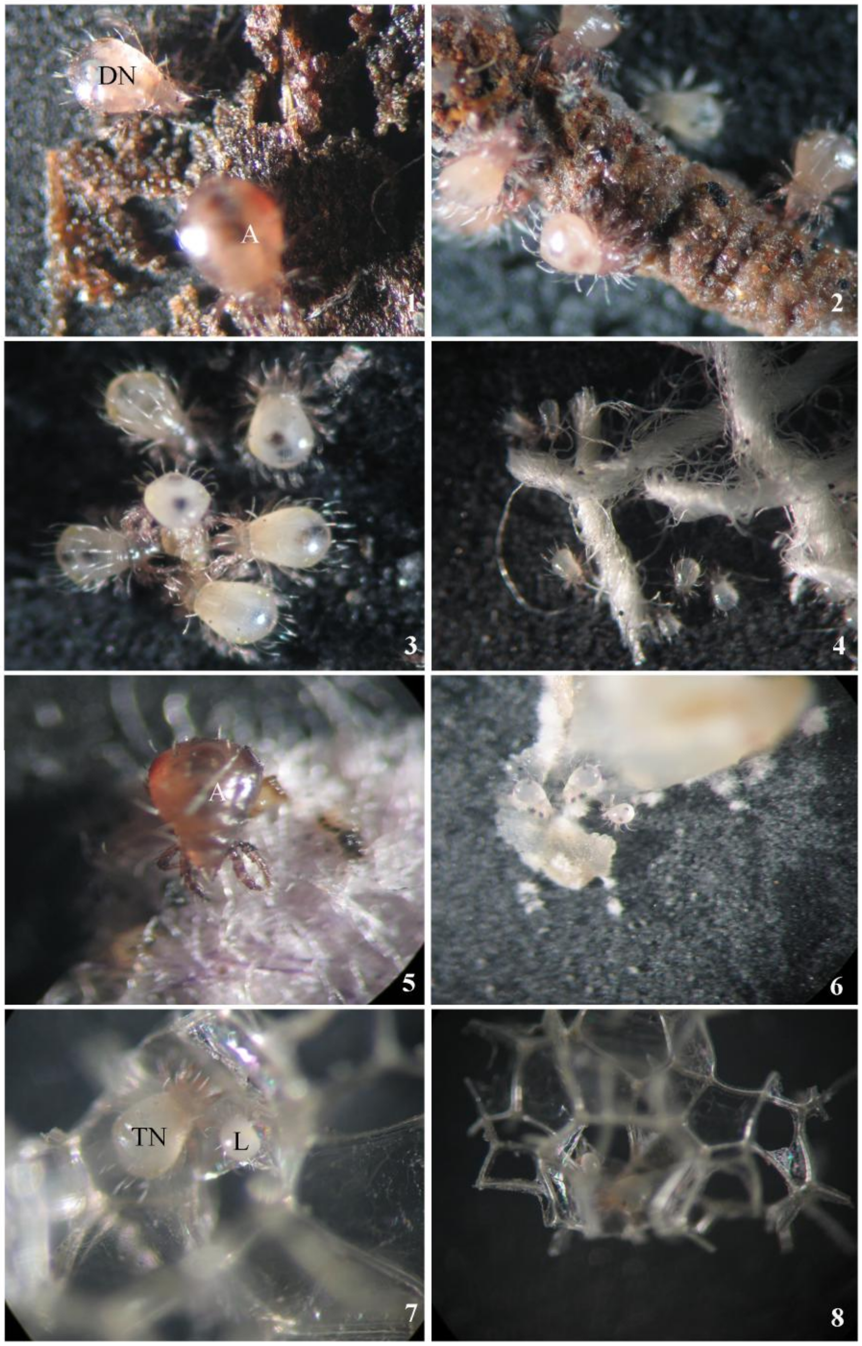
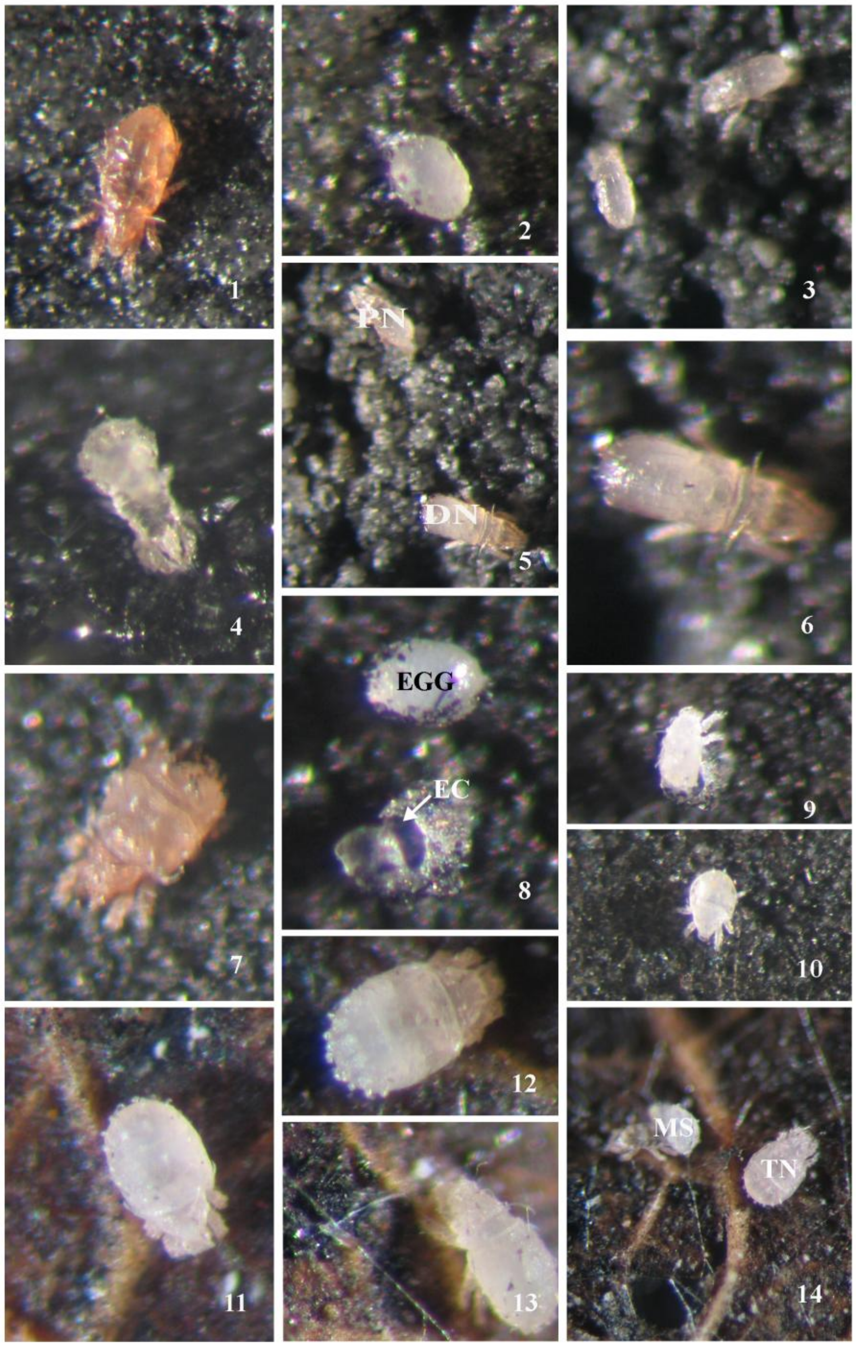


PLATE 23



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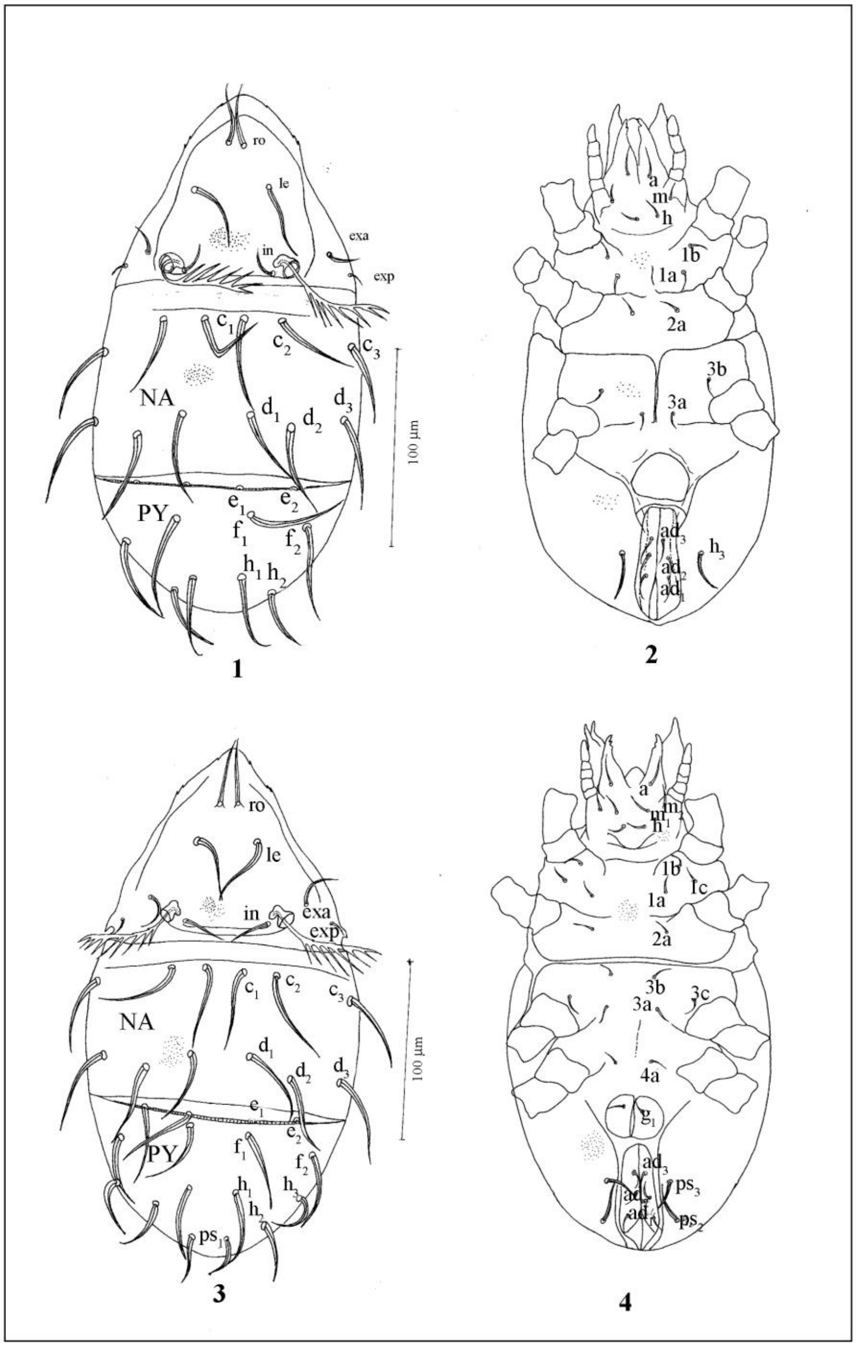
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PLATE 25

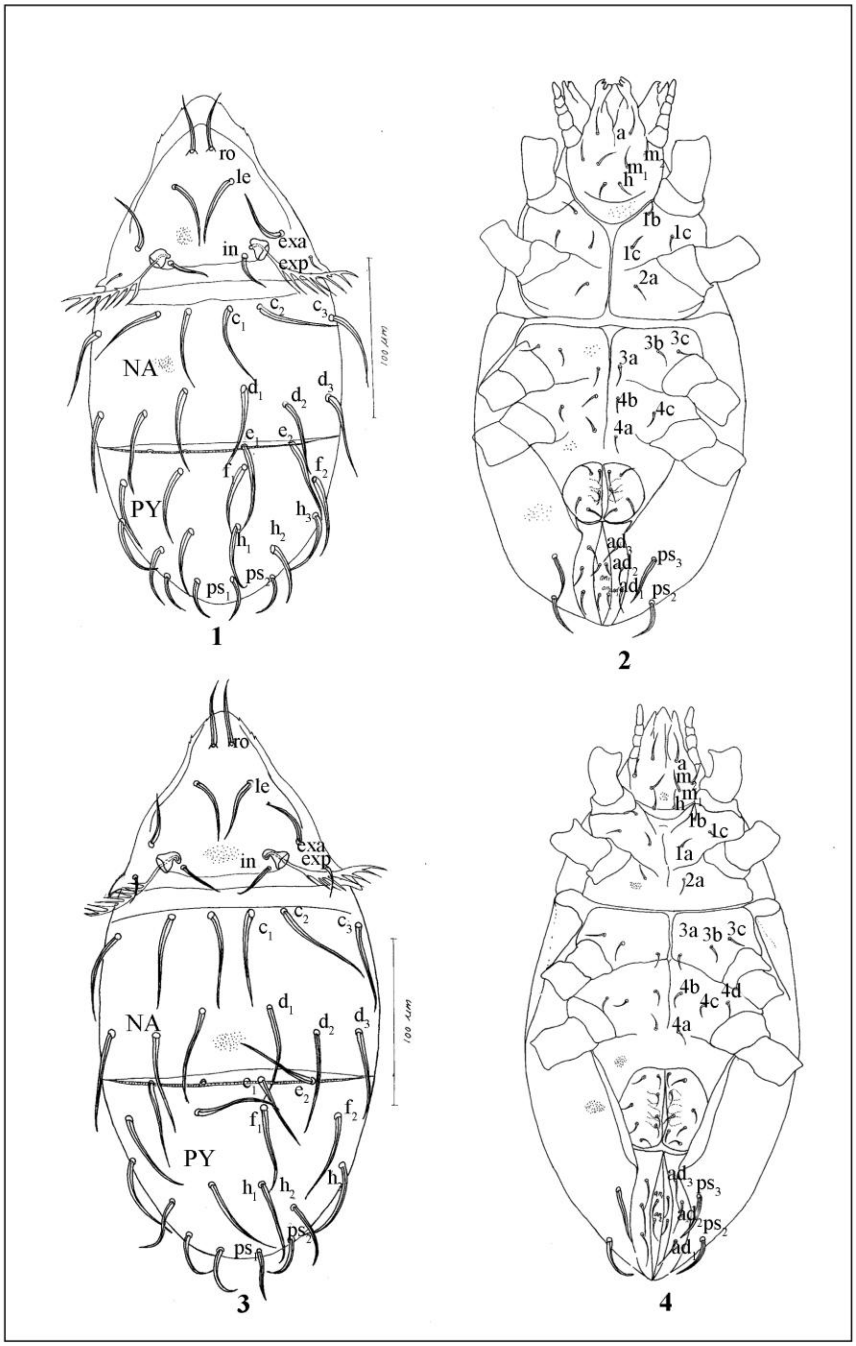

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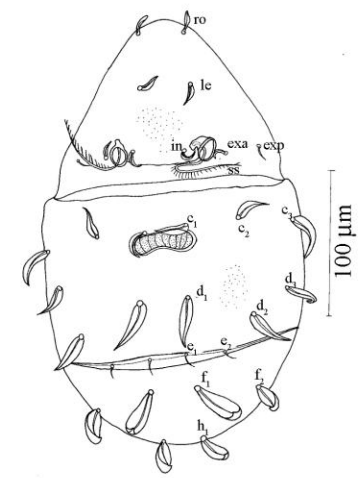
PLATE 26



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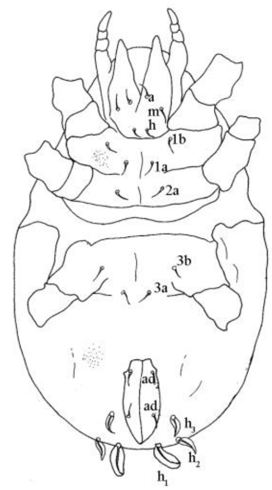

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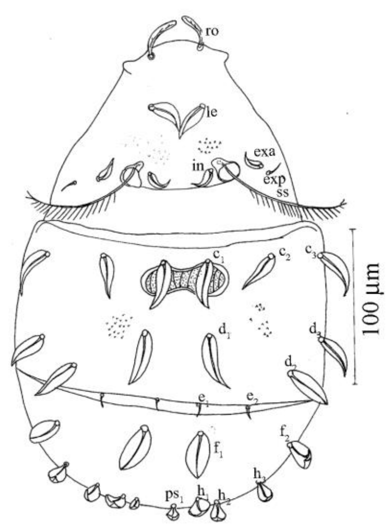

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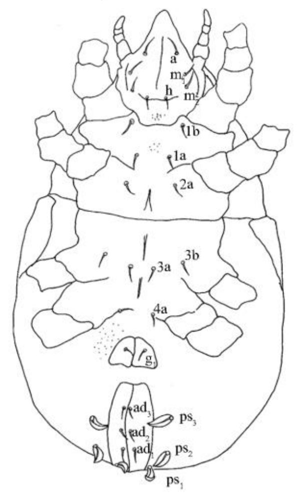

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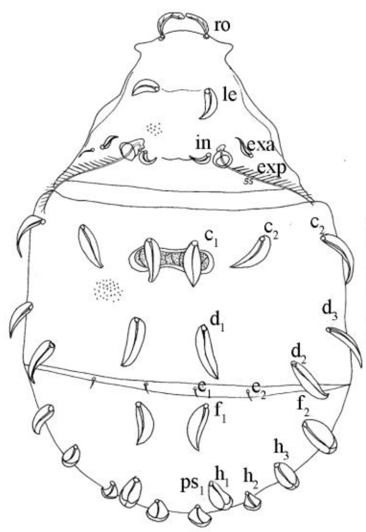

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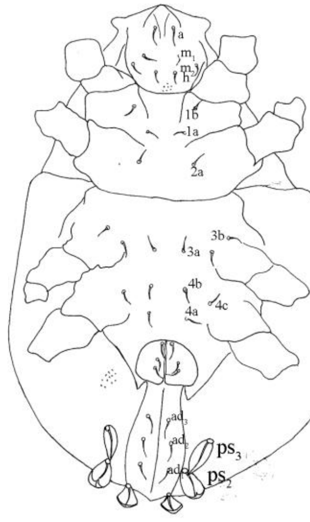

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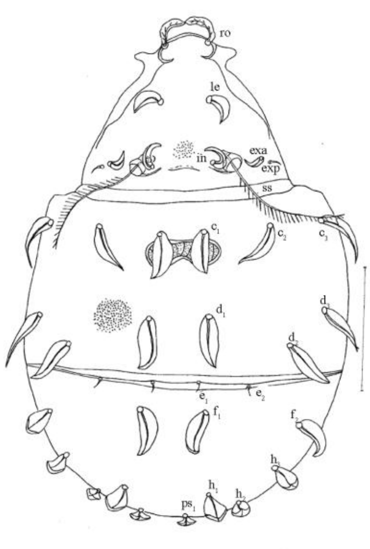

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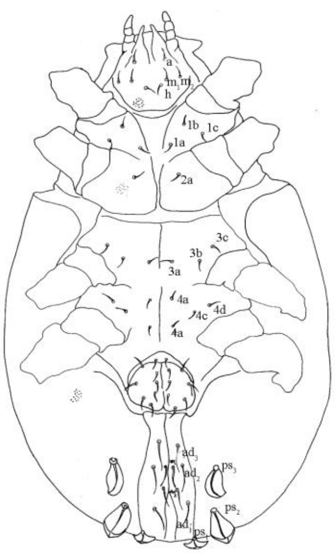

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PLATE 28

PLATE 29

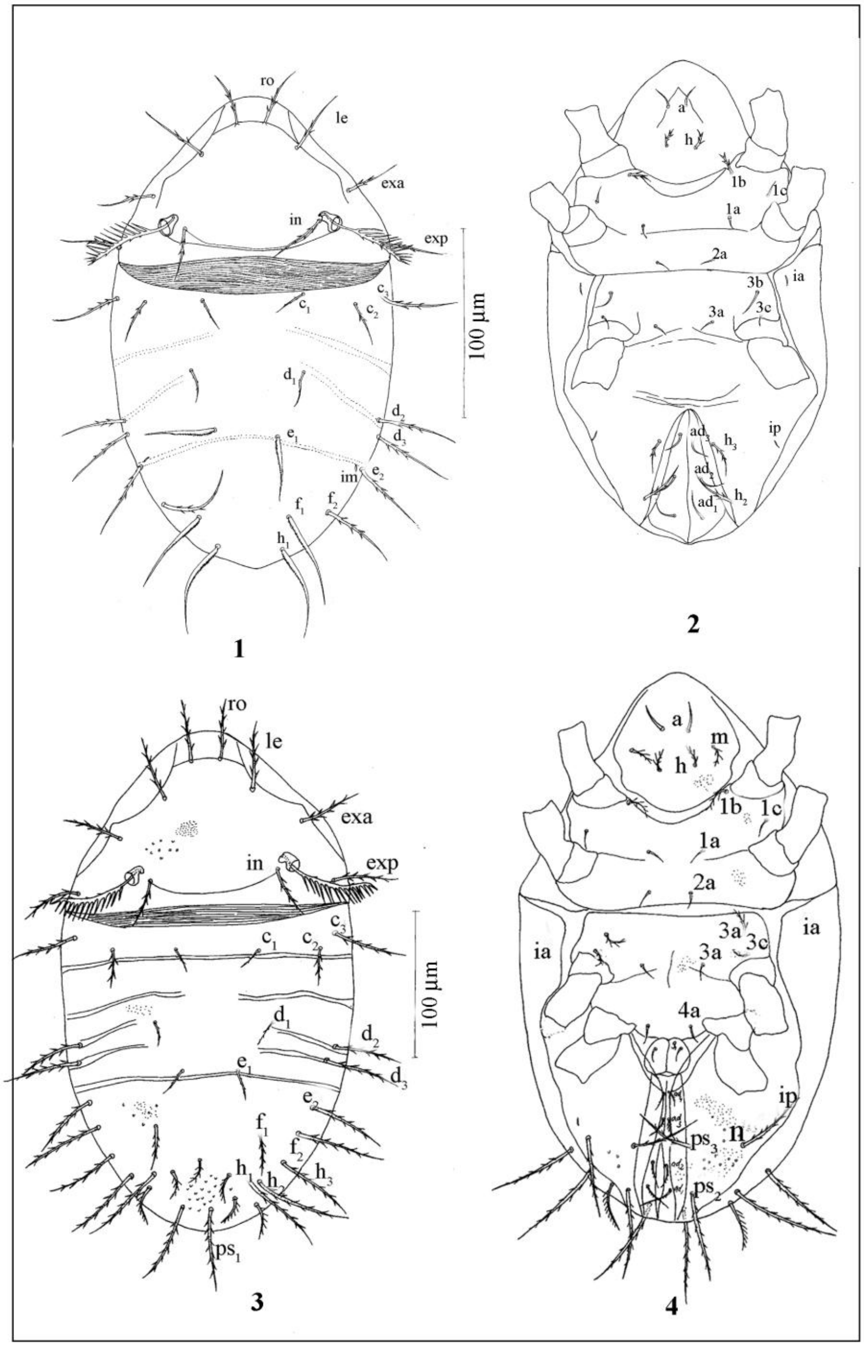

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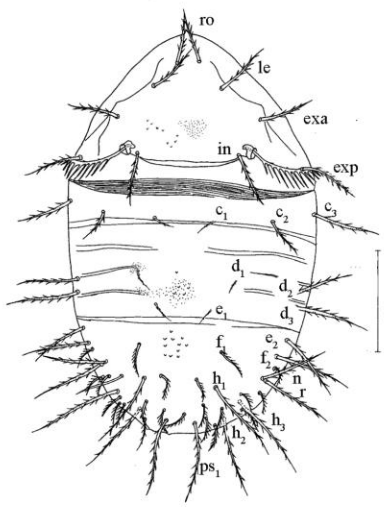
PLATE 30



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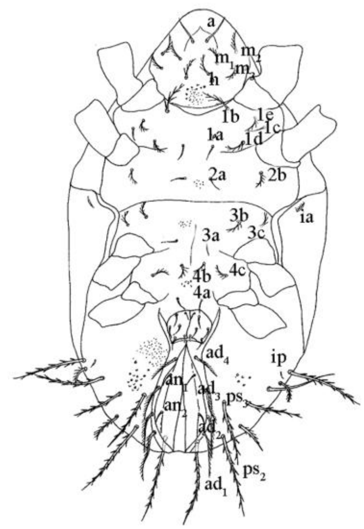

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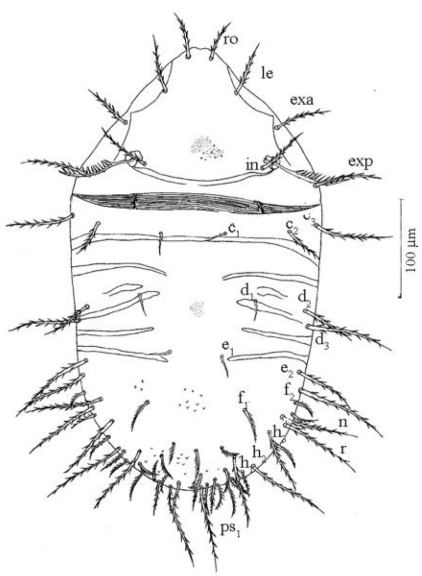

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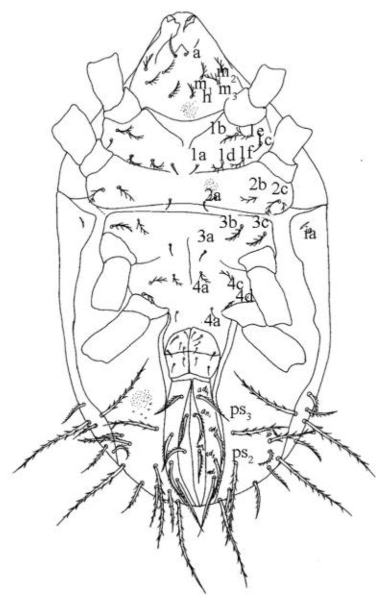

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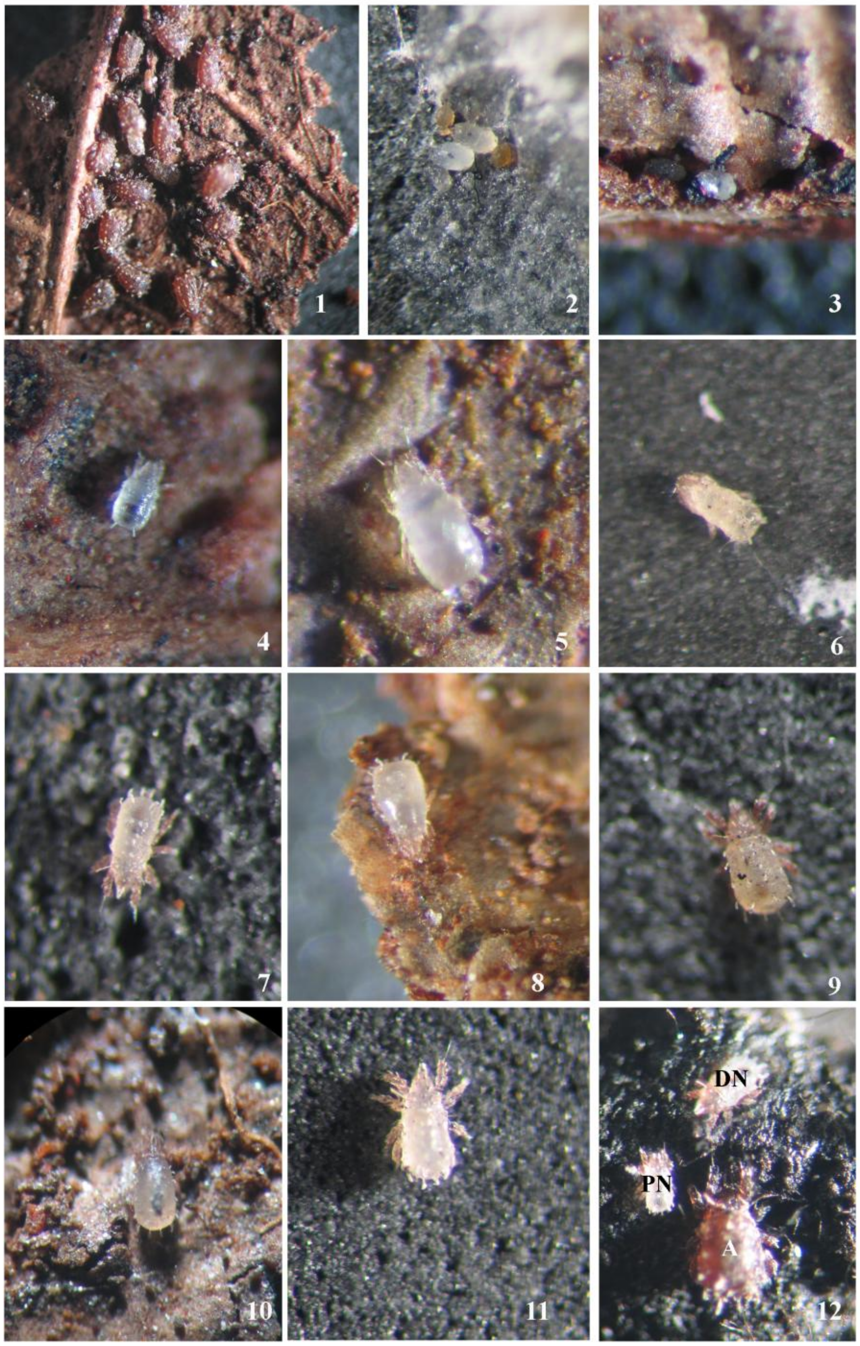

PLATE32

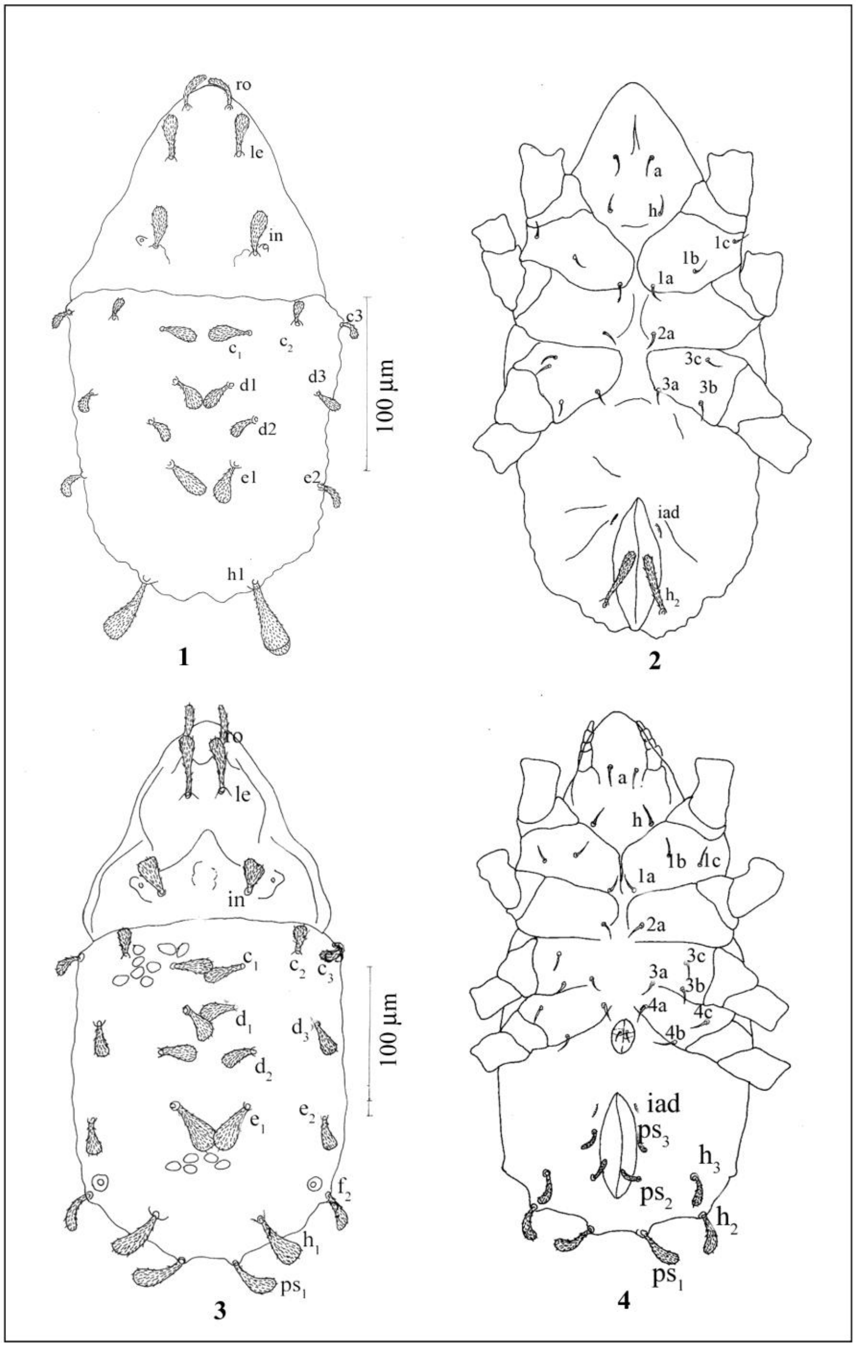

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PLATE 33

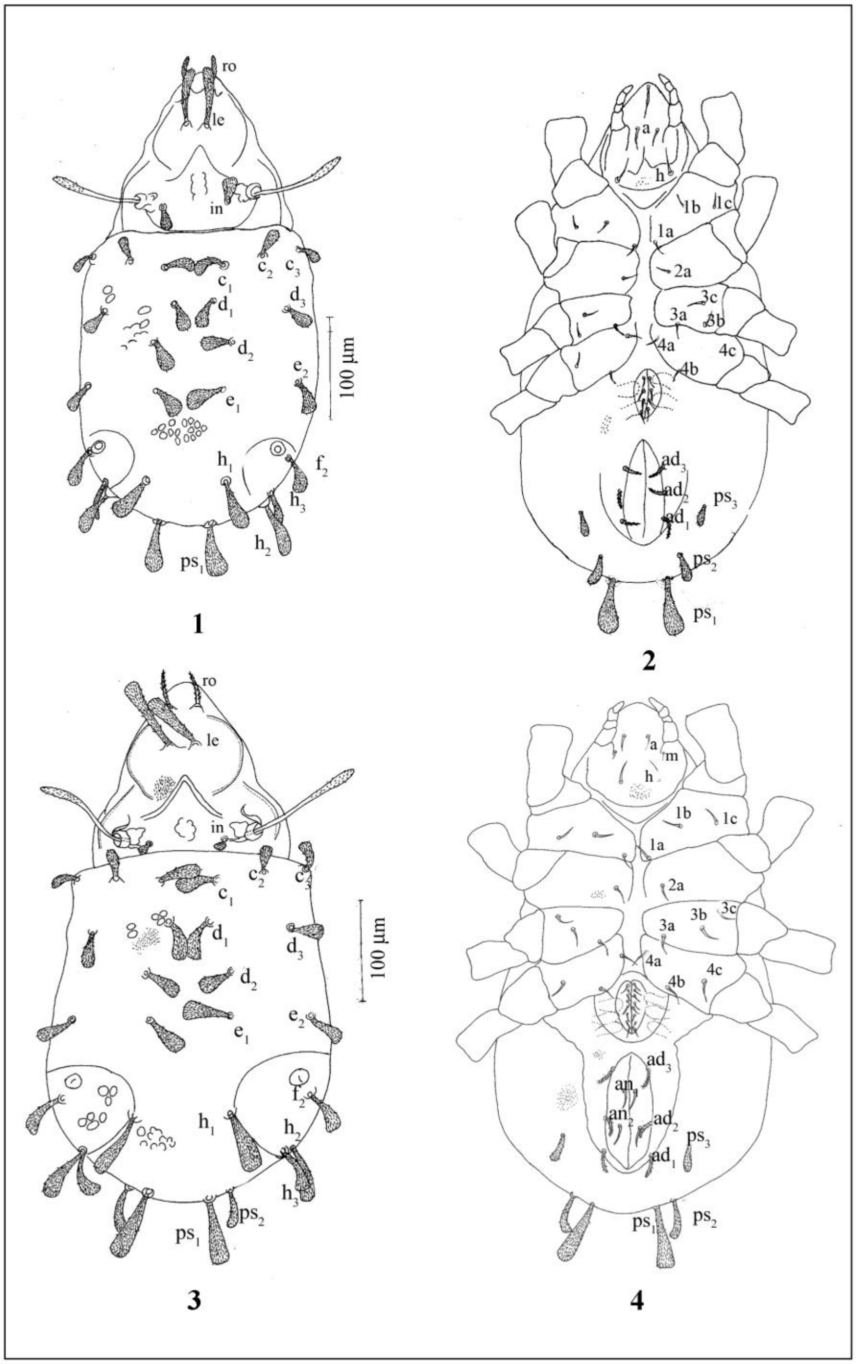

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PLATE 35

PLATE 36

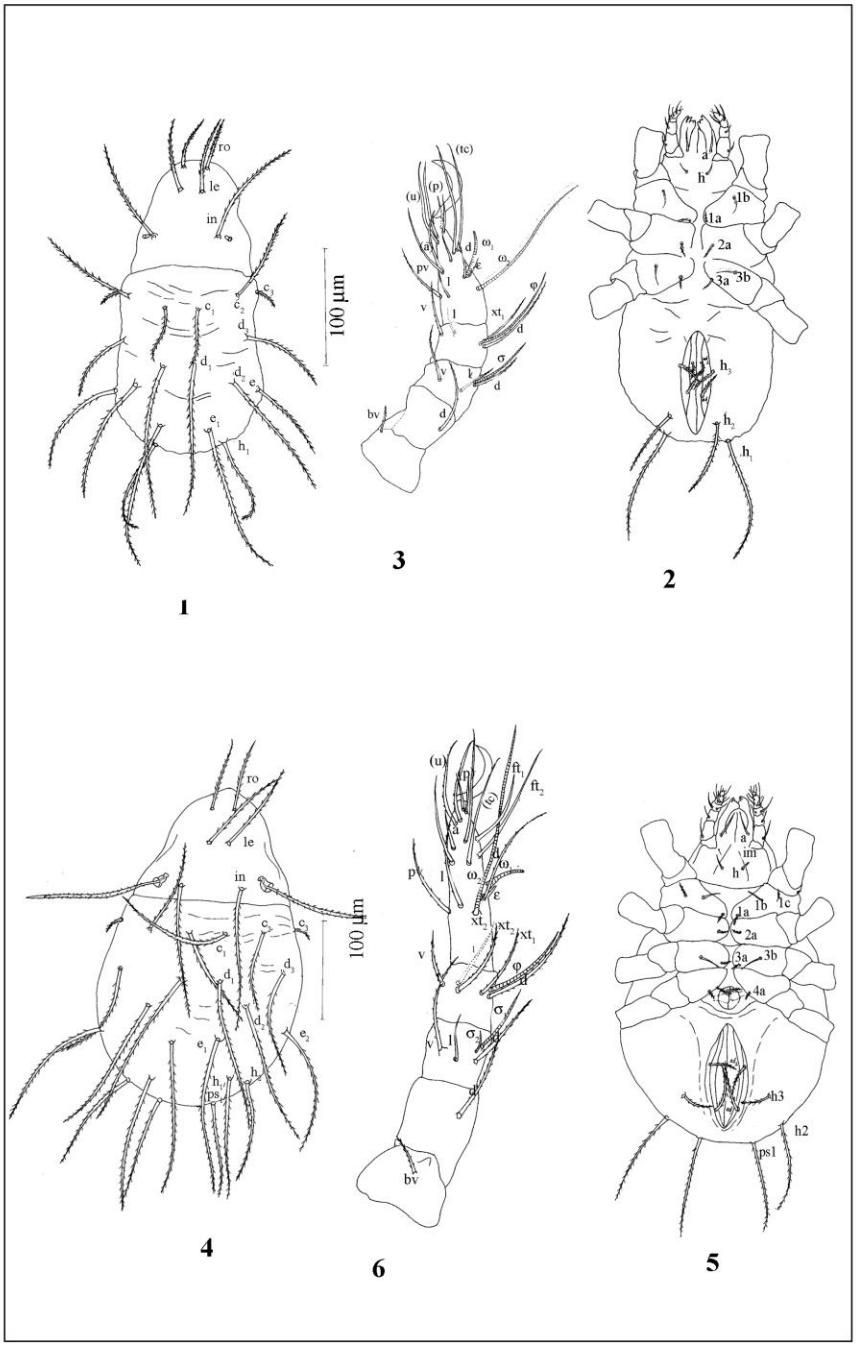

PLATE 37

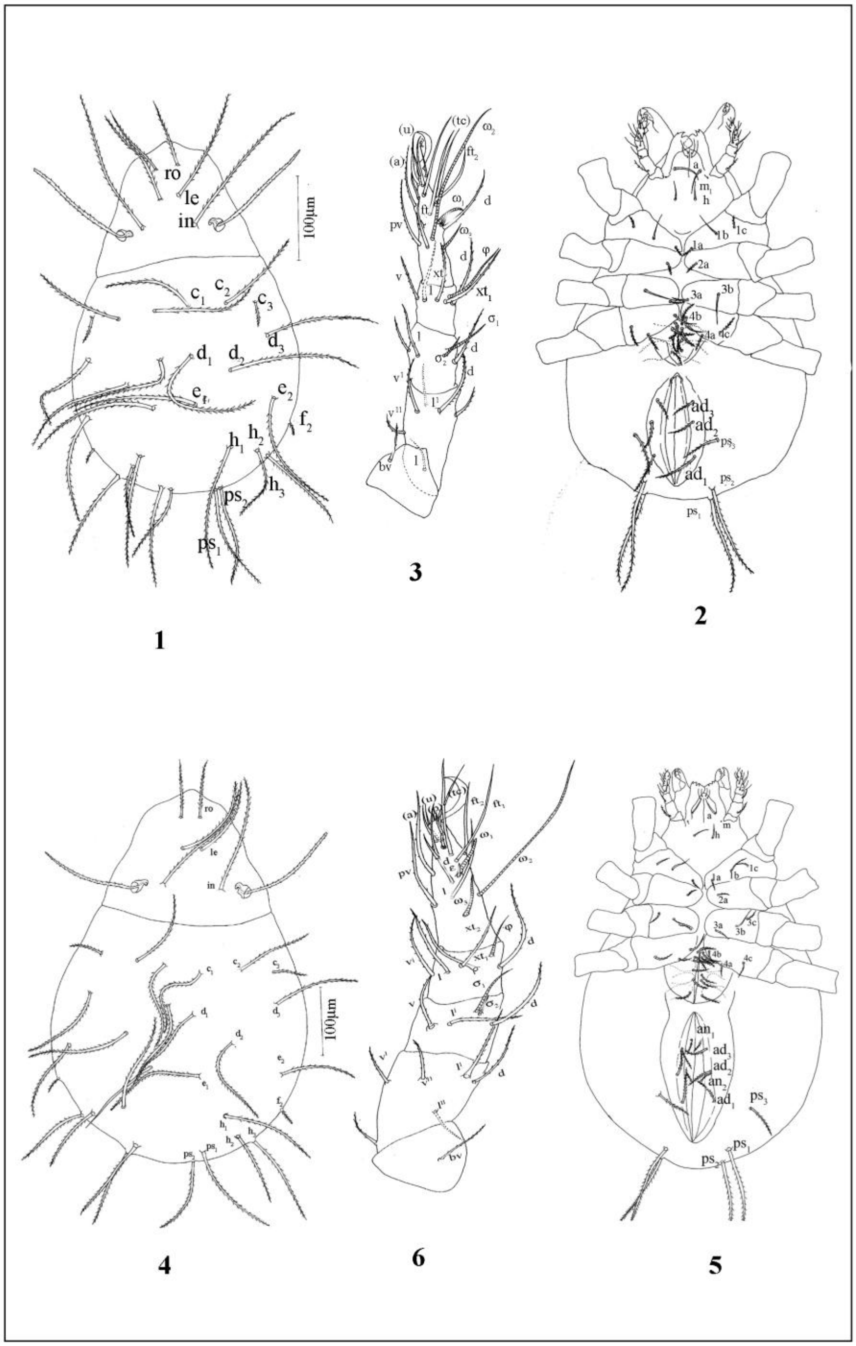

Table 14: Diagnostic features of Life Stages of *Malacoangelia hygricola* sp. nov.

Features / Stages	Larva	Protonymph	Deutonymph	Tritonymph	Adult
Nature of Sensillus	Sensillus pectinate with a bifurcate tip	Sensillus pectinate with a bifurcate tip	Sensillus pectinate with a bifurcate tip	Sensillus pectinate with a bifurcate tip	Sensillus pectinate with a bifurcate tip
Number of notogastral setae	12	16 pairs	16 pairs	16 pairs	16 pairs
Epimeral setal formula	2-1-2	2-1-2-1	2-1-3-3	3-1-3-4	3-1-3-4
Number of genital setae	0	1 pair	3 pairs	8 pairs	10 pairs
Number of genital suckers	0	1 pair	2 pairs	3 pairs	3 pairs
Number of adanal setae	2	3 pairs	3 pairs	3 pairs	3 pairs
Number of anal setae	0	0	0	2 pairs	2 pairs
Legs	3 pairs monodactylous	4 pairs of monodactylous	4 pairs monodactylous	4 pairs monodactylous	4 pairs monodactylous
Length/width (Average)	292 µm/ 178µm	303 µm/ 199 µm	360 µm/ 237 µm	390 µm/ 252 µm	432 µm/ 292 µm

Table 20: Diagnostic features of Life Stages of *Papillacarus baloghi* sp. nov.

Stages / Features	Larva	Protonymph	Deutonymph	Tritonymph	Adult
Nature of Sensillus	Sensillus pectinate	Sensillus pectinate	Sensillus pectinate	Sensillus pectinate	Sensillus pectinate
Number of notogastral setae	13 pairs	19 pairs	28 pairs	32	30
Epimeral setal formula	3-1-3	3-1-3-1	5-2-3-3	6-3-3-4	9-4-3-4
Number of genital setae	0	1 pair	6 pairs	7 pairs	10 pairs
Number of genital suckers	0	1 pair	2 pairs	3 pairs	3 pairs
Number of adanal setae	3	4 pairs	4 pairs	4 pairs	4 pairs
Number of anal setae	0	0	2 pairs	2 pairs	2 pairs
Legs	3 pairs monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous
Length/width (Average)	250 µm/ 165 µm	340µm/ 199 µm	406 µm/ 226 µm	472 µm/ 250 µm	577 µm/ 269 µm

Table 26: Diagnostic features of Life Stages of *A. Keralensis* sp. nov.

Features \ Stages	Larva	Protonymph	Deutonymph	Tritonymph	Adult
Nature of Sensillus	Not developed	Not developed	Rod shaped with a swollen and roughened head	Rod shaped with a swollen and roughened head	Rod shaped with a swollen and roughened head
Number of notogastral setae	10 pairs	15 pairs	15 pairs	15 pairs	15 pairs
Epimeral setal formula	3-1-3	3-1-3-3	3-1-3-3	3-1-3-3	3-1-3-3
Number of genital setae	0	1 pair	4 pairs	8 pairs	15 pairs
Number of genital suckers	0	1 pair	2 pairs	3 pairs	3 pairs
Number of adanal setae	0	0	3 pairs	3 pairs	3 pairs
Number of anal setae	0	0	0	2 pairs	2 pairs
Legs	3 pairs monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of Tridactylous
Length/width (Average)	296 µm/ 139 µm	369 µm/ 188 µm	446 µm/ 235 µm	510 µm/ 265 µm	644 µm/ 350 µm

Table 32: Diagnostic Features of Life Stages of *Archegozetes longisetosus* Aoki, 1965

Features / Stages	Larva	Protonymph	Deutonymph	Tritonymph	Adult
Nature of Sensillus	Not developed	Setaceous with barbs	Setaceous with barbs	Setaceous with barbs	Setaceous with barbs
Number of notogastral setae	10 pairs	12 pairs	15 pairs	15 pairs	15 pairs
Epimeral setal formula	2-1-2	3-1-2-1	3-1-2-3	3-1-3-3	3-1-3-3
Number of genital setae	0	1 pair	4 pairs	6 pairs	7 pairs
Number of genital suckers	0	1 pair	2 pairs	3 pairs	3 pairs
Number of adanal setae	2 pairs	2 pairs	3 pairs	3 pairs	3 pairs
Number of anal setae	0	0	0	2 pairs	2 pairs
Legs	3 pairs monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous
Length/width (Average)	250 µm/ 152 µm	332 µm/ 216 µm	434 µm/ 292 µm	577 µm/ 402 µm	910 µm/ 541 µm

Table 8: Diagnostic Features of Life Stages of *Eohypochthonius payyoliensis.* sp. nov.

Features \ Stages	Larva	Protonymph	Deutonymph	Tritonymph	Adult
Nature of Sensillus	Pectinate with 8-9 branches	Pectinate with 8-9 branches	Pectinate with 8-9 branches	Pectinate with 8-9 branches	Pectinate with 8-9 branches
Number of notogastral setae	13 pairs	16 pairs	16 pairs	16 pairs	16 pairs
Epimeral setal formula	2-1-2	3-1-3-1	3-1-3-3	3-1-3-4	3-1-3-4
Number of genital setae	0	1 pair	5 pairs	8 pairs	10 pairs
Number of genital suckers	0	1 pair	2 pairs	3 pairs	3 pairs
Number of adanal setae	3 pairs	3 pairs	3 pairs	3 pairs	3 pairs
Number of anal setae	0	0	2 pairs	2 pairs	2 pairs
Legs	3 pairs monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous	4 pairs of monodactylous
Length/width (Average)	206 µm/ 106 µm	225 µm/ 113 µm	255 µm/ 120 µm	262 µm/ 124 µm	296 µm/ 126 µm

TABLE 1: Site Wise Distribution of the Primitive Oribatid Species Recovered

Superfamily	Family	Species	Sampling localities	KKD					MLP					WAD
				MRP	JKD	AKD			CUC				KZH	COP
						M	W	K	LH	BG	ZD	QT		
Mesoplophoroidea Van der Hammen,1959	Apoplophoridae Niedbala, 1984	1	*Apoplophora pantotrema* Berlese, 1913	-	-	-	-	-	+	+	-	-	-	-
Phthiracaroidea Grandjean, 1954	Phthiracaridae Perty, 1841	2	*Hoplophthiracarus pakistanensis* Hammer, 1977	+	-	-	-	-	-	+	-	-	-	-
		3	*Hoplophthiracarus bengalensis* Sanyal, 1992	-	-	-	-	-	+	+	-	-	-	-
		4	*Atropacarus (Hoplophorella) sensillatus* sp. nov.	-	-	+	-	-	+	-	+	-	-	-
		5	*Rhysotritia aruda* Baran and Ayyildiz, 2000	+	-	-	-	-	-	+	-	-	-	-
Hypochthonoidea Balogh, 1961	Hypochthoniidae Berlese, 1910	6	*Eohypochthonius payyoliensis* sp. nov.	-	-	-	+	+	-	-	-	-	-	-
		7	*Malacoangelia hygricola* sp. nov.	-	-	-	+	+	-	-	-	-	-	-
Cosmochthonoidea Grandjean, 1947	Cosmochthoniidae Grandjean, 1947	8	*Cosmochthonius ugamaensis* Gordeeva, 1980	-	+	-	-	-	-	-	-	-	-	-
		9	*Cosmochthonius zanini* Penttinen & Gordeva, 2003	-	+	-	-	-	-	-	-	+	-	-

Superfamily	Family	Species	Sampling localities	KKD					MLP					WAD
				MRP	JKD	AKD			CUC				KZH	COP
						M	W	K	LH	BG	ZD	QT		
Cosmochthonoidea, Grandjean, 1947	Sphaerochthoniidae Grandjean, 1947	10	*Sphaerochthonius bengalensis* Sanyal and Sengupta, 1990	-	+	-	-	-	-	-	-	-	-	-
Brachychthonoidea Thor, 1934	Brachychthoniidae Thor, 1934	11	*Brachychthonius berlesei* Willamn, 1928	-	-	-	-	-	-	-	-	-	-	+
Lohmannoidea Grandjean, 1967	Lohmanniidae Berlese, 1916	12	*Annectacarus longisetosus* Aoki, 1965	-	+	+	-	-	-	-	-	-	+	-
		13	*Annectacarus wallworki*, Clement and Haq, 1989	-	-	-	-	-	-	-	+	-	-	-
		14	*Annectacarus aokii* Jaikumar *et al.*, 1994	-	+	-	-	+	-	-	-	-	-	-
		15	*Annectacarus hammerae* Shiji *et al.*, 2007	-	-	-	-	-	+	-	-	-	-	-
		16	*Annectacarus nortoni* sp. nov.	-	+	-	-	-	-	-	-	-	-	-
		17	*Cryptacarus dendrisetosus* Bhattacharya, *et al.*, 1974	-	+	-	-	-	-	-	-	-	-	-
		18	*Cryptacarus keralensis* Shiji, *et al.*, 2007.	-	-	+	-	-	-	-	-	-	-	-

Superfamily	Family	Species	Sampling localities	KKD					MLP					WAD
				MRP	JKD	AKD			CUC				KZH	COP
						M	W	K	LH	BG	ZD	QT		
Lohmannoidea Grandjean, 1967	Lohmanniidae Berlese, 1916	19	*Haplacarus foliatus* Wallwork, 1962	-	-	-	-	+	+	-	-	-	-	-
		20	*Haplacarus keralensis* Haq *et al.*, 1984	-	-	-	-	-	-	+	+	-	-	-
		21	*Haplacarus porosus* Haq and Clement, 1987	-	+	-	-	-	-	-	-	-	-	+
		22	*Javacarus kuehnelti* Balogh, 1961.	+	-	-	-	-	+	-	-	-	-	-
		23	*Javacarus porosus* Hammer, 1980	-	-	-	-	-	+	-	-	-	-	-
		24	*Meristacarus degradatus* Haq and Jaikumar, 1993	-	-	-	-	-	-	-	+	-	-	-
		25	*Meristacarus unilateralis* sp. nov.	-	-	-	-	-	+	-	-	-	-	+
		26	*Papillacarus baloghi* sp. nov.	-	-	-	+	+	-	+	-	+	-	-
Epilohmannoidea Grandjean, 1969	Epilohmanniidae, Oudemans, 1923	27	*Epilohmannia pallida pacifica*, Aoki, 1965	-	-	-	-	-	-	+	-	-	+	-
		28	*Epilohmannia pallida indica* Bhattacharya and Banerjee, 1980	-	-	-	+	-	-	+	-	-	-	-

Superfamily	Family	Species	Sampling localities	KKD					MLP					WAD
				MRP	JKD	AKD			CUC				KZH	COP
						M	W	K	LH	BG	ZD	QT		
Nothroidea Grandjean, 1954	Trhypochthoniidae Will'mann, 1931	29	*Allonothrus russeolus* Wallwork, 1960	-	+	-	-	-	-	-	-	-	-	-
		30	*Allonothrus sinicus* Wang Hu Fu and Norton, 1988.	-	+	-	-	-	+	-	-	-	-	+
		31	*Allonothrus keralensis* sp. nov.	-	+	-	-	-	+	-	-	-	+	-
		32	*Archegozetes magnus* (Sellnick, 1925)	-	-	-	-	-	-	-	-	-	+	-
		33	*Archegozetes longisetosus* Aoki, 1965	+	-	+	+	+	-	+	-	+	-	-
	Malaconothridae Berlese, 1916	34	*Malaconothrus dipankari*	-	-	-	-	-	-	-	+	-	-	-
		35	*Trimalacononthrus duoaculeus* Yamamoto *et al.*, 2004	-	-	-	-	-	-	+	-	-	-	-

TABLE 2: Food Preference of 5 Species of Oribatid Mites Under Laboratory Conditions

	Food	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Remarks
	Species	**Moss**	**Yeast**	**Mushroom**	***Curvularia geniculata***	***Colletotrichus sp.***	***Pestalotia* sp.**	***Trichoderma harzianum***	***Alternaria alternata***	***Phytophthora sp.***	***Fusarium sp.***	**Leaf litter**	**Filter paper**	**Cotton thread**	**Boiled rice**	**Artificial sponge**	**Faecal pellets**	**Hard plastic**	**Live animals**	
1	*Eohypochthonius payyoliensis* sp. nov.	R	R	R	R	A+	A	R	R	R	R	A+	R	N	N	N	R	R	N	Panphytophage
2	*Malacoangelia hygricola* sp. nov	R	R	R	R	R	R	R	R	R	R	A+	R	N	N	N	R	R	N	Macrophytophage
3	*Papillacarus baloghi* sp. nov.	R	R	R	R	R	R	R	R	R	R	A+	R	N	N	N	R	R	N	Macrophytophage
4	*Allonothrus keralensis* sp. nov.	R	A+	R	A+	A+	A+	R	R	R	R	A+	A	N	N	N	R	R	N	Panphytophage
5	*Archegozetes longisetosus*	A	A+	A	A+	A+	A+	R	A+	R	R	A+	A	A	A	A+	A	R	A	Panphytophage

A+ - *Development completed*
A - *Feed and produce faecal pellets*
R - *Rejected*
N – *Not tried*