STUDIES ON THE BRACHYPYLINE ORIBATID MITES OF KERALA

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FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY IN ZOOLOGY

By

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DECLARATION

I, **E. JULIE**, hereby declare that this thesis entitled "**STUDIES ON THE BRACHYPYLINE ORIBATID MITES OF KERALA**" has not been submitted by me for the award of any degree, diploma, title or recognition before.

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CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON THE BRACHYPYLINE ORIBATID MITES OF KERALA"** has been carried out by **Mrs. E. JULIE**, 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: Calicut University Campus **Dr. N. RAMANI**

Date : .2010

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INTRODUCTION

Acarology, the study of mites and ticks is challenging, yet an exciting discipline which has reached a level of world wide accomplishment that deserves eminence apart from the broader aspects of arachnology and entomology. Acarological problems have reached to such an extend that man cannot overlook acarines -the mites and ticks- as they often influence human welfare tremendously. Most acarines are minute to small i.e. 0.08 - 1.0mm, but the largest acari (some ticks and red velvet mite) may reach lengths of 10- 20 mm.

Unlike mites, ticks are exclusively parasitic on vertebrates, mainly on mammals and birds but occasionally on some reptilian and amphibian hosts also. They are remarkable vectors occupying the second position, next to mosquitoes, transmitting a range of pathogenic viral, rickettsial and bacterial diseases to our live stock, wild animals and even to human beings.

Despite this, mites are extraordinarily diverse in morphology, habits and habitats. Owing to their minuscule size and cryptic nature, they most often escape notice even by the scientific sector. However, man is getting more exposed to increasing instances of mite invasion, either in the positive or in the negative manner. The positive outlook reflects them as ecofriendly agents, exerting significant roles in biodegradation leading to enrichment of soil fertility, biological control of pests and parasites, forensic sciences for crime detection and so on. Looking at a negative angle, mites are notorious pests of an array of plants of all economic categories, parasites, pathogens and vectors of various pathogenic agents affecting our livestock, wild animals and even man.

Mites play important roles in agriculture as many species are plant feeders causing various types of direct damages to all types of agricultural crops, medicinal plants, horticultural plants etc. Plant-parasitic mites are extremely damaging pests with rapid generation times, high fecundity and potency to over exploit their hosts. The most important invasive plant pests come under the families Tetranychidae, Eriophyidae, Tenuipalpidae and Tarsonemidae. Apart from direct damages, there are many species under Eriophyidae and Tetranychidae which are known as vectors of phytopathogenic agents like viruses, bacteria and fungi, causing more potential loss to the growers. From an economic stand point, there are some very important groups of mites which are parasitic upon vertebrates like mammals and birds. Members which come under the families Gamasidae, Trombididae, Sarcoptidae and Demodiecidae are excellent examples. Dust mites, hair follicle mites etc. have gained tremendous importance owing to their direct involvement in human health.

Contrary to the injurious mites, there are several beneficial mites too which act as our friends by predating upon phytophagous mites and some insect pests like aphids, coccids, thrips etc. thereby helping in biological control. The most important predatory mites explored in this regard include members of Phytoseiidae, Cheyletidae, Cunaxidae, Stigmaeidae, Bdellidae, Tydeidae, Ascidae, Anystidae, Erythraeidae and some Tarsonemidae. Phytoseiid mites deserve special mention in this regard owing to their successful exploitation in the control of agricultural pests, domestic pests and stored product pests.

Apart from the above potential use, recent findings provided concrete evidence to assign an entirely different but extremely important beneficial status to mites. Very often, mite activity has been considered as decisive in

determining energy transfer, nutrient cycling and humification process of soil leading to enrichment of soil health and productivity.

Soil is the stage for a number of slow chemical changes to occur, leading to the transfer of the various organic materials it receives. Organic residues, irrespective of plant/animal origin when applied to soil, get converted into a dark-coloured complex, known by the name "humus", which becomes slowly oxidized to carbonic acid, water, nitric acid and other simple organic substances, ultimately serving as food for plants. These changes, though once regarded as purely chemical are now documented as dependent upon the vital processes of certain minute organisms, universally distributed throughout soil horizons, and subject to the same laws of nutrition, multiplication, life and death as hold for the higher organisms with which we are more generally familiar. The surface layer of soil is constantly receiving additions of organic matter, either as leaves or other debris of vegetation covering the ground, together with the droppings of animals or dung and other animal and vegetable residues supplied as manure to cultivated land. These materials rapidly get changed in ordinary soil, losing almost immediately any structure they possess and becoming dark-coloured humid bodies. The major heterotrophs in soil systems exist in elaborate food webs containing several trophic levels. Some soil animals are true herbivores, still others are carnivores, parasites or top predators. Animal members of the soil biota are numerous and diverse and the array of species is very large, including representatives of all terrestrial phyla. The soil fauna encompasses a rich pool of species. Communities of soil fauna offer opportunities for studies of phenomena such as species interaction, resource utilization, or temporal and spatial distribution.

Soil fauna is classified into microfauna, mesofauna and macrofauna. Soil mites are the most abundant micro arthropods in many types of soils. Four suborders of mites occur frequently in soils viz., the oribatida, prostigmata, mesostigmata, and astigmata. The oribatid mites are the characteristic mites of the soil and are usually fungivorous or detritivorous. They are an ancient group, the fossils of which are known atleast since the Devonian period and their sheer number is impressive in most soils. Compared to the larger "easily visible" arthropods, the minute oribatid mites are still poorly known, although they are the most abundant and morphologically highly diverse group. Most oribatid species have specific habitat preferences. The vast majority lives in terrestrial habitats, such as plant litter, soil, suspended soils mosses and lichens. They are particularly species rich and abundant in humid habitats, such as forest soils and moorland. In addition, a range of markedly xerobiont species, occur in semi-deserts, in arid meadows, on rocks and on the bark and leaves of trees and shrubs. Small numbers of oribatid mites are bound to various aquatic habitats including springs, seepages, temporary and permanent pools, reed belts around lakes, rivers, streams, phytotelmata and other water filled microhabitats, as well as the brackish and marine sub- littoral and littoral habitats. The density of oribatid mites is influenced by soil pH, temperature, pore size and moisture content. Maximum density of oribatid mites is found at a depth of 0-5 cm and minimum density at a depth of 10-15cm of litter. These mites play multitude of roles in their natural habitats like biodegradation, bioindication, biological control of pests and parasites, transmission of pathogens and so on.

Certain oribatid mites belonging to the super families Oribatuloidea, Ceratozetoidea and Galumnoidea have been proved to be successful as

vectors of various cestode parasites of vertebrates. More than 100 species have already been enlisted to serve as vectors of 8 genera of cestodes, including the common sheep tapeworm, *Moniezia expansa*. Occasionally, these mites are known to bore into live roots or tubers and some species burrow into healthy aquatic plants. Species like *Paralamellobates bengalensis* is reported to colonise the leaves of the common tuber crop *Dioscorea alata* where the various life stages feed on the leaf tissues.Similiar instances of phytophagy has been reported among the immmatures and adults of species like *Siculobata malabarica*, *Notogalumna nortoni* and *Scheloribates sp*. also on the leaves of the fiber crop viz *Pandanus kaida* in Kerala.

Despite the above isolated cases of negative roles, majority of oribatid mites are known to exhibit a multitude of beneficial roles, thereby exerting tremendous impact on mankind either directly or indirectly. To mention a few are the areas like bioindication, biological control and the most significant one, the biodegradation. These mites are seldom exploited as useful indicators of various microclimatic conditions. Distinct pH preferences of many species of oribatid mites make them as good indicators of acidification caused by acid rain and other air pollutants. Several species like *Rhyzotritia duplicata* and *Nothrus silvestris* quickly accumulate and retain heavy metals and are able to indicate heavy metal pollution. The relative proportion of thelytokous oribatids has been reported to show an increase in response to heavy metal and pesticide pollution. Some other oribatid species like *Oppiella nova*, *Ceratozetes peritus*, *Punctoribates punctum* and *Tectocepheus velatus* colonize zinc metallurgic dump. *T. velatus, O. nova* and *Zygoribatula* spp. inhabit soils relatively poor in organic matter while *Eremulus* sp., and *Xylobates capaucinus* harbour organic matter

rich areas. Oribatid representatives like *Oppia translamellata* and *Heptacarus hirsutus* are reported to possess a close association with moist habitat and hence serve as indicators of humid conditions. Two other species viz., *T. velatus* and *Malaconothrus globiger* are good indicators of wet condition.

Certain members of oribatid mites have gained considerable importance in the field of pest management by acting as efficient biological control agents of nematode pests, weeds etc. Water hyacinth, *Eichhornia crassipes* is considered as one of the world's notorious weed invading aquatic bodies like the lakes, ponds, canals and rivers. The extensive growth of this weed has become a rigour threat to agriculture, fisheries and water transport besides causing environmental hazards like water pollution, mosquito problems and so on. Herbicidal treatment or mechanical harvesting of water hyacinth often damages nearby vegetation also. It is in this context the feeding potential of the water hyacinth mite, *Orthogalumna terebrantis* becomes significant as it exerts an effective control over this weed. The above mite has been imported to various countries as a part of biological control programme of water hyacinth. Similarily, species like *S. decarinatus* has been reported as a promising agent for the regulation of the terrestrial weed, *Chromolaena odorata*. Species of *Hydrozetes* are reported to destroy the duckweed, *Lemna* spp. by burrowing into the floating thallus of the plant. Several oribatid species of the families Galumnidae, Scheloribatidae etc. are recorded as efficient predators of plant parasitic nematodes inhabiting the roots of agricultural crops. Species like *Diapterobates humeralis*, an arboreal oribatid species has been reported as a highly effective control agent of the notorious pest, Hemlock Woolley adelgid in Japan, by dislodging it from the

trees and killing it by feeding on the woolley filaments surrounding the ovisacs.

Apart from the above mentioned beneficial roles of oribatid mites, the most important, enchanting and admirable function of oribatid mites in all types of soils is their role in the decomposition of organic matter and subsequent humification and energy transfer process. In this regard, the contribution made by various species of oribatid mites in the degradation of plant residues and other substances shows great variation. The higher plant feeders (macrophytophages), especially the primitive oribatid mites like members of Phthiracaroidea, Lohmannoidea etc., through their voracious wood boring, tunneling as well as leaf skeletonising habit, process a considerable amount of organic residues in the form of litter for subsequent incorporation in to the soil. Low plant feeders (microphytophages) represented mainly by the higher taxa of oribatid mites like members of Oppiidae, Eremulidae, etc. assist the process of degradation by feeding on the fungal cushions, bacteria and so on and disseminating their spores to litter layers of varying ecosystems. Combined feeders (panphytophages) comprising members of both lower and higher taxa assist biodegradation through disseminating the microbial colonies as well as directly feeding on the plant residues. This establishes the fact that each of the feeding group mentioned above contributes its own role in the conversion of highly complex organic residues to simple and easily assimiable units.

The macrophytophagous oribatids which feed on higher plant materials act as primary decomposers, playing a momentous role in the turn over of soil organic residues. They are provided with strong chelicerae and rutella and they actively devour significant amount of litter accumulated on the surface of earth. These species because of their sluggish habit and

restricted food selection exhibit only localized and often confined distribution pattern. But they exert a considerable role through their high rates of ingestion and ejection. Moreover, manifold increase in ingestion and ejection rates exhibited by the immatures of macrophytophagous species accelerate the process of litter degradation in natural conditions.

Micro and panphytophagous species put forth a deep influence in the soil ecosystem in a multitude of ways. Most of the micro and panphytophages commence very active migratory movements in vertical and horizontal directions in soil and thus increase the soil porosity and hence soil aeration. While performing such migratory movements, these species trace the various microbial colonies in soil profiles and reactivate the senescent colonies through their voracious grazing. Moreover, they disseminate the spores of such microbes by carrying the same on their body setae and through their faecal pellets to different depths of the soil. These species while reaching the soil surface thus inoculate the fungal and bacterial spores in to fresh litter accumulated on the surface thereby leading to the initial process of degradation. The panphytophagous species, in addition to the above role support the process of litter degradation directly by consuming the various litter fragments and transforming the same to simple units in the form of faecal pellets. Thus they perform a dual role as far as the process of biodegradation is concerned.

Kerala is enriched with varied floral elements, providing bountiful food resources not only to the plant parasitic forms but also to the members of the soil fauna, when the floral rudiments reach as litter in the soil. Oribatid mites which are known to be free living detritus feeders are abundant in such litter accumulated areas. The detection of panphytophagy in majority of species studied earlier indicates that in Kerala soils, mites take part a much

significant role in degradation. Mites play earth-shattering role in the usual transaction of the organic residues in the soil ecosystem due to their speckled activities. They render an innovative service to mankind aiding in the process of biodegradation thereby helping in the nutrient cycling and energy flow. Other acarine activity is their performance in the field of bioindication of soil conditions. This incredible ability is acquired through their extreme sensitivity to the physico-chemical characteristics of their immediate surroundings. Above all, most of the brachypyline oribatid mites on which the current study is concentrated are panphytophagous in nature, which exert an energetic influence on soil humification process, leading to enrichment of soil fertility. They show uniform world wide distribution and high adaptability to survive and replenish in altering environmental conditions. The present study is envisaged with a view to carry out an in-depth study on the systematic and biological details of some brachypyline taxa of oribatid mites, which exert a terrific impact on soil humification and nutrient cycling, leading to enrichment of soil fertility. In the present study, attention has also been focused to assess the potential of these mites to degrade highly recalcitrant materials like the coconut pith, left behind after coir retting process. Quantitative studies have also been carried out to analyze the positive impact, resulted due to the feeding activity of these oribatid mites, towards the enrichment of the fertility status of soil.

REVIEW OF LITERATURE

Scientific study of any organism begins with an analysis of its taxonomic position. A proper understanding of the functional significance of the individual species of oribatid mite in its natural ecosystem is possible only through the acquisition of a sound knowledge on its systematic position. Taxonomic studies of oribatid mites have witnessed considerable progress during the recent years resulting in the addition of hundreds of new taxa all over the world. Incorporation of all these information, though not possible here due to limitations of space, an attempt is made in the present study to include the most relevant literature on the taxonomy and distribution of oribatid mites.

Pearse (1906) was the pioneer in the study of oribatid fauna of Indian subcontinent. He recorded 20 species of these mites along with a new genus *Chaunoproctus* from Sikkim. New records of oribatid species from New Zealand were made by Michael (1908). Ewing (1909) surveyed the oribatid fauna of America and recorded several new species. The same author conducted a survey on the oribatid fauna of Nilgiris during the next year (1910). Warburton (1912) carried out a survey on the oribatid fauna of Seychelles. Ewing (1917) brought forth a synopsis on the oribatid mites of North America. The same author (1918) provided data on the oribatid fauna of Mary's park, Oregon.

Sellnick (1925) carried out a survey on the oribatid fauna of Sumatra. Jacot (1929) gave a detailed description of the orbiatid genus *Neolides*. The same author (1933) described 2 species of galumnoid mites, *Galumna tesselata* and *G. nilgiria* from Nilgiris. A new species of *Scheloribates*,

S. chauhani was described by Baker (1945). Hammer (1953) investigated the oribatid fauna of Queensland and reported a new species. Grandjean's (1954) classification of oribatid mites is a classical work in oribatid taxonomy. Wallwork (1957) studied the oribatid mites of a Hemlock-Yellow birch forest. Balogh (1958) conducted a survey on the oribatid fauna of African soils. Aoki (1958) studied the oribatid mites of Japan and reported a few species of the family Carabodidae. Hammer (1958) conducted studies on the oribatid fauna of Andes Mountain. Two new genera of oribatid mites, *Nippobodes* and *Lasiobelba* were added by Aoki (1959). Balogh (1959) presented the results of a survey made on the oribatid mites of Eastern Africa. Oribatid mites from Polynesia were studied by Sellnick (1959).

Balogh (1960) conducted a survey on the oribatid mites of Congo. Wallwork (1961) described 2 new species viz., *Basilobelba retiarius* (Warb.) n. comb and *B. Africana*. The same author (1961a) described 2 new genera and several new species and subspecies from Ghana viz., *Tectoppia nigricans* n.g.n.sp; *Papillonotus maculatus P. granulosus*; *Teratoppia ciliata*; *T. minor*; *Granuloppia conogensis. ghanensis, G. maior nuda, Caloppia papillata, Machadobelba symmetrica, M. dispar*; *Hexoppia heterotricha*.

Csizar (1961) recorded new taxa of oribatid mites from Indonesia. Oribatid mites from Chile were studied by Hammer (1962) who reported several new species. Hartenstein (1962) carried out taxonomic and biological studies of 3 species viz., *Belba kingi, Ceratozetes gracilis* and *Platynothrus peltifer*. Wallwork (1962) studied the taxonomy and distribution of oribatid fauna of Ghana. Wolley and Higgins (1963) gave the detailed description of a new species of *Eremulus*. Four new species of oribatid mites were described by Aoki (1963) from Japan. The same author (1964) also studied the oribatid fauna of Laysan Island and New Guinea.

Two new genera, *Sadocepheus* and *Oscesobates* were erected by Aoki (1965) while studying oribatid mites of Japan. Further, he (1965a) made a revision of the family Otocepheidae along with a description of 12 new species. He (1965b) conducted a survey on the oribatid fauna of Himalayas and reported 4 new species. Another survey conducted in Thailand by the same author (1965c) yielded 6 new genera and several new species and subspecies of oribatid mites. A new species of galumnoid mite, *Orthogalumna terebrantis* was found tunnelling on the leaf tissues of the aquatic weed, *Eichhornia crassipus* as reported by Wallwork (1965) from Uruguay. Balogh (1965) provided a synopsis of the world genera of oribatid mites.

Aoki (1966) erected a new family based on the type species, *Tokunocepheus mizusawai*. The same author (1966a) described 3 new species and a new subspecies of galumnoid mites from Japan. A new species, *Podoribates cuspidatus* from pasture soils of Japan was described by Sakakibara and Aoki (1966). Aoki (1967) erected a new genus, *Rhabdoribates* and described two new species and a new subspecies. The same author (1967a) reported a new species in the genus *Sphodrocepheus*. Aoki (1967b) revised the family Otocepheidae and erected a new subfamily Tetracondylinae. He (1967c) also reported two new species of *Liacarus* and one new species of *Xenillus*. A new genus, *Nemacepheus* was erected by Aoki (1968) from Japan with *N. dentatus* as type species.

A new species of the genus *Oppia* viz. *O. coloradensis* was reported by Woolley (1969) from the dust samples collected from Colorado. Information on the zoogeography of cryptostigmatid mites in Antarctica was provided by Wallwork (1969). Grandjean (1969) classified the suborder Oribatida into 6 major groups. Balogh and Mahunka (1969) erected a new

family, Sternoppiidae, 15 new genera and 56 new species of oribatid mites. Aoki and Suzuki (1970) added a new species to the genus *Pedrocortesella*. Aoki (1970) described a new species *Oribatula sakamori* from melon fruits. A new subgenus and 7 new species of oribatid mites were collected by the same author (1970a) from living trees from Mt. Izhizuchi and Mt. Odaigahara of Japan. A new genus, *Consteremaeus* from the Island of Tsushima was erected by the above author (1970b). Suzuki and Aoki (1970) described a new species of galumnoid mite, *Galumnella nipponica* from Izu Peninsula, Japan. Two new species of the family Xenillidae were reported by Wolley (1970) from Lebanon. Feider *et al*., (1970) erected a new genus, *Romanobates* and 3 new species belonging to the family Oribatulidae.

Aoki and Fujikawa (1971) provided an illustrated account of a new species of *Allodamaeus* viz., *A. adpressus*. Woolley (1972) presented a critical review of the European and American species of the oribatid family Liacaridae, particularly on the genus *Liacarus*. Little Wood and Wallwork (1972) described a new genus and species of the oribatid mite of the family oppiidae viz., *Multioppia pulchra* from st. Kilda. Studies conducted by Aoki (1973) on the oribatid fauna of Southern Japan yielded 1 new genus, 6 new species and a new subspecies.

Balogh and Mahunka (1974) provided a better understanding of the oribatid fauna of Malaysia by furnishing illustrations of a number of new taxa. Kardar (1974) described 2 new species of *Tectocepheus* viz. *T. latilamellaris* and *T. translamellaris* from the oribatid materials collected from soil samples taken around the roots of *Gossypium herbaceum* at Aligarh. Davydov and Ipat-eva (1974) reported an unidentified nematode larvae from the body-cavities of *Liebstadia similis*, *Scheloribates laevigatus*

and *S. laticeps*. The authors found that 20 to 40% of the mites were infected with 1 to 16 nematodes.

While conducting studies on the occurrence and abundance of oribatid mites on a submontane sheep pasture field in Southern Polland, Zyromska and Rudzka (1974) reported 8 species viz., *S. laevigatus, S. minutus, L. similis, Platynothrus,* sp., *Furcoribula furcillata, Punctoribates punctum* and *Achipteria coleoptrata* as intermediate hosts of cestodes. Nevin (1975) described *Pilogalumna cozadensis,* a new species of galumnid mite from Nebraska, U.S.A. Metz and Sharma (1975) added a new species, *O. durhamensis* to the family Oppiidae. Studies of Biswas and Bhaduri (1976) helped to add 3 new species to the genus *Scheloribates* from West Bengal.

Van Der Hammen (1977a,b) in a series of papers provided a collective summary of the taxonomic works of Berlese. Norton (1977) described the family Damaeidae while reviewing Grandjean's system of leg chaetotaxy. Kardar (1977) described 4 new speices of *Scheloribates* viz. *S. bicuspidatus, S. translamellaria, S. baloghi* and *S. reefafulvus* from India. Bernini (1978) reported 2 new species of *Oribatella* from Italy. Investigation carried out by Gjelstrup (1978) led to the recovery of 27 species of oribatid mites associated with moss and lichen from Faroe islands. Aoki (1978) conducted a survey of the family Carabodidae and established a new genus, 3 new species and a new subspecies. Trave (1978) made discussions on the superfamily Carabodidea along with the descriptions of 3 nymphs of *Dolicheremaeus dorni*. The genus *Dolicheremaeus* and the family Otocepheidae were very near to the Carabodidae.

Mahunka (1978) added 5 new species of oribatids and 1 known species. The author also erected 3 new species and 3 new genera viz.,

Hauserozetes with type species *H. mausiae*; *Neostrinatina* with *N. mixoppia* as the type and *Guatemalozetes* with type-species and the new species, *G. aelleni*, *Alloglumna microporosa* and *O. strinatii* sp. nov.

Nevin (1978) designated *Parachipteria heintoogensis* as a new species from Carolina, based on its size (<0.601mm), possession of larger porose area, minute notogastral setae (*ti),* smooth interlamellar setae, and by presence of a distinct spine on the ventral surface of the pteromorphae.

Bellido (1978) studied the morphology of the adults and immature stages including the prelarva of *Carabodes willmanni*. He gave an account of chaetotaxic features along with the comparative aspects of *Carabodes labyrinthicus*. Bayoumi (1978) made an observation on the distribution of oribatid mites within and outside earthworm cavities in a deciduous woodland on a mountain site. Oribatids, especially members of Oppiidae, were found to occur in large numbers in earthworm cavities than in the outlying soil.

Ghosh and Bhaduri (1979) reported 5 species of oribatid mites under 5 genera, of which 2 species, viz. *Eremobelba indica* and *A. monensis* were new to science while the other 3 species were newly recorded from Nagaland. Norton (1979) described 3 new genera under the family Damaeidae from North America viz. *Caenobelba alleganiensis, Lanibelba pini* n. g., n. sp and *Quatrobelba montana* n. g., n. sp.

Studies on the species-composition, abundance, biomass and annual cycle of oribatid-mites in the high-Alps were made by Schatz (1979). Several population parameters at different altitudes were investigated along with data on environmental conditions like geology, climate, weather, vegetation, soil, etc.

Haq (1979) described a new species, *Xiphobelba ismalia* under the family Basilobelbidae from South India. A survey on the oribatid mites of Sikkim, Himalaya was conducted by Dhalli *et al*. (1980) and they described 2 new species of *Scheloribates* and 1 new species of *Chaunoproctus*. Corpus-Raroz (1981) added 7 species to the genus *Peloribates* as a result of survey on the Philippine oribatid mites. Bhattacharya and Banerjee (1981) described a new species of *Neoppia* from Santhiniketan, India. A review on taxonomy and distribution of oribatid mites in India was made by Bhaduri and Raychaudhuri (1981). Raju *et al.* (1981) added a new species to the genus *Pergalumna* viz. *P. andhraensis*. Trave (1981) described a new species of Indian oribatid, *Vaghia blascoi* from the soils of Palani Hills. Hammer (1981) erected a new genus *Spinotocepheus* with four new species from Java.

Luxton (1981) collected oribatd mites from the litter of a beech wood floor monthly for a period of one year, from various depths like 0-3cm, 3-6cm and occasionally between 6 and 15 cm and showed that the oribatids were most abundant in the 0-3cm layer and 3-4% of the total community was present at 6-15cm. The author also reported that the depth distributions of oribatids varied with taxa, habitat and climatic regime and he concluded that many species exhibited true vertical migrations under the influence of climatic variables (temperature being of prime significance) and in the search for seasonally available exploitable resources.

Asperemaeus was erected as a new genus by Behan (1982) from the collections made from the subalpine habitats of Soviet far east. A new species of *Porogalumnella* viz. *P. setosa* was reported by Balakrishnan and Haq (1982). A new genus of oribatid mite, viz., *Pelokylla* with *P. malabarica* as the type species was erected by Clement and Haq (1982). Mondal and

Chakrabarti (1982) reported a new species of *Oppia* along with several new records from the tea gardens in Darjeeling.

Lions (1982) studied the biometery, sex distribution, morphology and taxonomy of 2 subspecies viz. *Quadroppia quadricarinata virginatis* and Q. *quadricarinata maritalis*.

Sanyal (1982) studied the influence of organic carbon and available phosphate on the structure and size of soil oribatid population. He reported that the oribatid population showed an annual increase in May and November, when the levels of organic carbon and available phosphate were highest. Rabatin and Rhods (1982) observed the presence of azygospores of *Acaulospora bireticulata* with in the exoskeleton of oribatid mites and in soil samples collected under a mixed stand of *Solidago sp*. and *Aster sp.* Spores with in oribatids comprised less than 1% of the total number of azygospores extracted from the soil. Mites containing azygospores were dead and partly decomposed, and fungal penetration of the decomposed carapace was suggested as the most likely mode of entry. Chakrabarti and Mondal (1983) provided information on the distribution of 18 species of soil oribatid mites belonging to 16 genera and 13 families, from Darjeeling district, India.

Norton (1983) made a discussion on the oribatid mite genus *Mochloribatula* and its placement under the family Mochlozetidae. He proposed 2 new species, *M. babaminsis* from halophilic shrubs in the Bahama Islands and *M. metzi* from *Spartina alterniflora* in North Carolina. Species like *Eremaeus floridanus, Notaspis depilis* and *N. texana* were included in the genus *Mochloribatula* and the ontogeny of *M. texana* was also discussed. Balogh and Balogh (1983) studied the oribatid fauna of

Australia and erected a new family, Platyamaeridae with 3 new genera and 12 new species.

Ramani and Haq (1984) studied the oribatid mites associated with the terrestrial weed, *Eupatorium odoratum*. Mondal (1984) described 2 new oribatid mites from Indian soil viz., *Flagrosuctobelba flabella* and *P. intermedius*. The genus *Flagrosuctobelba* was reported for the first time from India and the genus *Peloribates* was recorded for the first time from West Bengal. Schatz (1984) erected *Eremaeozetes sabinae* as a new species from Molokai, Hawiian Islands.

Luxton (1985), reviewed the oribatid mites of New Zealand, incorporating 366 species belonging to 160 genera and 58 families. Aoki and Honda (1985) collected a new species of *Austrachipteria, A. pulla* from moss samples in Japan. Balogh (1985) discussed the taxonomic status of genera like *Phereliodes*, *Pedrocortesia* and *Pedrocortesella* from Australia with descriptions of 5 new species. Based on the results of a survey on the oribatid mites of Hawaiian Islands, the above author (1985a), erected 1 genus, 4 new species and 1 subspecies belonging to the superfamily Oribatuloidea. Information on the distribution of *C. gracilis* in Arctic area of Western North America was provided by Behan (1985). Subias and Rodriguez (1985) while studying the oribatid mites collected from Spain redefined the subfamily Mystroppinae and described two new subgenera, *Karamella (Stakerenoppia)* and *K.(Glabroppia)*.

Balogh and Balogh (1986) collected 2 new genera and 22 new species from the forest ecosystems of New Guinea. The same authors (1986a) in a discussion on the distribution of oribatid mites in Western Pacific region, described 6 new species and 1 new subspecies. Aoki (1986) added a new

species to the genus *Cepheus viz.*, *C. kurswai* from Yonizawa, Japan. The same author (1986a) described 2 new species of the genus *Fissicepheus*. Fujikava (1986) recorded 14 oribatid species including 2 new subspecies from a nature farm in Nayoro. Balogh (1986) provided a key for the identification of the species group of *Xenillus ornatus*, adding 4 new species from the Neotropical region. In another paper, the same author (1986a) described 3 new species of *Hamotegaeus* from South America and provided a key to the known species of the genus. The same author (1986b) added a new species of *Phyllocarabodes*, viz. *P. ornatus* from Columbia and provided a key to the above genus. A new species was added to each of the genera, *Oppia* and *Scheloribates* by Bayoumi and Alkhaufa (1986). Choi (1986) described new and unrecorded species of oribatids under the family Oppiidae. Three new species of *Pedrocortesia* were reported from USSR by Ryabinin (1986).

Perez-Inigo and Baggio (1986) reported 15 species of oribatid mites from Cardoso Island, Brazil. Mahunka (2000) depicted a new oribatid genus *Malgasodes* to include 2 species, *M. curvisetus* and *M. hungarorum* under the family carabodidae from the rainforest of Malagasy Republic.

Marshal *et al.*, (1987) brought out a catalogue of oribatid mites of the continental United States and Canada. Mahunka (1987) revised the family Carabodidae and redescribed the species of *Carabodes* and *Austrocarabodes,* adding new species to the above genera as well as to the genus *Odontocepheus* from North and East Africa, Asia and Europe. Karppinen *et al.* (1987) listed 725 species by conducting a survey on the oribatid fauna of Crimea and Caucasus. Balogh and Balogh (1987) devised identification keys for Ptycoid Mixonomata of the Neotropical region. A revision of the superfamily Oppioidea was made by Balogh (1987). The subgenus

Ametroproctus from Western North Africa was redescribed by Behan (1987), adding 4 new species and incorporating a key.

Colloff and Seyd (1987) described a new species, *Parachipteria snowdonensis* from moss habitats on the summits of two peaks at Snowdonia National Park, North Wales. The new species was closely related to *P. punctata* from which it differed by having shorter notogastral setae, longer free-ended tutoria and larger *Aa* and A_1 area porosae. Palacios-Vargas and Vazquez (1988) described the adults and immatures of a new species of *M. royi*.

Perez-Inigo and Baggio (1988) erected 8 species and 1 subspecies of oribatids which were new to the science along with other nine previously known species from Brazil. Sheela and Haq (1988) reported 6 species of oribatid mites associated with the aquatic weed *E. crassipes* from Kerala. Grobler (1989) described 4 new species belonging to the genus *Eupelops* and made a comparison of the South African species. Balogh (1989) investigated the oribatid fauna of Ecuador, and erected a new family, Tubutozetidae to accommodate a new genus and a new subspecies. Two new species of Damaeidae viz., *Damaeus exspinosus* and *D. costonotus* from China were described by Wang and Norton (1989). Mahunka (1989) collected four new species of galumnoid mites, 2 each belonging to the genera *Galumna* and *Pergalumna* viz. *G. aba*, *G. khoii*, *P. kokschyi* and *P. margaritata* from Vietnam.

Steiner (1989) presented the classification of the larval and nymphal stages of 5 species of the family Oribatulidae. Using discriminant analysis, the larvae and protnymphs of *Oribatula tibialis*, *Zygoribatula exilis* and

Z. propinquus could be well separated. All stages of *Phaceloppia lucorum* differed from other species by their larger size. Perez-Inigo and Baggio (1989) described 15 species of oribatid mites including a new genus *Xenilloides*. Fernandez (1989) erected a new species, *Pirnodus cryophilus*, an inhabitant of crustaceous lichens on the eastern slope of "Cordon del plata", frontal cordillera, Mendoza, Argentina, lying at a height of 3,200 meters. The complete ontogenetic cycle was studied and comparisons were made with other species of the same genus, *P. detectidens* and *P. soyeri* along with data on its behaviour and feeding preferences. Subias and Balogh (1989) provided a review of the world genera of Oppiidae and a systematic catalogue of the genera and subgenera of the family.

Bagdanavichene *et al* (1990) studied the effects of organophosphorus insecticides like phosalone and chlorofos (trichlorfon) on the distribution and activity of soil micro organisms and the ability of the soil fauna to degrade pesticides in Sandy loam soil. Three species of oribatid mites, *Nothrus silverstris*, *S. confudatus* and *Tectocepheus velatus* were selected for investigation on the activity of intestinal microflora of soil animals.

Ramani and Haq (1990) gave the systematic description of a new oribatid species viz. *Notogalumna nortoni* inhabiting the foliage of coconut palm cultivated in Kerala, South India. Alberti and Fernandez (1990) studied the lenticuli of *Hydrozetes lemnae* and *Scutovertex sculptus*, together with the clear spot of *Oribatella quadricornuta* and *Chamobates voigtsi*, owing to their ultrastructural properties, as photosensitive organs. Lenticuli presented a more complicated structure and both structures showed secondary origin. Fernandez (1990) made description of a new species, *P. montis* along with data on its complete ontogentic cycle. A comparison of the species was made with the genus *Pheroliodes*. Eguaras *et al* (1990) gave description of 2 new

species of the genus *Pedrocortesella* viz. *P. monicai* and *P. tristius* from the arid zone of Argentina. The genera *Pheroliodes* and *Pedrocortesella* were compared and the feeding habits of the different species were also analyzed.

Sengupta and Sanyal (1990) collected 12 genera and 200 species of oribatid mites from the soils of the Himalayas. An identification key to oribatid fauna of Neotropical region was prepared by Balogh and Balogh (1990), providing 830 illustrations contained in 142 plates. A redescription of the types preserved in "Berlese collection" was made by Mahunka (1991) who provided supplementary notes supported with figures. The same author (1991a) studied the oribatid fauna of East Malaysia and erected 2 new genera and 7 new species. He (1991b) also explored the oribatid mites of Capeverde Islands from where he collected 29 species including four new ones. Schatz (1991) expressed his ideas on the arrival, establishment as well as speciation of oribatid mites on Oceanic Islands of the Galapagos.

Norton (1991) erected a new species of oribatid mite, *Veloppia kananaskis* from aspen woodland soil in Alberta, Canada, and the original description of *V. pulchra* was amended and expanded. The genus *Veloppia* was redefined, removed from the family Damaeidae and tentatively placed in Caleremaeidae. Grobler *et al* (1991) described 2 new spcies, *A. turkeyensis* and *Z. lanceolata* from Turkey and recorded 7 known species as new records to Turkish fauna. Morell (1991) described a new species of the genus *Lauritzenia,* with *L. hispanica* as the type. Results of a survey conducted by Jaikumar *et al* (1992) on oribatid mites associated with coconut palm yielded a total of 21 species belonging to 19 genera and 14 families. Arillo and Subias (1993) described some new taxa belonging to the superfamily Galumnoidea from Spain. A new genus, *Iberogalumna* with *I. alandalusica* as the type species was described. *Setogalumna diminuta* was erected as a

new species along with other new taxa like *P. semistriata matritensis* and *Vaghia uniporosa*.

Behan (1993) studied the systematic and ecological problems in oribatid mites of Canada and the same author (1993a) gave an account of oribatid mites of the family Eremaeidae of North America. Phylogenetic perspectives of oribatid mites were discussed by Norton *et al.* (1993). Behan and Bissett (1994) gave an account of the oribatid mites of the Canadian peatlands. Monetti *et al.* (1994) collected a new oribatid spcies of the genus *Eremaeozetes* viz. *E. araucana* from the arid zones of Argentina.

Baratti and Bernini (1994) redescribed *C. coriaceus* and *C. arduinii* from typical and topotypical materials. SEM microscopy was used to determine the unknown morphological details and intra-and interspecific variability of the species. Monetti *et al.* (1994) gave description of a new species of the genus *Eremaeozetes* viz., *E. araucana*, from de Arid Zone of Argentina.

Block and Convey (1995) described *Alaskozetes antarcticus* as a dominant member of many terrestrial communities in the Antarctic. Two new species of the genus *Liodes* viz. *L. marplatensis* and *L. elongatus* were described from the Argentinean republic by Fernandez *et al.* (1995). The same authors (1995) redescribed *Pseudopirnodus persetosus* and studied its ontogenetic development. On the basis of new and complementary data, they established a new genus, *Huarpescopes* with *Prinodus cryophilus* as the genotype. Distribution pattern of *Pergalumna* sp. was discussed by Oppedisana *et al.* (1995). Lebrun and Straalen (1995) examined the prospectus of using oribatid mites in ecotoxicology.

Reeves (1995) described the adults of 2 new species of *Carabodes* viz. *C. spiniformis* and *C. coweetaensis*. Both the species were most abundant in coniferous or hard wood leaf litter, with the former also common in rotten wood. Miko and Trave (1996) based on their studies on the type species *Hungarobelba visnyai* and of the new species *H. pyrenaica* erected a new family Hungarobelbidae under the superfamily Eremuloidea. Subias and Arillo (1996) described a new species, *S. guanicola* from bat guano from a cave in Central Spain. Iberian species identity of the genus *Seratoppia* was also discussed and an identification key was also given.

Behan (1996) reported *Naiazetes reevesi*, a new genus and species of oribatid mite, based on adult specimens from semi-aquatic habitats in eastern Quebec and Alabama. This genus was tentatively placed in the Zetomimidae based on the shared presence of an unusually large male genital sclerite in *Naiozetes, Heterozetes* and *Zetomimus. Naiazetes* showed unique sexual dimorphism, with differences in shape of the rostrum, and shape and position of genital papilla *Va*, between male and female specimens.

Andriyevskiy (1996) described oribatid mites as an ecosystem component, their role in soil formation and the cycling of elements was evaluated and their possible use for the zoological method of identifying soils was indicated. Quantitative data were summarized on the population of oribatids of Siberia and the Russia far East. Pugh (1996) revealed that the moss *Prepanocladus uncinatus* harboured 2 species of hemi-edaphic oribatid mites, *Edwardzetes elongatus* and *Trimalaconothrus flagelliformis*. Both the mites fed upon microbiota and tolerated prolonged submersion in freshwater and their survival among the aquatic moss resulted from their pre-adaptation to similar conditions in flooded soil and vegetation, absence of predators and minimal competition from other aquatic invertebrates.

Luxton (1996) presented a list of 135 genera and 303 species, 7 of which were new records of British oribatid mites, along with a general review on their biogeography. It was suggested that their distribution indicated a north/south divide, complicated by the presence of discrete and special upland and southern/ south-western glacial relicit communities. Oribatid mites from 5 post-industrial dumps were investigated by Skubala (1997) who collected 108 species. Shtanchaeva (1997) studied the fauna of oribatid mites inhabiting lichens in a pine forest of the Bryansk region, Central Russia.

Ramani and Haq (1997) described a new speices, *Caloppia sejugatus* from coconut palms in Kerala, India. The same authors (1997a) described a new oribatid mite, *Scapheremaeus nuciferosa* collected from the green foliage, particularly on the lower surface of the leaflets, of coconut palm and also the leaves of *Chromolaena odorata*. The genus was reported for the first time from India.

Iturrondobeitia and Arillo (1997) described *Medioppia producta* as a new species of oppiid mite from a cave in Biscay. Alberti *et al* (1997) studied the fine structure of the humeral organ of the juveniles of *Edwardzetes edwardsii* and compared it with the porose areas of the adults for the first time with TEM and SEM. Fernandez and Cleva (1997) described a new species of the genus *Scapheremaeus* viz. *S. tillandsiae* living on the epiphytes of the genus *Tillandsia*, small tree of the "Monte" and arid zone of Argentina. Perez-Inigo and Baggio (1997) described 8 new speices of soil oribatid mites from Para state and established a new genus, *Belemacarus*. Fifteen previously known species were also recorded.

Reeves (1997) redescribed *Yoshiobodes irmayi* collected from eastern United States. The larvae, protonymphs, deutonymphs and tritonymphs of the species were described for the first time. It was also reported that all adults from both field collections and cultures were females, suggesting it as the third thelytokus species known in the family Carabodidae. The same author (1997a) described the adults of a new species, *K. littoristicus* from beach litter of southern Florida. The new species differed from the known species by having shorter, spoon-shaped interlamellar and notogastral setae, shorter adanal setae, and a fan shaped sensillus. Subias and Arillo (1998) described a new genus *Forminoppia* belonging to the subfamily Oxyoppiinae to accommodate 2 new species, *F. iturrondobeitiai* and *F. salonae*. Iturrondobeitia *et al*. (1998) proposed a new species of the family Ctenobelbidae viz. *Ctenobelba apatomorpha*.

Ramani and Haq (1998) provided the taxonomic description of a new species of *Siculobata*, viz. *S. malabarica* collected from the green foliage of coconut palm cultivated at different localities of Kerala, South India. Perez-Inigo and Sarasola (1998) made descriptions of 3 new species, one new subspecies and 4 previously known species from South America. Behan (1998) erected 9 species of oribatid mites under 7 genera, representing 4 families from a variety of habitats in primary and secondary low land tropical rainforest at Estacion Biologica La selva, Heredia, Costa Rica. Seven of these species were new to science.

Schatz (1998) presented the results of an investigation carried out for a period of 10 years on the oribatid mites of the Galapogos Archipelago. A total of 202 oribatid species belonging to 64 families were encountered, of which 81 species were new to science. He also reported that the oribatid mites were present from the littoral zone to the summit of the volcanoes and

their diversity and abudance increased from the arid to the moister zones at higher elevation.

Description of 2 new species of oribatid mites along with a report of a new record from Haryana state of India was published by Bose *et al*. (1998). Collof and Halliday (1998) published the first catalogue of Australian oribatids containing a comparative taxonomic coverage including many new records of species and genera. Gil Martin and Subias (1998) carried out a geographic analysis of 982 speices and subspecies of oribatids from the West Mediterranean. Thirty nine species of oribatid mites belonging to 13 families inhabiting Western coast of the Taimyr Peninsula in Northern Siberia were reported by Grishina *et al*., (1998). Hunt *et al*., (1998) brought out an interactive glossary of oribatid mites and an interactive key to the oribatid mites of Australia. Lebrun *et al.* (1998) reported that oribatid mites hold a great potential use in ecotoxicology, due to the structural and functional complexity of their communities and several other peculiarities which were not exhibited by other arthropods.

Schatz (1998) described a total of 202 oribatid species belonging to 64 families, of which 81 were new to science from the Galapagos Islands. Weigmann (1998) gave an analysis of segmentation in oribatid mites from a phylogenetic and ontogenetic point of view.

Badejo *et al*. (1999) studied the oribatid fauna of 7 terrestrial environments over a period of 5 years. Oribatid mite biodiversity in an agroecosystem was studied by Behan and Paoletti (1999). Jain *et al*. (1999) quantified the oribatid fauna inhabiting forest plantations. Species richness, abundance and diversity of oribatid mites in soil and plant litter were investigated by Migliorini and Bernini (1999). Skubala (1999) studied

colonization of a dolomitic dump by oribatid mites and recovered 82 species in Poland. Skubala and Ciosk (1999) collected oribatid mites representing 32 species from an old zinc metallurgic dump at Poland. Grobler and Skubala (1999) proposed a new species, *O. dentata* for the oribatid mite which was previously recorded as *O. macrostega*. This new species was characterized by prominent, bidentate lamellar cusps.

Ramani and Haq (1999) gave the taxonomic description of a new species of oribatid mite belonging to the genus *Zygoribatula* viz. *Z. keralensis*. The members of the new taxon were found mainly confined to the lower surface of the crinkled leaves and terminal receptacles of the terrestrial weed, *C. odorata* and also on the leaves of bitter gourd, *Momordica charantia*. Fernandez (1999) described a new species, *Oripoda benegasi*, living on *Tillandsia* sp. found on the rocky surfaces in the mountains of the Translasierra valley, Cordoba Province, Argentina based on the adult and tritonymphal stages.

Schatz and Vargas (1999) reported 5 species of Microzetidae in Galapagos Islands, of which 3 species belonged to the genus *Acaroceras* with the new species being *A. galapagoensis*, *A. interiunctus* and *A. taurus*. The diagnostic features and figures of *Kalyptrazetes* sp. were also presented along with notes on the distribution and ecological preferences of these species as well as that of *Berlesezetes auxiliaris*.

Gil-Martin *et al* (2000) described a new genus and species of oribatid mite under the family Machuellidae, *Gredosella fraternalis* collected from the soils of a burned pine forest at Arenas de San Pedeo. Its most important distinguishing character was the fused nature of tibia and tarsus on all the legs. The authors (2000a) created and characterized a new subfamily of

Oppiidae, viz., Paternoppiinae based on the type genus and species and a new species, *Paternoppia andalusicablensis*. The specimen studied was extracted from a soil sample collected in a burned pine forest at Candeleda in the Sierra de Gredos (Province of Avila, Central Spain) and it showed an original mosaic of characters with similarities to subfamilies Multioppiinae and Antilloppiinae. Fernandez and Cleva (2000) gave description of a new species, *Eremaeozetes chaneanii* found in the Chancani Park and Forestry Reserve.

Maraun and Scheu (2000) compiled data on the relative abundance of oribatid mites from different sites especially Europe and Germany. Park Hong-Hyun and Lee-Joon Ho (2000) conducted community analysis of oribiatid mites in Namsam and Kwangriung, coniferous forests. Species abundance, biodiversity, distribution and population dynamics within oribatid communities were studied by Tian *et al*. (2000).

Schuster *et al*. (2000) isolated 6 species of adult oribatid mites belonging to superfamilies Galumnoidea and Certatozetoidea from a lawn at Ondersteport in South Africa. Maraun (2001) conducted a study on the evolutionary and phytogenetic implications of sexual and unisexual oribatid mites. The same author (2001a) gave a report on the sexual and parthenogenetic oribatid mite strategies in relation to environment. Bayartogtokh (2001) described 3 new species of oribatid mites belonging to the genus *Liebstadia* from Mongolia. The new species were characterized by the poorly developed pteromorphae, the club shaped head of the sensilli, the absence of the dorsosejugal suture, the dorso-ventral thickness, and the length and arrangement of notogastral setae. In addition, *L. similis* was

redescribed and recorded for the first time in Mongolia. *P. serratomarginatus* was synonymized with *L. similis*. A key to the known species of the genus *Liebstadia* was also given.

Choi *et al.* (2001) described 2 new species of oribatid mites viz., *D. tenuisetosus* and *Liacarus unjangensis* from Korea. Badejo *et al.* (2002) described 10 new species of pterogasterine oribatid mites, belonging to 3 genera, *Scheloribates, Mulicercula* and *Peloribates.* Croft and Jung (2002) conducted stability analysis of soil oribatid mite community from Namsand and Kwangreung deciduous forests in Korea. Battigelli and Berch (2002) gave a report on the short time changes in oribatid mite abundance. Haq and Ramani (2003) described the various methods for sampling and extraction of oribatid mites along with a dichotohous key to the identification of these mites.

Behan and Eamber (2003) redefined the oribatid mite genus *Pelopsis* inhabiting the forest litter and swamp habitats in North America. The genus was most closely related to *Minunthozetes, Punctoribates* and *Zachvatkinipates* in the mycobatid subfamily Minunthozetinae. A new species, *P. baloghi* was proposed, based on materials recovered from the swamp vegetation in low land tropical rainforest of Costa Rica.

Grobler *et al.* (2003) described 2 new gustavioid species viz. *Stenoxenillus incisus* and *Xenillus sestosus* from Turkey. Taxonomic problems concerning the genera *Liacarus, Stenoxenillus* and *Xenillus* were also briefly discussed and the genus *Stenoxenillus* was placed in the family Liacaridae. Fujikawa (2003) collected and identified 13 new species from the beech forests in the Shirakami-Sanchi World heritage Area in Nippon. Badejo *et al.* (2003) described 2 new species of *Protoribates* viz.

P. oscenensis from South Eastern Nigeria and *P. rioensis* from South Eastern Brazil. The morphological differences between these two species and the type species, *P. dentata* and the classical species were compared. Critical attention was drawn to the taxonomical value of the families Protroibatidae and Xylobatidae and which had to be incorporated in to the family Haplozetidae. The genus *Brasilobates* was considered as a synonym of *Protoribates*.

Maraun *et al.* (2003) sequenced the D_3 domain and its flanking regions of 28S rRNA of 4 pairs of closely related sexual species (*Eupelops hirtus* and *E. torulosus*; *O. calcarata* and *O. quadricornuta*; *Chonobates voigtsi* and *C. borealis*; *L. coracinus* and *L. subterraneus*) and 4 pairs of closely related parthenogenetic species (*Nanhermannia nana* and *N. coronata*; *N. silvestris* and *No. palustris*; *Tectocepheus sarekensis* and *T. minor*; *Camisia spinifer* and *C. segnis*) and showed that there was no intra-specific genetic variation of the D_3 region in any of the species studied and it was even identical in 2 closely related parthenogenetic species (*N. nana* and *N. coronata*) and 2 closely related sexual species (*E. hirtus* and *E. torulosus*). The genetic differences of other species indicated that both parthenogenetic and sexual lineages had various ages. On average, however, the differences between the closely related parthenogentic species were larger than those between closely related sexual species, indicating that the parthenogenetic lineages existed historically and had radiated slowly than sexual species. The above findings supported the hypothesis that some of the parthenogenetic oribatid mite taxa (*Tectocepheus, Nothrus*) were ancient 'asexuals'.

Sidorchuk (2004) a while studying the composition of the oribatid complexes in soil layers of different ages showed that the soil fauna of the

northern part of the Runian plain changed deeply during the Holocene peiod. These changes were connected not only with the shift of the zonal boundaries, but also with the fundamental transformations of the structure of soil communities. His investigation further showed that some faunistic complexes that had no recent analogues survived until 6000 years ago.

Bayartogtokh (2004) described 2 new species of oribatid mites, viz. *B. heterosetosa* and *Belbodamaeus rarituberculatus* from the eastern part of Mongolia. In addition, 2 known species, *B. mongolica* and *B. crassisetosa* were also discussed. Baran and Ayyildiz (2004) described the characteristic features and figures of *O. nitens* for the first time from Turkey. Maraun *et al.* (2004) studied the nucleotide sequences of D_3 to evaluate phylogenetic relationship among representative sexual and asexual oribatid mites and investigated the hypothesis that oribatid mites consisted of species rich clusters of asexual species that have radiated while being parthenogenetic. The authors further investigated the systematic position of astigmatid mites which were hypothesized to represent a paedomorphic lineage within oribatid mites. Karasaw and Hijii (2004) reported morphological modifications among oribatid mites in relation to habitat differentiation in mangrove forests. The same authors (2004a) studied the effects of microhabitat diversity and geographical isolation on oribatid mite communities in mangro ve forests.

Anibal *et al.* (2005) surveyed forest sites in the eastern half of the state of Sao Paulo to determine the oribatid fauna in areas of Cerrado and Mata Atlantic ecosystems. Samples of bark, fruit leaves, litter, soil and terminal shoots were taken from selected species of Myrtaceae (*Cerrado*) and Arecaceae (Mata Atlantica). Fifty-six oribatid species, belonging to 48 genera and 34 families were represented, seven of which were new records

for the state of Sao Paulo and 20 were new records for Brazil. Lebedeva *et al.* (2006) identified 18 species (2906 specimens), 9 species (40 specimens) and 17 species (42 specimens) of oribatid mites in ornithogenous soils from breeding and resting sites, the nests of Arctic ferns and snow buntings, and bird plumage, respectively.

Mahunka (2006) conducted studies on newly collected oribatids from Venezuela. Seven species were discussed, of which 6 were new to science. One new subgenus *Rostrozetes* (*Rostrozetella*) was established, belonging to the family Haplozetidae and the species *Acrozetes biscuspidatus* was redescribed. Mahunka (2006) gave a list of 32 species of oribatids collected at several sites in the Carpathian Basin. Krystyna *et al.* (2006) presented a detailed list of oribatid mite species occurring in the Bug River protected landscape area of Eastern Poland. Twenty microhabitats with diversified ecological conditions were investigated, 96 taxa were identified including 37 new records.

Akrami and Subias (2007) described a new species of oribatid mite of the family Oppiidae, *Anomaloppia mazandaranica* from Mazandaran Province, Northern Iran. The same authors (2007a) conducted studies on the oppiid mites of Mazandaran province, Northern Iran and described a new species viz. *Medioppia bipectinata*.

Mahunka and Mahunka (2007) enlisted the oribatid mites collected from Kenya, of which 8 species were found belonging to the families Hermanniellidae, Tetracondylidae, Oppiidae and Scutobelbidae.

Schatz and Behan (2008) reported that oribatid mites were primarily terrestrial and added that only about 90 species (less than 1% of all known oribatid species) from 10 genera were truly aquatic, with reproduction and all

stages of their cycle living in fresh water. Adaptation to aquatic conditions evolved independently in different taxa and many terrestrial species could also be found in aquatic habitats, either as chance strugglers from the surrounding habitats, or from periodic or unpredictable floodings, where they could survive for long periods.

Based on a survey made on the soil and litter dwelling oribatid mites of Muthanga forest reserve in Wayanad district, Julie and Ramani (2008) reported a total of 51 species belonging to 31 genera and 20 families. Mahunka and Mahunka (2008) identified 11 newly collected oribatids from Kenya, of which 6 were new species belonging to the family Micreremidae, Oribatulidae, Haplozetidae and Scheloribatidae. A review on Scheloribatidae was made by Ivan and Vasiliu (2008) and the authors described 2 new species under the genus viz., *S. longisensillus* and *S. (Topobates) vasillui*.

Julies *et al.* (2009) reported the diversity of oribatid mites in some mangove ecosystems of Calicut district, Kerala.

GENERAL EXTERNAL MORPHOLOGY OF BRACHYPYLINE ORIBATID MITES

The mite suborder Oribatida (Crypotstigmata, Oribatei) includes about 7,000 nominal species. They have existed at least since the Devonian period (Norton *et al*, 1988) and even some rather derived genera are known from the Jurassic (Krivolutsky and Druk, 1986). This group displays extreme species diversity with respect to their morphological features. Therefore, it seems desirable to comprehend the terminology used in the study of the identifying characters of oribatid mites. For this reason, the current description is meant to prepare a common treatment of the morphological terms used in the study of oribatid mites. The typical sample of terminology followed here is based on Wallwork (1965), Balogh (1972), Woolley (1988) and Balogh and Mahunka (1990). Brachypyline oribatid mites generally range from 100 to 1000μm in length with a dorsoventrally flattened, but sometimes cylindrical or a convex dorsal surface. Body is uniformly covered with a thin and hard cuticle, which becomes sclerotised to different degrees among individual species.

I. Dorsal region (Plate I, Figs. 1, 1a-1e)

The body can be easily divided into two parts (i) an anterior propodosoma or proterosoma or prosoma covered with a dorsal shield called the prodorsum (ii) a posterior hysterosoma or opisthosoma is covered with the dorsal shield called the notogaster. The dorsosejugal suture separates the

prodorsum from the notogaster which may sometimes be interrupted or even absent in some cases and other times may bear an area porosa on both sides called areae porosae dorsosejugales. The proterosoma represents the anterior part of the original prosoma while hysterosoma is a composite structure formed of posterior part of prosoma 'bearing legs III and IV and the original opisthosoma. The region carrying legs I and II is designated as propodosoma while legs III and IV are carried by metapodosoma. The propodosoma along with metapodosoma form the podosoma.

A. Prodorsum

The proterosoma is covered on the dorsal and dorsolateral regions by a cuticular shield known as the prodorsum. The proterosoma is either slightly movable or firmly attached to the hysterosoma. Generally, the prodorsum has a triangular outline and its anterior end is designated as rostrum. There are 4-6 pairs of invariably present setae on the prodorsum viz., 1. sensillus (*ss*) or pseudostigmatic organ, 2. interlamellar seta (*in*), 3. lamellar seta (*le*), 4. rostral seta (*ro*), 5. anterior exostigmatal or exobothridial seta (*exa*) and 6. posterior exostigmatal or exobothridial seta (*exp*). Only a single pair of exostigmatal seta resulting in five pairs of prodorsal setae or sometimes both the exostigmatal setae may be absent, bringing the number down to four pairs. Each sensillus arises from a cup shaped invagination called the bothridium (*bo*) or pseduostigmata. The sensillus represents in many groups as one of the best specific characters. But this characteristic sense organ may be very small or even absent in some members. It takes a variety of forms in different individuals and accordingly named as setiform, fusiform, lamelliform, clavate, pectinate, spathulate etc.

The setae which originate just below or above the rostral tectum are known as rostral setae. Lamellar setae are seen near the lamellar apex or lamellar cuspis. Interlamellar setae arise from the inter-bothridial region, between the lamellar base or they may be located close to the dorsosejugal suture. The anterior and the posterior exobothridial setae originate from the anterior and posterior sides of bothridium respectively. The nature of these setae varies from one species to the next. Running from the base of the prodorsum, or from the bothridium towards the rostrum, there are frequently decurrent on both sides, appendages generally called lamellae. If the structure is flat, lath shaped or lamelliform with a horizontal extension, it is referred as lamella and if, however, it is rib like and projects from the level of the prodorsum it is defined as costula. The lamellae of both sides are quite often connected by a translamella. The tip of the lamella is called the cuspis. The surface of the prodorsum is marked by reticulations and punctations of varying size and shape, characteristic of each species.

B. Notogaster

It signifies the cuticular shield covering the dorsal part of the hysterosoma and lies posterior to the prodorsum. The shape of the notogaster is extremely variable among different species, it may be elongated, round, oval, globular, pentagonal or hexagonal, sometimes becoming broader towards the posterior end. Usually notogaster is undivided or in certain cases divided by 1-3 transversal sutures into 2-4 parts. Commonly 10 or 14 pairs of notogastral setae are present. Grandjean (1954) has applied a special system of chaetotaxy to refer to the notogastral setae. While naming setae, it is customary to name the segment first followed by a number indicating the relative position of seta, from the mid-dorsal region towards the lateral side.

B 1. Notogastral Setal Notation:

a. Notation for Higher Oribatids with 14 or 15 pairs of Setae

The first and last two rows are homologous to those of primitive oribatids and therefore the same notation is used. But the homology of the middle six pairs of setae is doubtful and are named according to their relative positions in to three transverse rows as follows

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

Sixth row : ps_1, ps_2, ps_3

Here *d* stands for dorsal, *l* lateral, *a* anterior, *m* median, *p* posterior.

b. Notations for Higher Oribatids with 10 Pairs of Setae

There are only four rows of setae and the rows are named as *t, ms, r* and *p*. Setae in the first row are indicated by three small letters of the alphabet viz., *a*, *e* and *i*. Second row has only one seta which is named as *ms*. The last two rows have three setae each and named as *r* and *p* respectively using serial numbers 1, 2 and 3 as follows:

First row : *ta, te, ti*

Second row : *ms*

Third row : r_1, r_2, r_3

Fourth row : p_1, p_2, p_3

Here *a* means anterior, *e* exterior and *i* interior.

B.2. Different Types of Setae (Plate – 3, Fig. 1-15)

Setae in oribatid mites are highly varied and appear in greatly specialized forms (Mahunka and Zomberi, 1985).

1. Flagelliform (Plate 3, Fig. 1): Irregularly, bending, slender like a thread, resembling a whip.
2. Setiform (Plate 3, Fig. 2): Slender gradually tapering apically, bristle like.
3. Spiniform (Plate 3, Fig.3): Broad based, gradually tapering apically, resembling a spine or thorn.
4. Clavate (Plate 3, Fig. 4): Petiolate basally, thickened towards the end, club-shaped.
5. Foliate (Plate 3, Fig.4): Slightly broad based, broadest in the middle, gradually tapering to a point.
6. Arboriform (Plate 3, Fig. 6): With branches arising, from the base.

Setae may be provided with special types of ornamentations as follows.

1. Pectinate (Plate 3, Fig. 7): Unilaterally beset with hair or bristles arranged so as to resemble a comb.
2. Ciliate (Plate 3, Fig. 8): Irregularly beset with fine hairs.
3. Pennate (Plate 3, Fig. 9): Bilaterally densely fringed with long fine hairs resembling a feather.
4. Brocate (Plate 3, Fig. 10): With very fine bristles towards the tip.

Margins of setae can exhibit variations as described below:

1. Entire (Plate 3, Fig. 11): With an even margin, without any kind of indentation.
2. Serrate (Plate 3, Fig.12): Regularly notched like a saw.

3. Barbed (Plate 3, Fig. 13): Densely covered with short bristles, like a stubby, Unshaven face.
4. Ciliate (Plate 3, Fig. 14): Provided with fine cilia.
5. Spinose (Plate 4, Fig. 15): Having spine like projections.

Apices and endings of setae exhibit great variations as described below (Plate 4, Figs. 1-11)

1. Acuminate (Plate 4, Fig. 1): Strongly tapering to a point.
2. Acute (Plate 4, Fig. 2): Having a sharp point.
3. Conical (Plate 4, Fig. 3): Shaped like a cone
4. Obtuse (Plate 4, Fig. 4): Having a blunt apex.
5. Rounded (Plate 4, Fig.5): Assuming a round shape.

Surfaces of setae exhibit various types of ornamentations as described below:

1. Glabrous (Plate 4, Fig.6): Entirely devoid of hairs or bristles, smooth-skinned.
2. Roughened (Plate 4, Fig.7): Having an uneven or irregular surface, not smooth.
3. Barbed (Plate 4, Fig.8): Completely covered with fine hairs.
4. Ciliate (Plate 4, Fig. 9): With uniformly distributed cilia.
5. Spinose (Plate 4, Fig. 10): Covered with strong, sharply pointed spines, or thorn like structure.
6. Plumoses (Plate 4, Fig.11): Densely covered all over with long fine hairs.

B. 3. Microsculpture of Integument (Mahunka and Zomberi, 1985) (Plate 5, Figs. 1-10)

An important feature of oribatid mites is the micrsculpture of the integument. The pattern of microsculpture varies from one species to the other and has been categorized as follows.

1.	Punctulate	:	Marked with minute points or dots
2.	Punctate	:	Marked with points or dots.
3.	Foveolate	:	Marked with small pits, interspaces larger than diameter of one pit.
4.	Alveolate	:	Marked with large, mostly round spaces.
5.	Maculate	:	Marked with spots or marks of irregular outline and of different sizes.
6.	Polygonate	:	Marked with fine granules grouped into polygonal masses.
7.	Granulate	:	Covered with small grains
8.	Rugulose	:	Covered with rather fine wrinkles
9.	Rugose	:	Covered with wrinkles
10.	Reticulate	:	Forming a fine reticulum

Some members possess wing-like expansions antero-laterally and these are called pteromorphae. They may even extend beyond the body and may curve ventrally over the legs. Pteromorphae may be movable or immovable.

II. Lateral Side (Plate 1, Fig.2)

Higher oribatids develop chitinous, longitudinal ridges called pedotecta which form a protective cover for the bases of legs, their usual number being 2, but rarely 3. Pedotectum 1 is longer than the rest. Lateral projections of various shapes called discidia (*dis*) are produced from ventral plate, which protect the base of IV^{th} leg. In some oribatids, a wedge shaped crista called custodium (*cus*) arises from leg IV.

III. Ventral Region (Plate 2, Fig. 3, 3a-3c and Fig. 4)

Consists of the gnathosoma, epimeral region, genital and anal regions.

A. Gnathosoma

The region of the body carrying the oral appendages or mouth parts is called the gnathosoma. It is contained in an anterior cavity called the camerostome. The mouth parts consist of the sub or infracapitulum, paired palps and chelicerae. The infracapitulum is the basal part of gnathosoma which consists of an unpaired mentum or hysterosoma, a dorsal neck or cervix, the paired genae and their continuation in the rutellum. The articulation between mentum and genae is the labiogenal articulation which can be of the following four types.

1. Anarthric : Without any special articulation
2. Stenarthric : With posteriorly directed labiogenal articulation and mentum appears triangular
3. Diarthric : With transverse labiogenal articulation and mentum appears quadrangular
4. Suctorial : With united mento-genal plate.

In suctorial type of labiogenal articulation, rutellum becomes modified into tubes. Three pairs of setae are usually seen on the infracapitulum, one pair called *h* on mentum and two pairs, *a* and *m* on genae. The palps have 2-5 segments and setation is species specific. Chelicerae may be wide, chewing type or elongate piercing type (peloptoid type). The first type possesses a fixed digit or digitus fixus and a movable digit or digitus mobilis. Both digits bear teeth of varying number and nature. Two setae, *cha* and *chb* are present on the chelicerae.

B. Epimeral Region:

The region between the infracapitulum and the genital plate is known as the epimeral or coxisternal region. Laterally, it extends up to the coxae of

the legs and forms the ventral side of the propodosoma. The four epimeral plates viz., ep_1, ep_2, ep_3 and ep_4 cover this region. The four epimeral plates are bordered by chitinous thickenings called apodemata of which there are five, apo_1, apo_2, apo_3, apo_4 and apo_5 (apodemata sejugalis). The number of setae on the epimera varies in different species and is usually represented by an epimeral setal formula of four figures. The setae are counted on each epimeral plate from the middle towards the margin.

C. Genito-Anal Region

The region behind the epimeres is occupied by the genital and anal plates. These two plates do not touch each other and situated on a distinct ventral plate. A pair of small triangular aggenital plates are seen laterally below the genital plates. Lateral to the anal plate is a pair of longitudinally placed adanal plates which may be either fused with the anal plate or may lie separate. Except the preanal plate, all others carry setae. The chaetotaxy is six or four pairs of genital setae, one pair of aggenital setae, two pairs of anal setae and three pairs of adanal setae.

IV. Legs (Plate 2, Fig. 4)

Adult oribatid mites possess four pairs of legs, each consisting of five segments: trochanter, femur, genu, tibia and tarsus (proximal to distal). The chaetotaxy varies from species to species and also from leg I to IV. This can be represented in the form of a formula. Tarsus is the longest segment of the leg and it bears the maximum number of setae including the fundamental and accessory setae. Tip of the tarsus bears 1-3 claws depending upon the species. Tarsal segment of leg I is characterized by the presence of various setiform organs. Leg setae are of four major types (Norton, 1977).

1. Normal setae (Plate 4, Fig.12)– They are the most abundant setiform organs on legs. They are homogenous with a median cavity and contain actinochitin.
2. Solenidia (Plate 4, Figs. 13-16) – They are hollow, thin walled and can be easily distinguished from the others by the lack of actinochitin. They are mainly of four 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 with fine tip.

   The solenidial notation varies with segments and accordingly they are noted as sigma (σ) when they are on genu, Phi (φ) when they are on tibia and omega (ω) when they are on tarsus.
3. Eupathidia:- These are generally seen only on tarsus of leg I and represent modified setae with a hollow canal penetrating the small root and a large alveolus. They are devoid of any ornamentation and are sensory in function. They are the result of regressive evolution.
4. Famuli (Plate 4, Figs. 17-19): Are restricted to tarsal segments. They resemble solenidia but stand out separately by the presence of actinochitin. Their internal surface is not striated but somewhat rugosed. They are also formed by regressive evolution.

MATERIALS AND METHODS

I. Collection Localities

Soil ecosystem supports a composite of faunal communities, of which microarthropods are of prime importance. The oribatid mites depict the commonest of soil microarthropods owing to their numerical abundance and population density. Giving due consideration to the impact of vegetational characteristics and geographical peculiarities on the species composition, density and diversity of soil biota, during the present study sites of diverse topographic features were selected for sampling and subsequent extraction of oribatid mites. Thus, a total of 25 sites distributed over 6 districts (Plate 6, Fig.1) of Kerala viz., Wayanad, Kozhikode, Malappuram, Thrissur, Idukki and Thiruvananthapuram as described below were surveyed during the present study period for the collection of adequate number of soil/litter samples (Plate 6, Figs. 1-6). Regular/intermittent sampling was made covering different seasons, for subsequent extraction and recovery of the most common and locally important taxa of brachypyline oribatid mites (Table 1).

(a) Wayanad District (Sites 1-11) (Plate 7, Fig. 1-6; Plate 8, Fig. 7-11)

Wayanad District lies in the north east part of Kerala and stands on the Southern top of Decan plateau. Its chief glory is the majestic Western Ghats with lofty ridges interspersed with dense forest, tangled jungles and deep valley. The average annual rainfall recorded was 2322 mm. Eleven sites (Sites 1-11) were selected from the Wayand District located at Kalpetta, Sultan Battery and Muthanga Reserve forest. Kalpetta which is 60 Km away from Kozhikode, with a latitude and longitude, 11^0 36’32.15’’N,76

04’54.55’’E respectively. The site selected in this area (Site 1) was Malankara (Table 1; Plate 7, Fig. 1). Sultan Battery formed the second site with 11° 39′ 37.57 N,76° 15′ 28.98” E, and located 90 Km from Kozhikode. The site selected from this area was the Santhigiri Ashram (Site-2) at Nambiyarkunnu (Table 1; Plate 7, Fig.2). Muthanga Reserve forest was a major sampling locality on the way from Mysore to Sultan Battery. This site was spread over 344 square Km with a latitude and longitude, 11° 48 ′32.14”N, 76° 06′ 21.23” E. Nine study sites (3-11) (Table 1; Plate 7, Figs.3-6; Plate 8, Figs. 7-11) of varied vegetational characteristics and litter composition were surveyed from Muthanga Reserve forest for analyzing species diversity of oribatid mites.

(b) Kozhikode District (Sites 12-16) (Plate 8, Fig. 12; Plate 9, Figs. 13-16)

Kozhikode is located at 11. 25° N, 75.77°E with an average rainfall of 3266mm. The five study sites in this district were Beypore, Feroke, Mankavu, Chaliyar Kadavu and Kadalundi (Table 1). Beypore is 10 Km away from Kozhikode and is located at 11° 11′02.13”N, 75°48 ′55.67”E. The study site (Site-12) selected was situated near the Beypore river, Kizhekumpadam palam where regular retting was practiced for many years and the area was bordered by mangrove vegetation (Table 1; Plate 8. Fig.12). The second site (Site-13) selected was Feroke, a census town known as the “cradle of the tile industry” in Kerala and located at 11° 11′ 01.38”N, 75° 50′ 54.10”E. The study site was a regular retting ground bordered by trees like *Cocos nucifera, Avicennia officinalis* and *Acanthus ilicifolius* (Table 1; Plate 9, Fig. 13). Mankavu lies 5 Km away from the Kozhikode city where the Kallai river flows (Table 1; Plate 9, Fig. 14), has a latitude and longitude of 11° 15′ 25.28” and 75° 52′ 02.44”E. The site selected was bodered by

A. officinalis and *Acanthus ilicifolius*. Site-15 was on the bank of the river Chaliyar (Plate 9, Fig. 15). Kadalundi forms one of the oldest town in Kerala with rich tidal mangrove forest on the banks of Kadalundi river which makes it a picturesque area. The area selected was Kottakkadavu (Site-16) which is located 11° 08′ 25 .40N, 75 50 13. 99 E with mangrove vegetation along the bank of Kadulundi river (Table 1; Plate 9, Fig. 16).

(c) Malappuram District (Sites 17-20) (Table 1; Plate 9; Figs. 17, 18; Plate 10, Figs. 19,20)

Malappuram District lies on the'' top of hills'' and situated 50 Km southeast of Kozhikode and 90 Km North west of Palakkad and it formed one of the regular collection locality. The average annual rainfall of the area recorded was 2900 mm. Four sites were selected from the district, two located at Kizhissery (Sites-17, 18) one at Vazhakkad (Site-19) and one at Edavannappara (Site-20) (Table 1; Plate 9, Figs.17, 18; Table 1; Plate 10, Figs. 19-20). Site-17 at Kizhissery was an area of mixed vegetation and Site-18 was a homeyard. Edavannappara lies at a latitude and longitude, 11° 14 ′37. 50" N, 75°58′ 39. 67" E and the Chaliyar river flows through this area. The Site selected at this area was on the bank of the river. The Site at Vazhakkad formed a paddy field bordered with *Pandanus odoratissimus* and represented a semi-water logged area.

(d) Thrisssur District (Site-21) (Table 1; Plat 10, Fig. 21)

Thrissur District is located at 10.52° N, 76.2 2° E and the average rainfall received was recorded to be 3500mm. The site selected in this district was Punkunnam, located 10° 32′ 14 .97 "N, 76 °12′ 01. 55"E and formed an area of mixed vegetation.

(e) Idukki District (Site-22) (Table 1; Plate 10, Fig. 22)

Idukki covering an area of 5,105.22 Km² represents a hilly district with many topographical and geographical characteristics. The area was located at 9° 50′ 29".16"N, 76° 57′" 37.24" E and 97% of which comprised of regular mountains and forests. The average annual rainfall of the area was recorded as 3265 mm. The study site selected at Idukki was Mannakudy.

(f) Thiruvananthapuram District(Sites 23-25) (Table 1;Plate 10,Figs.23-25)

Thiruvananthapuram represents an area sand-witched between Western Ghats and Arabian Sea. The annual rainfall of this district was 1700 mm. The area located here was Santhigiri Ashram lying at Pothencode, 22 Km North of the capital city. The Santhigiri Ashram embraces 25 acres of herbal garden maintained in natural form, located at 8° 38′2" N and 76° 54′ 24"E and supports varied medicinal plants. This area of herbal garden was selected as Site 23. The second site represented an area (Site-24) where biowastes left behind after the extraction of raw plant extract were accumulated and the third (Site-25) represented a site of mixed vegetation (Table 1; Plate 10, Figs. 23-25).

II. Collection of Soil/litter Samples

Collection of soil/litter samples from the above sites was carried out for a period of four years. Random samples of soil/litter were collected in the early hours of morning between 6.00 to 8.00 am. Soil along with partially decomposed litter were carefully removed from the upper surface, at a depth of 0-5Cm using a showel. Frequently, a rectangular iron corer measuring 10Cm height and 5Cm diameter was also used for the purpose. The collected samples were transferred into plolythene bags, labelled and tied loosely with

a rubber band for transportation to laboratory as early as possible, for the purpose of extraction. Samples of partly decomposed plant litter, algae, fungi, lichen and moss were also collected for the extraction of mites. Such collected resources were treated as test food items for the conduct of feeding experiments. Maximum care was taken while handling the samples during collection and subsequent transportation. While collecting the samples, data were also recorded on various parameters like the soil temperature, humidity, type, texture, vegetational characteristics, relative humidity etc.

III. Extraction of Mites

The soil and litter samples collected from the various sites described above were subjected to extraction in the laboratory for the collection of oribatid mites. The process of extraction was carried out in an Open brass funnel apparatus following the extraction principles of Berlese (1905) and Tullgren(1918).

i. Principle of Extraction

The extraction technique employed in the present study was based on Berlese's (1905) original funnel apparatus modified by Tullgren (1918).

Soil animals including oribatid mites are highly sensitive to the intensity of light and heat in the environment and desiccation of soil in which they live. Majority of soil animals are negatively phototropic and hence when exposed to heat and light, they try to move away. This behaviour of soil animals is best utilized for their extraction from soil/litter samples. Desiccation of soil samples by heat help to drive the fauna from top to bottom and gradually out of the sample, through the sides of the funnel into the collecting vial. Larger animals during this process could escape through the gap between the lower rim and base of the sample container.

ii. Extraction Apparatus (Plate, XI, Figs 1)

Open Brass Funnel Apparatus

The open brass funnel apparatus was found effective for the last 2 decades for the successful extraction of microarthopods, particularly the soil mites. The frame of this rectangular unit (185cm x 50cm x 170cm) is made of steel and it rests on four legs. The bottom and top of the unit are covered by steel sheets. Two rows of wooden planks with 13 and 12 holes respectively are provided with funnels and sample container on each plank. Each funnel is provided with a collecting vial beneath it, which rests on a metal based spring over the iron sheet attached to each row. Each row has 12-13 units, arranged on either side consecutively, thus the apparatus having a total of 25 units. Each unit is composed of four parts:(1) an electric bulb to generate the required heat (2) sample container to keep the sample (3) a vial to collect the fauna driving out of the sample and (4) a metal spring to hold the vial in position. The heat source in each unit is provided with an electric bulb, the intensity of which is decided by considering the season, size and moisture content of the soil sample to be extracted. Though the distance between the bulb above the sample below is normally 12cm, it can be increased or deduced by raising or lowering the wooden planks with the help of screws provided at the corners. In summer season, when the samples are comparatively dry, 40 and 60W bulbs are used, while during the rainy season, 100W bulb is used as heat source.

The sample container made of brass is circular with a diameter of 15cm, and height of 9cm. This is attached to a fine mesh of 0.8 mm size and 16 cm. diameter which serves as the base of the sample container. There is a gap of 1 cm between the base and lower rim of the sample container. Below

the sample container is a rounded resting shield, which is also made of brass, having a diameter of 17 cm and with larger mesh size of 0.5 cm. The brass funnel which holds the resting shield and sample container, is having a length of 20cm and mouth diameter of 18cm. The tail region of the funnel has a diameter of only 2cm.It is conical in shape with steep and smooth inner sides. The upper rim of the funnel is well flattened like a platform with raised edges, where the diameter is 20cm, so that it could snugly hold on the hole in the wooden plank. A glass or plastic specimen tube of 6 c.m length serves as the collecting vial, it is placed below the tail end of the funnel with the help of a spring mounted on a brass square block. This helps to mount the vial conveniently below the funnel in position.

For operation of the unit, the principle of using heat to desiccate the sample gradually, thereby enabling the fauna to drive out is employed here. This is possible owing to behavioural response of the cryptic soil organisms. The animals under extraction move deeper into the sample, reach the fine mesh screen and fall into the vials through the funnel. Mites recovered can be hand-sorted under a stereomicroscope.

iii. Process of Extraction (Plate 11, Fig. 2 & 3)

Soil samples for extraction were placed in the sample containers. The distance between sample and light/heat source was adjusted as per requirements and the bulbs were switched on. The combined effect of heat and light caused gradual desiccation of the soil sample, there by compelling the cryptic mites to come out of the soil. On reaching the fine mesh screen they fell into the collecting vials. Depending up on the moisture content of the soil sample, the period of extraction varied from 48 to 72 hours. About 5ml of 70% alcohol was taken in the collecting vial and kept under the

funnel. This helped to preserve the animals falling into the vials. Mites collected in this way were used for taxonomic studies.

IV. Preparation of Mites for Taxonomic Studies

The extracted mites in the vials were transferred into petridishes and sorted out using a fine needle and camel hair brush No.1 under 32x magnification of a Carl Zeiss stereomicroscope. The specimens were dehydrated by upgrading in alcohol series and were finally transferred to vials containing clearing medium prepared by mixing absolute alcohol and lactic acid in the ratio 1:1. The vials were closed with cotton plugs and kept at room temperature in plastic containers. The time taken for clearing depended on the sclerotisation of the mite species. Well cleared specimens were mounted on microscopic slides for microscopic examination.

(A) Mounting of Cleared Specimens

Two types of mounting of mite specimens were practiced during the present study.

1. **Temporary mounting**: This was followed for daily and immediate observation of cleared specimens. For this, a drop of glycerin was placed in the centre of a clean microscope slide. The mite specimen was then transferred carefully into the glycerin drop. After orienting the specimen properly, a glass bristle larger than the size of the specimen was placed near the specimen, which helped to handle the mite in the desired position without damage. The use of glass bristle larger than the size of the specimen enabled to prevent crushing of the mites while mounting. The specimen was then mounted using a cover glass of 18 mm diameter.
2. **Permanent mounting –** Permanent slides were prepared either by using polyvinyl alcohol or Hoyer's medium (Baker and Wharton, 1952). This

was performed by placing a drop of the mounting medium in the center of the microscope slide. The specimen was placed in position using a fine camel hair brush. It was then oriented in the desired position using glass bristles as mentioned above and was covered by a cover glass. The prepared slides were kept at 50^0C in an incubator until desired clarity was obtained. After this, the cover glass was sealed with commercial nail polish. The mounted slides were properly labelled and stored in slide boxes.

B. Preparation of Mounting Media

(a) Polyvinyl Medium:

1. Elvanol 71-24 (Du pont poly vinyl Alcohol) dissolved in 4 volumes of distilled water at 90^0C.
2. Filtered the solution.
3. Concentrated the clear filtrate in a water bath until solution became syrupy.
4. Added 22 parts of lactic acid to 56 parts of PVA and used for mounting.

(b) Hoyer's Medium

1. Weighed 30 gms of gum arabic and 200 gms of chloral hydrate and transferred the same into a 1000 ml beaker.
2. Added 50 ml of distilled water.
3. Added 20 ml of glycerin and thoroughly mixed at room temperature.
4. Filtered the mixture and used for mounting.

V. Identification of Mites

Slide mounted specimens of oribatid mites were subjected to microscopic examination to reach their taxonomic identity. Morphological characters were studied under a Carl Zeiss Research Microscope and

sketches were drawn using Camera Lucida. Identification of the various species was made following Balogh (1965, 1972), Balogh and Balogh (1990, 2002) and Haq and Ramani (2003). Concerned literature were also referred for confirmation of each species. Erection of new species was made after censorious analysis of the novel characters detected and in consultation with the supervising teacher. Measurements of the type specimens were made using ocular micrometer placed in a calibrated Meopta Research microscope employing stage micrometery. The method proposed by Aoki (1965a) was followed for entering measurements of the body or body parts and all the measurements were made in μm. Detailed sketches of the various species were made under a Meopta Research Microscope with the help of a prism type Camera Lucida.

OBSERVATION

I. SPECIES DENSITY AND DIVERSITY OF BRACHYPYLINE MITES IN THE STUDY SITES

Results of the general survey carried out on the brachypyline oribatid mites inhabiting the varied collection sites disclosed the rich diversity of these mites and the impact of geographic characters on their relative distribution pattern. A total of 57 species belonging to 36 genera under 20 families and 14 superfamilies (Table-2) could be collected as representatives of Brachypylina, during the study period.

The Superfamily Oripodoidea exhibited the maximum family diversity, accommodating members of 4 families viz. Caloppiidae, Haplozetidae, Scheloribatidae and Protoribatidae. Three Superfamilies viz. Amerobelboidea, Tectocepheoidea, and Otocepheiodea comprised members of 2 families each while the remaining 10 superfamilies supported members of a single family each. Thus the superfamily representation of the brachypyline oribatids recovered during the present study could be presented as (Plate 12, Fig. 1): Oripodoidea > Amerobelboidea = Tectocepheoidea = Otocepheoidea>Gustavioidea=Carabodoidea=Licneremaeoidea=Microzetoidea =Oppioidea =Galumnoidea =Phenopelopoidea =Plateremaeoidea =Trizetoidea =Zetomotrichoidea.

The families Haplozetidae and Oppiidae showed maximum generic diversity, supporting 6 genera each. The families Scheloribatidae and Galumnidae were represented by members of 3 genera each while Basilobelbidae and Carabodidae included members of 2 genera. The rest of the families were found represented by a single genus each (Plate 14, Fig.1).

Scheloribates was recognized as the most diverse genus, represented by members of 7 species. The second position was achieved by *Galumna*, which included members of 5 species. The third position was shared by *Eremulus* and *Protoribates*, comprising 4 species each, followed by *Pergalumna* with 3 species. The genera *Dolicheremaeus*, *Ischeloribates*, *Trachyoribate*s and *Brachioppia* were represented by 2 species each. The remaining genera were found represented by a single species, thereby disclosing the minimum diversity.

Results of the quantitative and qualitative distribution pattern of the various oribatid species recovered during the study provided substantial evidence to confirm the influence of vegetational characteristics on the faunal composition of brachypyline oribatids. This was quite evident in the Wayanad District, where Kalpetta, Sultan Battery and Muthanga Reserve Forest with 11 varied vegetational and geographic peculiarities were the sites surveyed for oribatid mite collection. Site 1 located at Kalpetta with the major vegetation represented by *C. arabica* yielded 11 species belonging to 9 genera, 9 families and 8 superfamiles. The site 2 at Sultan Battery with *C. sinensis* plantation yielded 14 species belonging to 11 genera, 10 families and 7 superfamilies. Muthanga Reserve Forest (Sites 3-11) with 9 different types of vegetation, disclosed the maximum species diversity supporting 38 species belonging to 22 genera and 15 families and 12 superfamilies. Site 3 supported 29 species belonging to 18 genera, 12 familieis and 9 superfamilies. Site 4 supported 3 species belonging to 3 genera and 3 families and superfamilies while Site 5 was harboured by 19 species belonging to 13 genera, 10 families and 7 superfamilies. Site 6 supported 5 species, coming under 5 genera, 4 families and 3 superfamilies. The species diversity of Site 7

was striking with 21 species belonging to 14 genera, 10 families and 8 superfamilies. Site 8 showed only 3 species belonging to 3 genera, 3families and 3 superfamilies and Site 9 disclosed the presence of 18 species belonging to 15 genera, 10 families and 7 superfamilies. Site 10, which was a waterlogged area was found devoid of any species, though it was located in the Muthanga Reserve Forest and was bordered by different trees. The only species recovered from site 11 was *Tegeocranellus laevis* representing family Tegeocranellidae. Thus, the 11 sites selected in the Wayanad district enabled to procure 40 species of brachypyline oribatid mites.

The species diversity of oribatid mites in the Kozhikode District (Sites 12-16) was comparatively low. The 5 Sites selected in this District were highly contrasting, comprised of the mangrove vegetation, river banks and retting grounds. A total of 12 species belonging to 10 genera, 7 families and 5 superfamilies could be collected from the various sites selected in this district. Site 12 with mangrove vegetation along with the pith accumulated area contributed 9 species belonging to 8 genera, 6 families and 4 superfamilies. Site 13 was a retting ground near Kadalundi river and it harbored 7 species coming under 6 genera, 6 families and 4 superfamilies. Site 14 also represented a mangrove vegetation near Kallai river and which supported only 5 species belonging to 4 genera, 2 families and 2 super families. Site 15 occupied by *S. officinarium* supported 2 species, 2 genera, 2 families and 2 superfamilies of oribatid mites. Site 16, an area of mangrove vegetation at Kottakkadavu near Kadalundi river contributed 11 oribatid species belonging to 9 genera, 7 families and 5 superfamilies.

The soil samples collected from the various sites in Malappuram District (Sites 17-20) revealed the presence of a total of 28 species. Of these,

Site 17 with *X.xylocarpa, Mimusops elengi*, *Dalbergia lanceolaria, Mangifera indica* and *Semecarpus anacardium* supported a total of 24 species representing 19 genera, 14 families and 9 superfamilies. Site 18 with *E. officinalis* and *T. indica* disclosed 13 species belonging to 10 genera, 9 families and 6 superfamilies. Site 19 which was a water logged area bordered by *B. arundinacea* showed the minimum number of 2 species belonging to 2 genera, 2 families and 2 superfamilies. Site 20, a semi water-logged area of paddy field bordered by *P. odoratissimus*, also disclosed the minimum species diversity of 2 species.

The single site at Thrissur District (Site 21) occupied by *A. heterophyllus* yielded a total of 6 species belonging to 3 genera, 3 families and 2 superfamilies.

The single site at Idukki District (Site 22) revealed the presence of 14 species belonging to 11 genera, 9 families and 6 superfamilies. This site comprised *H. brasiliensis* plantation with high litter accumulation.

In the Thiruvananthapuram District, out of the 3 sites surveyed (23-25), site 23 supported 27 species representing 21 genera, 16 families and 12 superfamilies; site 24, though an area of a bio-waste accumulation showed high species diversity, represented by 27 species belonging to 19 genera, 12 families and 9 superfamilies; site 25 supporting plants like *A. hirsutus, A. racemosus, P. glabra* and *E. varigeta* revealed 15 oribatid species belonging to 13 genera, 8 families and 5 superfamilies. Thus the various sites in Thiruvananthapuram District contributed a total of 30 oribatid species.

The species diversity of the brachypyline oribatid mites included in the 25 sites could be presented as:

Site 3 > Site23= Site 24> Site 17> Site 7> Site 5> Site 9> Site 22> Site 25 > Site 2> Site 18> Site 16> Site 1> Site 12> Site 13> Site 21> Site 6= Site 14> Site 8> Site 15> Site 19> Site 20> Site 10 (Plate 13, Fig.1).

The results of survey enabled to recognize *Trachyoribates* (*Rostrezetes) foveolatus* as the widely distributed species, as it was recovered from 14 out of the 25 sites surveyed. *S. praeincisus interruptus* occupied the second position, which could be collected from 11 sites.The third species in this regard was *Berlesezetes brazilozetoides* which was found distributed in 10 sites. *T. laevis, P.seminudus, P. punctatus, S.praeincisus rotundiclava, Peloribates asejugalis* and *Oppia kuehnelti* showed their presence in 9 sites. Species like *E. curviseta, S. praeincisus, Galumna discifera* and *Dolicheremaeus fijiensis* could be recovered from 7 sites. Species like *Megalotocepheus kizhisseriensis* sp. nov., *Pheroliodes ciliata* sp. nov., *Allogalumna pelluicida* and *Galumna* (*Indogalumna*) *intermedius* sp. nov. were unique with respect to their respective sites. *T. laevis* showed preference to semi-water logged sites. Certain new taxa of oribatids could be recorded from 2-3 sites. Examples were *Xiphobela santhigiriensis* sp. nov. and *Corynoppia ajaii* sp. nov. and *Pilobatella genitae* sp.nov. recovered from sites 23, 24 and 25; *Arcoppia spotus* sp. nov., from sites 17 and 18. *T. (Rostrozetes) striata* sp. nov. were recorded from sites 12, 13, 14 and 16. These all species occurred mostly in nearby sites. The immature stages of most of the species were also present in abundance in all the sites surveyed. The cerotegument as well as the body and leg setae of both the adults and immature stages of several species were found carrying the spores and hyphae of different species of fungi. In addition, the body cavity of many species contained food boli, the number of which often ranged from 1-3. The distribution pattern of the 57 species recovered was not uniform as

represented in table 3. From table 3, it is evident that none of the species could be located in all the 25 sites studied and instead was recognized in 1, 2, 3, 4, 9, and 11 sites. The immature stages of most of the species were also present in abundance in all the sites surveyed.

II. DESCRIPTION OF NEW SPECIES

Infraorder : Brachypylina Hull, 1918

Superfamily : Amerobelboidea Grandjean, 1954

Family : Basilobelbidae Balogh, 1961

Genus : *Xiphobelba* Csiszar, 1961

Generic Characters

Exuvia affixed on the median tubercle at the anterior part of the notogaster. Genital plates with 6 pairs of setae.

***Xiphobelba santhigiriensis* sp.nov.**

(Plate 15, Figs. 1, 1a-1f & 2; Plate 16, Figs.4-7)

Colour : Yellowish brown

Measurements : Length: 384 µm (380-386 µm)

Width : 256 µm (250-270 µm)

Dorsal region (Plate 15 & 16, Figs. 1, 1a-1)

Prodorsum

Prodorsum crown shaped, with closely adhered granulated cerotegument; rostrum pointed with peloptoid chelicerae, bearing a pair of ridges dorsolaterally; an arched inverted T- shaped structure invades deeply between the rostral ridges; seta *ro* roughened, measures 38 µm; seta *le* very feebly barbed, measures 42µm and not closely situated; seta *in* feebly barbed, measures 36µm; seta *ex* thin and clearly visible; bothridial opening wide;

sensillus flagelliform and tapering with closely arranged barbs on its upper margin, lower margin with a few number of barbs.

Notogaster

Dorsosejugal suture straight; notogaster more or less ovoid posteriorly; trito-nymphal scalp or exuvium consisting of polygonal, reticulated microsculptures covers the notogaster, 9 pairs of minute stiff hairs present on the notogaster as shown in Fig. (1f); fissures *ia* and *im* clearly visible; opening of the lateroabdominal gland represented by small irregular circle near the notogastral fissure *im*.

Ventral region

Infracapitulum with 3 pairs of curved and barbed setae; cerotogument covers the mentum; epimeral setae easily visible, epimeral setal formula, 3-1-3-3, all setae long, slender provided with small barbs; genital setae 6 pairs, g_1 elongated than all other genital setae; 2 pairs of barbed anal setae; outside the anal and genital plates 11-14 pairs of feebly barbed setae present.

Scalp

Tritonymphal scalp attached to notogaster by means of buckle connection. 2 pairs of setae, c_1 and c_2 both slightly barbed, thick.

Legs

Legs stout, monodactylous; leg I with 36 setae; chaetotaxy 2-5-5-7-17.

Etymology

Named after the name of the collection locality.

Materials examined

Holotype: Adult ♀, paratypes: 8♀♀ and 6 ♂♂ collected from the litter samples of the Herbal Garden, Santhigiri Ashram, Thiruvananthapuram, Kerala, on 24.08.2006., coll. E. Julie.

Remarks

The genus *Xiphobelba* was erected by Csiszar in 1961 with the type species *X. hamanni* from Indonesia. The present specimen on comparison with the other known species of the genus was found to resemble *X. ismalia* described by Haq (1979) in the presence of the straight anterior margin of the notogaster, 2 pairs of anal setae, deutonymphal scalp setae c_1, c_2 and the type of reticulation found on the surface of the scalp. However, possession of the following features enables its distinction from the above species.

1. Setae c_1 and c_2 thick and slightly barbed.
2. Difference in the prodorsal ornamentation.
3. Setae *le* and *in* feebly barbed.
4. Seta *ex* easily visible.
5. Seta *ro* roughened.
6. Presence of 9 pairs of notogastral setae in the case of *X. setosa*
7. Difference in the shape of sensillus.

Infraorder : Brachypylina Hull, 1918
Superfamily : Amerobelboidea Grandjean, 1954
Family : Eremulidae Grandjean, 1965
Genus : *Eremulus* Berlese, 1908

Generic Characters:

Prodorsum of the members of this genus is indistinctly punctate or foveolate; seta *in* originates nearer to each other and far from the bothridia; genital plate carries 6 pairs of setae; prodorsum with weak, S-shaped costula; some of the epimeral, genital and aggenital setae 3-6 branched.

***Eremulus avenifer* Berlese, 1913**

(Plate 17, Figs. 1, 1a, 2)

Colour : Light brown

Measurement : Length: 348-368 μm

Width : 238 – 310 μm

Dorsal region (Plate 17, Figs. 1&1a)

Prodorsum

Prodorsum elongated and ends in a conical rostrum, rostral apex pointed, seta *ro* smooth, curved inwards tapering towards the tip, measuring 54μm in length, inserted far below the rostral tip; costulae ribbon shaped and anteriorly carrying the seta *le*, the latter measures 52μm in length and smooth; seta *in* long, roughened basally; seta *ex* roughened; bothridial cup widely open, from which arises the curved, long and slender sensillus (*ss*), the latter unilaterally serrated and more or less sickle shaped as shown in Fig.(1a); prodorsal surface foveolated, particularly at the lateral and medial regions; cerotegument present, closely adhered to the prodorsal surface.

Notogaster

Dorsosejugal suture almost straight; notogaster with 11 pairs of barbed setae; below the level of a seta c_2 a band formed of closely arranged, incomplete foveoles present; prodorsum and notogaster punctated; cerotegument secretion covers the notogastral surface also.

Ventral region (Fig. 2)

Infracapitulum carries 3 pairs of setae, *a* simple, *m* barbed and *h* branched (triradiate); epimeral setal formula 3-1-3-3, setae *1c*, *3c* and *4c* simple while all others triradiate; epimeral surface punctated; genital plates

some what oval with 6 pairs of setae, g_1 simple while the other 5 pairs branched; 3 pairs of aggenital setae present, all triradiate; anal plates with 2 pairs of simple and smooth setae; adanal setae 3 pairs, all barbed, ad_1 post-anal, ad_2 para-anal and ad_3 pre-anal in position.

Legs

All legs monodactylous, with a single, smooth claw.

Materials examined

5 ♀♀ and 8 ♂♂ collected from soil/litter samples of Santhigiri Herbal Garden, Santhigiri Ashram, Thiruvananthapuram, Kerala, India on 24.08.2006, coll. E. Julie.

Remarks

Eremulus is a consmopoitan genus erected by Berlese (1908) with the type species, *E. flagellifera*. The present species shows resemblance to *E. avenifer* Berlese, 1913 collected and figured by Hammer (1972) from wet moss in Tahiti in several respects such as the nature and arrangement of prodorsal setae, presence of barbed notogastral setae and in the general shape of the body but it differs in the nature of sensillus and presence of band formed of incomplete foveoles below the level of seta c_2.

Infraorder : Brachypylina

Superfamily: Galumnoidea Jacot, 1925

Family : Galumnidae Jacot, 1925

Genus : *Galumna* (Heyden, 1826)

Subgenus : *Galumna* (*Indogalumna*) (Balakrishnan, 1985)

Generic characters

Mandibles normal; lines *L* and *S* present; lamellar setae originating between *L* and *S*; prodorsum foveolate; notogaster rounded posteriorly, with

true area porosae and ten pairs of alveoli; pteromorphae with fissures; genital plate with longitudinal striations; 6 pairs of genital setae; all legs tridactylous.

***Galumna (Indogalumna) intermedius* sp. nov.**

(Plate 18, Figs. 1, 1a-1c, 2, 3 & 4)

Colour : Dark brown

Measurements: Length: 628μm (620 - 632 μm)

Width: 421 μm (418 – 422 μm

Dorsal Region (Plate 18, Figs.1, 1a-1c)

Prodorsum

Prodorsum broadly conical, entire prodorsum punctated; seta *ro* small with fine barbs, measures 58μm; seta *le* distinctly barbed, measuring 62μm, thickened basally with pointed apex, arises between lines *L* and *S*; seta *in* (Fig.1b) also barbed, measures 66 μm in length and thinner than *le*; *bo* circular, from which sprouts the setiform, barbed *ss*, the latter directed posteriorad; prodorsal integument ornamented with small foveoles.

Notogaster

Dorsosejugal suture slightly convex, notogaster with a wavy, broadly spherical border; pteromorphae (Fig.3) well developed, bearing curved, scattered ridges and punctations, seta *ta* and fissure *ia* present on each pteromorph; the remaining 9 pairs of setae arranged on notogaster as shown in (Fig.1), all setae represented by alveoli; notogaster bears 4 pairs of area porosae also, *Aa* largest and A_3 the smallest; notogaster bears longitudinal strigulae of varying lengths, median strigulae the largest; fissures *im* and *ip* clearly visible; glandular opening also present on notogaster; notogastral

integument heavily ornamented with foveoles and punctations; posterior border of notogaster with closely set notches and lateral borders with well separated notches.

Ventral Region (Plate 18, Fig. 2)

Infracapitulum bears 3 pairs of minute, simple setae *a, m* and *h*, mentum with dense punctations and foveoles; epimeral setal formula 1-1-2-1, all setae minute and simple, apodemes 1,2, 3 visible; genital plates with few longitudinal striations and 6 pairs of minute, simple setae arranged linearly; one pair of smooth aggenital setae present; 2 pairs of minute, simple anal setae and 3 pairs of adanal setae inserted as shown in Fig.2; setae ad_1 and ad_2 post-anally arranged and ad_3 located near the anterior corner; fissure *iad* oblique and located pre-anally above seta ad_3; area porosae *Apa* located posterior to the anal plates; circumpedal lines distinct.

Legs (Plate 18, Fig. 3)

All legs tridactylous; chaetotaxy of leg 1: 0-4-4-6-20; trochanter-1 devoid of any setae; femur-1 carries 4 setae, of which 3 barbed and 1 smooth; genu-1 carries 4 setae including 1 solenidion, σ, 1 barbed seta ν and 2 smooth setae; tibia bears 6 setae, of which 2 developed in to solenidia φ_1 and φ_2, ν' plumose, others barbed in various degrees; tarsus 1 bears 20 setae including 2 solenidia ω_1 and ω_2 and a famulus ε, setae (*p*), *s* and (*u*) smooth while others barbed; setae (*pv*) and *Ad'* plumose.

Etymology:

The specific name " *intermedius*" is coined based on the possession of intermediate characters of two known species of the genus viz., *G. (I.) microsulcata* and *G. (I.) undulatus*.

Materials Examined

Holotype: ♀, paratypes: 8 ♀♀colleted from the soil/litter samples of a mixed vegetation at Kizhissery, Malappuram (Dt.) Kerala, India on 30/08/2005., Coll. Julie. E.

Remarks

Indogalumna was erected as a new genus by Balakrishnan 1985 with the type species, *I. microsulcata* from Kerala. Later it was recognized as a subgenus under the genus *Galumna* Von Heyden (1826). The taxon currently is represented by 6 species. Of these, the present specimen resembles 2 known species viz., *G. (I.) microsulcata* and *G. (I.) undulatus* in features like. 1) Length of setae *in* and *le* equal 2) Presence of lines *L* and *S*. 3) Prodorsum foveolated 4) Presence of 6 pairs of genital setae and 5) Genital plate with longitudinal striations. However, possession of the following unique features clearly keeps its identify separate from the above two species.

1. Nature of setae *le*
2. *ss* with numerous barbs on the outer surface and few barbs on the inner surface.
3. Presence of thick striations on the notogaster.

Infraorder : Brachypylina Hull, 1918
Superfamily : Galumnoidea Jacot, 1925
Family : Galumnidae Jacot, 1925
Genus : *Allogalumna* Grandjean, 1936

Generic Characters

Lamellar line *L* absent; lyrissure *iad* adjacent to anal plate, longitudinally oriented; notogaster with median pore.

***Allogalumna pellucida* Wallwork, 1965**

(Plate 19, Figs.1, 1a & 2)

Colour : Brown

Measurements: Length: 280-290µm

Width : 212-218µm

Dorsal region (Plate 19. Figs. 1 & 1a)

Prodorsum

Rostrum pointed, seta *ro* minute, but discernible; setae *le* and *in* represented by alveoli; *ss* with an ´s´ shaped stalk and a dilated, barbed head, broadest at its apex, entire prodorsum marked with punctations.

Notogaster

Dorsosejugal suture present, arched in shape; irregular polygonal reticulation confined to the margin, fine punctation present throughout the notogaster; 4 pairs of area porosae with definite boundaries, *Aa* slightly larger than the other 3; 10 pairs of setae represented by alveoli; prominent median pore present.

Ventral region (Plate 19, Fig. 2)

Entire ventral surface covered with fine punctation, devoid of polygonal areas; 3 pairs of infracrapitular setae; epimeral setal formula 1-1-2-1; 6 pairs of genital setae, g_1 ,g_2, g_3 inserted longitudinally on the anterior margin of the genital plate, g_4, g_5 and g_6 inserted longitudinally; aggenital setae 1 pair, post-genital in position, represented by alveoli; 2 pairs of anal setae; 3 pairs of adanal setae, lyrifissure *iad* adjacent to anal plate, longitudinally oriented.

Legs

All legs heterodactylous in nature.

Material examined

6♂♂ and 9♀♀ recovered from the soil/ litter samples collected from a mixed vegetation at Kizhissery, Malappuram (Dt.) of Kerala on 26.10.2006, coll. E. Julie

Remarks

The genus *Allogalumna* was erected by Grandjean, 1936 with the type species, *A. integer* (Berlese, 1904). The present specimen shows resemblance to *A. pellucida* collected and figured by Wallwork, 1965 from Tchad in several respects such as the presence of median pore, absence of *le* and *in;* shape of sensillus, presence of dorsosejugal suture etc.

Infraorder : Brachypylina Hull, 1918
Superfamily : Microzetoidea Grandjean, 1936
Family : Microzetidae Grandjean, 1936
Genus : *Berlesezetes* Mahunka, 1980

Generic Characters

The lamellae of the members of this genus are provided with a short inner and a long outer cuspis, the latter is attenuating; notogaster provided with longitudinal lines of varying number.

***Berlesezetes brazilozetoides* Balogh and Mahunka, 1981**

(Plate 20, Figs.1, 1a & 2)

Colour : Brown
Measurements : Length: 189-220 μm
Width: 136-150 μm

Dorsal Region (Plate 20, Figs. 1 & 1a)

Prodorsum

Rostrum wide and truncate; seta *ro* thin and curved; seta *le* thick; translamella bears a median incrassation; seta *in* long and swollen; *ss* filiform, ciliate and pectinate (Fig.1a).

Notogaster

Notogaster somewhat rounded posteriorly and bears 5 longitudinal lines, notogastral setae 10 pairs, all simple and short; fissure *ia* located on the pteromorpha, *im* located medially on the notogaster.

Ventral region (Plate 20, Fig.2)

Infracapitulum diarthric; infracapitular setae *h*, *m* and *a* smooth; epimeral setae smooth and of varying size, epimeral setal formula 3-1-3-3; ventral plate bears several longitudinal striations which vary in number and shape; on the genital plate 3 pairs of setae arranged paraxially and 3 pairs antiaxially, seta g_1 long while the remaining setae short; 2 pairs of anal and 3 pairs of adanal setae located, all smooth.

Leg

All legs monodactylous.

Materials examined

5♀♀ and 8♂♂ collected from a mangrove ecosystem at Kottakadavu, Kadalundi, Kozhikode (Dt.), Kerala, India on 17.02.2006, coll. E. Julie.

Remarks

The present species of *Berlesezetes* collected from Kadalundi shows very close resemblance to *B. brazilozetoides* erected by Balogh and

Mahunka, 1981 from Argentina in the nature of prodorsal setae, shape of sensillus and the presence of 5 longitudinal lines on the notogaster.

Infraorder : Brachypylina Hull, 1918
Superfamily : Oppioidea Sellnick, 1937
Family : Oppiidae Sellnick, 1937
Subfamily : Arcoppiinae Balogh, 1983
Genus : *Arcoppia* Hammer, 1977

Generic Characters

Sensillus with 1-7 or sometimes more, long branches, arranged in either pectinate or radial positions, the stalk may be setiform or apically dilated, the branches either equal or of different length; sensillus exceptionally setiform with shorter cilia-like branches; genital plates mostly with 6 pairs of setae arranged in a longitudinal row.

***Arcoppia spotus* sp. nov.**

(Plate 21, Figs. 1, 1a-1c & 2)

Colour : Brown

Measurement : Length: 482μm (480 – 484μm)
Width : 247μm (246-248μm)

Dorsal Region (Plate 21, Fig. 1 & 1a-1c)

Prodorsum

The tip of the rostrum tripartite, the middle part short but the two lateral parts projecting beyond the middle part; seta *ro* slightly barbed and measures 18μm (Fig.1a); seta *le* also slightly barbed, the lamellar arch incomplete, being very faint at its anterior and posterior parts; seta *in*

extremely straight, and measures 26μm; below *in* 4 light spots present, arranged as two pairs on either side, anterior pair some what arch shaped, below the posterior pair, a faint curved ridge present radiating from *bo* of either side; *ss* (Fig. 1c) with a long stalk and distinctly capitate head, bearing two unequal branches, posterior one very long, while the anterior one very short; seta *ex* also finely barbed; integument on the sides of the prodorsum covered with small tubercles; three light spots seen in association with a thin one on each lateral side; just above the dorsosejugal suture, 12 light spot like structures arranged in two rows of 6 each.

Notogaster

Notogaster almost spherical; dorsosejugal suture almost straight medially; 10 pairs of thin and smooth setae of varying length arranged on the notogaster as shown in the figure; seta *ta* very small, inserted anteriorly, just above fissure *ia*; fissure *im* seen near seta r_3; integument of notogaster smooth.

Ventral region (Plate 21, Fig. 2)

Infracapitulum with 3 pairs of simple setae; 3 faintly granulated light spot like structures present on mentum; polygonal structures arranged linearly in the middle of epimeral plates, epimeral setal formula 3-1-3-3, seta *1c* barbed and long, *3c* long and simple, all the remaining setae simple and small; 6 pairs of short genital setae, all smooth and small; 1 pair of simple aggenital seta inserted posterolateral to the genital plates; 3 pairs of adanal setae and 2 pairs of anal setae present, all smooth, seta ad_3 placed far anterior to the anal plate, fissure *iad* located adjacent to anal plate, in a para-anal position.

Legs

All legs monodactylous.

Etymology

Name is coined based on the presence of 12 light spots above the dorsosejugal suture.

Materials Examined

Holotype: ♀; paratype: 6 ♀♀ and 3♂♂ collected from a mixed vegetation at Kizhissery, Malappuram (Dt.) Kerala, India on 31.08.2007., coll. Julie. E.

Remarks

The genus *Arcoppia* was erected by Hammer, 1977 with the type species *A. brachyramosa*. Currently, the genus includes 55 species described from various countries. Of these, the present species resembles *A. longisetosa* erected by Balogh, 1982 from Australia in the shape of sensillus and nature of rostrum. However, the following characters possessed by the present specimen keeps its identity separate from the above species.

1. Barbed nature of prodorsal setae
2. Seta *le* being extremely straight
3. Presence of 12 light spots just above the dorsosejugal suture, arranged in 2 rows.
4. Presence of 3 pairs of faintly granulated light spot like structures on mentum.
5. Polygonal structure arranged on the epimeral plates.

Infraorder : Brachypylina Hull, 1918

Superfamily : Oppioidea Sellnick, 1937

Family : Oppiidae Sellnick, 1937

Genus : *Brachioppia* Hammer, 1961

Generic Characters

Sensillus either pectinate or radiate or ciliate; genital plates with 6 pairs of setae.

***Brachioppia cajamarcensis* Hammer, 1961**

(Plate 22; Figs. 1 & 2)

Colour : Brown

Measurements : Length: 220-224µm

Width: 194-196µm

Dorsal Region (Plate 22, Fig.1)

Prodorsum

Seta *ro* feebly barbed; setae *le* and *in* also barbed, seta *in* longer than *le*, 6 light spots arranged in 2 rows present between setae *in*; seta *ex* very short; *ss* expanded distally with 6-7 radiating branches on its posterior border, proximal branches longer than distal ones; small dark tubercles present laterally on the prodorsum.

Notogaster

Notogaster long; light and dark band like structure present above the dorsosejugal suture; 10 pairs of barbed setae present on the notogaster, all

long with the exception of *ta*, the latter minute. Lyrifissures *ia* and *im* and opening of lateroabdominal gland, *gla* well developed.

Ventral region (Plate 22; Fig.2)

Infracapitulum with setae *a*, *m* and *h;* epimeral setal formula 3-1-2-3, on the epimeral region presence of polygonal structures: 5 pairs of simple genital setae, g_1, g_2, and g_3 placed vertically, g_4 and g_5 shifted posterolaterly: aggential seta 1 pair, barbed; anal setae 2 pairs, both simple; adanal setae 3 pairs, barbed.

Materials examined

10 ♀♀ collected from a mixed vegetation at Kizhissery, Malappuram (Dt.), Kerala, India on 13.10.2006, coll. E. Julie.

Remarks

The present species shows resemblance to *B. cajamarcensis*, collected and figured by Hammer, 1961 from Peru and it is the first report from Kerala.

Infraorder : Brachypylina Hull, 1918

Superfamily : Oppioidea Sellnick, 1937

Family : Oppiidae Sellnick, 1937

Genus : *Ramusella* Hammer, 1962

Generic Characters

Costula absent; rostrum not incised; seta *le* in half way or nearer to seta *in*; crista absent on notogaster; seta *ta* absent; notogaster with 9-10 pairs of setae; 5 pairs of genital setae; pori *iad* in adanal position.

***Ramusella philippinensis* Mahunka, 1982**

(Plate 23, Figs. 1, 1a & 2)

Colour : Light yellowish brown

Measurements: Length: 260-268 μm

Width : 198-200 μm

Dorsal Region (Plate 23, Figs. 1& 1a)

Prodorsum

Seta *ro* plumose basally and with a tapering tip; seta *le*, thin, roughed and placed medially; seta *in* resembles *le* in nature and directed posterolaterally; 3 pairs of light spots present at the interlamellar area as shown in figure; feebly developed reticulation present on lateral sides of prodorsum; seta *ex* barbed: bothridial cup (*bo*) circular, from which the *ss* originates, the latter with a barbed, clavate head and a curved stalk, the head bears 10-11 radiating branches of length as shown in Fig.1(a), a short proximal one, 2nd the longest and becoming evenly shorter distally; prolamellar line clearly visible; pedotectum well developed, lateral sides of prodorsum with feebly developed reticulation.

Notogaster

Notogaster elongated with a smooth integument; 9 pairs of slender, slightly barbed setae arranged on the notogaster as shown in figure; seta *ta* absent.

Ventral region (Plate 23, Fig.2)

Infracapitulum with setae *a, m* and *h*, all simple; epimeral setal formula 3-1-3-2, epimeral region covered with polygonal structures; 5 pairs

of genital setae and 2 pairs of anal setae, all simple and thin; seta ad_1 post-anal, ad_2 para-anal and ad_3 pre-anal in position; pori *iad* para-anally located.

Leg

All legs monodactylous.

Materials examined

8 ♀♀ collected from a mangrove ecosystem, Kottakadavu, Kadalundi, Kozhikode (Dt.), Kerala, India on 15. 10. 2007., coll. E. Julie.

Remarks

The present species of *Ramusella* collected from a mangrove ecosystem at Kottakadavu, Kadalundi shows very close similarities with *R. philippinensis* described from Philippines by Mahunka, 1981 in the possession of 9 pairs of notogastral setae and shape of the body but it differs from it in the nature of prodorsal setae, notogastral setae and in the shape of sensillus.

Infraorder : Brachypylina
Superfamily : Oppioidea Sellnick, 1937
Family : Oppiidae Sellnick, 1937
Subfamily : Mystroppiinae Balogh, 1983
Genus : *Corynoppia* Balogh, 1983

Generic characters

Costula absent; crista absent; 10 pairs of notogastral setae, seta *ta* tiny, setiform, remaining notogastral setae foliate, aciculate; genital setae 5 pairs; pori *iad* adanal.

***Corynoppia ajaii* sp. nov.**

(Plate 24, Figs. 1, 1a, 1b & 2)

Colour : Yellowish brown

Measurements : Length: 279µm (276 – 280µm)

Width : 148µm (146 – 151 µm)

Dorsal Region (Plate 24, Figs. 1, 1a & 1b)

Prodorsum:

Rostrum conical and without any incision; lamellae absent; seta *ro* slightly barbed, measuring 28µm and originates slightly below the rostral apex; seta *le* also feebly barbed, inserted medially on the prodorsum and measures 26 µm in length; seta *in* minute, roughened and inserted on either side of interlamellar ridge, the latter very short and extends laterally to the *bo*; interlamellar region with two pairs of foveoles surrounded by the interlamellar ridges; *bo* spherical, from which sprouts the *ss*, the latter setaeous and gradually 'thickened to form a unilaterally barbed, fusiform head; laterally the prodorsum bears 3-4 pairs of rectangular foveoles, arranged vertically as shown in figure; integument of prodorsum bears dense punctations laterally.

Notogaster

Dorsosejugal suture slightly convex with a median protruberance, directed anteriorad; notogastral setae of characteristic shape arranged as shown in figure, each seta dilated basally and with distal ciliated half; seta *ta* present; fissure *ia* spherical and located anteriorly near seta *ta*; fissure i*m* medially located.

Ventral Region (Plate 24, Fig. 2)

Infracapitular setae *m* and *h* barbed, *a* represented by alveolus; apodemes well developed; *ap.4* thinner; epimeral surface foveolated, setae barbed, setal formula 3-1-3-2; 5 pairs of genital setae, all thin and barbed; g_1-g_3 inserted equidistantly in a vertical manner, g_4 and g_5 more posteriorly located; 1 pair of aggenital setae similar to notogastral setae; 2 pairs of thin and barbed anal setae; 3 pairs of adanal setae similar to notogastral setae present, all thick and barbed, ad_1 post-anal, ad_2 para-anal and ad_3 pre-anal in location.

Leg (Fig)

All legs monodactylous; chaetotaxy of Leg I: 1-5-4- 6-20

Etymology

Dedicated to my husband who helped me in the collection of the specimen.

Materials Examined

Holotype: ♀; paratype: 8 ♀♀ collected from soil/litter samples from Santhigiri Herbal Garden, Santhigiri Ashram, Thiruvananthapuram(Dt.), Kerala, India on 24.08.2005, coll. E. Julie.

Remarks

The genus *Cornyoppia* was erected by Balogh, 1983 with the type species *C. turgiseta*. The genus presently comprises 6 species. Of these, the present specimen shows resemblance to *C. turgiseta* in the following characters, (1) presence of 2 pairs of foveoles surrounded by the inter lamellar ridge; (2) shape of the sensillus; (3) nature of notogaster setae.

However, the possession of the following features enables its distinction from the above species.

1. Seta *ro* and *le* feebly barbed;
2. Seta *in* thickened;
3. Seta *ta* present;
4. Epimeral and genital setae long and barbed;
5. Aggenital setae similar to notogastral setae.

Infraorder : Brachypylina Hull, 1918

Superfamily : Oripodoidea Jacot 1925

Family : Haplozetidae, Grandjean,1936

Genus : *Indoribates* Jacot, 1929

***Indoribates philippinensis* Corpuz-Raros, 1979**

(Plate 25, Figs. 1, 1a & 2)

Colour : Light brown

Measurements: Length: 320-324µm

Width : 286-289µm

Generic Characters

Dorsosejugal suture normal, without 3 arches, ptermorphae movable, notogaster with sacculi, genital plate with 5 pairs of setae.

Dorsal region (Plate 25, Figs. 1 & 1a)

Pordorsum

Rostrum broadly conical; seta *ro* slightly barbed, curved; seta *le* also barbed, not originating from the lamellae; seta *in* longer than *ro* and *le*; *ss* with a fusiform head, spinose from $^{3}/_{4}^{th}$ of its length.

Notogaster

Dorsosejugal suture slightly convex, notogaster elongate with movable ptermorphae; 4 pairs of sacculi and 9 pairs of notogastral setae present, all setae smooth; fissure *im* distinct and placed medially between setae *te* and *ms*.

Ventral region (Plate 25, Fig.2)

3 pairs of smooth infracapitular setate, epimeral setal formula 3-1-3-3; 5 pairs of simple genital setae, 1 pair of simple aggenital setae, 2 pairs of barbed anal setae and 3 pairs of barbed adanal setae, polygonal reticulations present on the ventral surface.

Legs

All legs monodactylous.

Materials Examined

7♂♂ and 9♀♀ recovered from the soil/ litter samples collected from a mangrove vegetation at Kottakadavu, Kadalundi, Kozhikode (Dt.) of Kerala on 16.1.2006, coll. E. Julie.

Remarks

The present specimen shows resemblance to the species, *I. philippinensis* erected by Carpuz-Raros (1979) in the general appearance, number and nature of notogastral and genital setae, presence of sacculi on the notogaster and movable pteromorphae. But it differs from the above species in the barbed nature of rostral and lamellar setae and *le* not originating from the lamella.

Infraorder : Brachypylina

Superfamily : Oripodoidea Jacot, 1925

Family : Haplozetidae Grandjean, 1936

Genus : *Pilobatella* Balogh & Mahunka, 1967

Generic characters

Notogaster with 10 or 10-11 pairs of setae and 4 pairs of sacculi; pteromorphae movable; 6 pairs of genital and 3 pairs of aggenital setae. All legs monodactylous.

***Pilobatella genitae* sp. nov.**

(Plate 26, Figs.1, 1a & 2)

Colour : Yellowish brown.

Measurements: Length: 523µm (520 – 556 µm)

Width: 229µm (227 – 297 µm)

Dorsal Region (Plate 26, Figs. 1 & 1a)

Prodorsum

Rostrum broad and conical, without any incision; seta *ro* barbed, arises slightly below the rostral apex; seta *le* the shortest, measuring 32µm, barbed and inserted medially, between *ro* and *in*; seta *in* the longest, measuring 43 µm, thin and barbed; *ss* long, setaceous and barbed with the barbs being increased towards the tip, *bo* cup shaped, heavily punctated posteriorly.

Notogaster

Notogaster elongate; dorsosejugal suture convex; 11 pairs of thin simple setae present as shown in Fig.1; pteromorphae short and movable; 4

pairs of sacculi of various dimensions present on notogaster; fissure *ia* located on the ptermorph, *im* transverse in position; punctations present throughout the notogaster.

Ventral Region (Plate 26, Fig. 2)

Infracapitulum with 3 pairs of setae *h*, *m* and *a*, of which seta *a* the longest and barbed; epimeral region with fine polygonal sculpture, epimeral setal formula 3-1-3-3; ventral plate with punctations; 5 pairs of genital setae, all simple, g_1 and g_2 long, others short; 3 pairs of aggential setae as shown in figure; 2 pairs of anal and 3 pairs of adanal setae; *iad* placed between ad_2 and ad_3 para-anally, anterior portion of anal plate with striae.

Leg

Legs monodactylous,

Etymology

The specific name is derived from the unique feature of the genital hairs, the difference in the number of which helps its easy segregation from other known members of the genus.

Materials Examined

Holotype: ♂, paratype: 6 ♀♀ and 5 ♂♂; collected from soil/litter samples of the Herbal Garden at Santhigiri Ashram, Thiruvananthapuram on 17.09.2007, coll. E. Julie.

Remarks

The genus *Pilobatella* was erected by Balogh and Mahunka, 1967 with the type species *P. punctulata* from Congo. The genus currently comprises 8 species. Of the 8 known species compared, the present specimen

shows resemblance to *P. berlesei* described from North India by Bhattacharya and Banerjee, 1979 in the features like nature of prodorsal and notogastral setae, elongated nature of notogaster and presence of punctations on the ventral plate. However, the following features observed in the present species enable its separation from *P. berlesei*.

1. Possession of 11 pairs of notogastral setae
2. Seta *in* being longer than *le*
3. Sparsely barbed nature of *ss*, with the barbs progressively increasing in length.
4. Possession of 5 pairs of notogastral setae, which forms the most unique feature, enabling its easy seggregation from all other known species.

Infraorder : Brachypylina Hull, 1918

Superfamily : Oripodoidea Jacot, 1925

Family : Haplozetidae Grandjean, 1936

Genus : *Trachyoribates (Rostrozetes)* Sellnick, 1925

Generic Characteristics

Legs monodactylous; 5 pairs of genital setae; 10 pairs of notogastral setae (exceptionally 14); dorsosejugal suture with three arches; notogaster mostly with coarse sculpture.

***Trachyoribates (Rostrozetes) foveolatus* Sellnick, 1925**

(Plate 28, Figs. 1 & 2)

Colour : Brown

Measurements: Length: 322 – 326 µm

Width : 248 – 252 µm

Dorsal Region (Plate 28, Fig.1)

Prodorsum

Rostrum rounded, foveolated throughout, seta *ro* small and barbed; seta *le* barbed, longer than seta *ro*; seta *in* shorter than *le*, inserted far below, just above the dorsosejugal suture; *ss* bears a swollen, brush like head, ciliated; seta *ex* not detected, prodorsum carries large foveoles.

Notogaster

Dorsosejugal suture with 3 arches; 10 pairs of notogastral setae, all smooth slender and simple; pteromorphae short, stumpy; whole surface ornanmented with hard, round foveoles, giving a wavy appearance to lateral and posterior margins; lyrifissures *ia* and *im* clearly visible.

Ventral region (Plate 28, Fig.2)

Infracapitular setae 3 pairs, all smooth; epimeral setae minute, simple, smooth, epimeral setal formula 3-1-2-2, epimeral surface foveolated; ano-genital plates well separated; genital plates small, bearing 5 pairs of simple minute setae; aggenital setae 1 pair, simple minute, short; anal plates rectangular; 2 pairs of anal and 3 pairs of adanal setae, all simple, fissure *iad* placed in between setae ad_2 and ad_3; the whole ventral surface foveolated.

Legs

All legs monodactylous.

Remarks

Trachyoribates (Rostrozetes) foveolatus is a cosmopolitian species erected by Sellnick, 1925. The present species shows resemblance to *T.* (*Rostrozetes) foveolatus* in several respects such as the nature and

arrangement of prodorsal setae, foveolated nature of dorsal and ventral surface; shape of sensillus and epimeral setal formula.

***Trachyoribates (Rostrozetes) striata* sp. nov.**

(Plate 27, Figs. 1, 1a-1e & 2)

Colour : Brown

Measurements : Length: 383 μm (Range 380-386 μm)

Width : 225 μm (Range 222-228 μm)

Dorsal Region (Plate 27, Figs. 1 & 1a-1e)

Prodorsum

Rostrum rounded and incised, seta *ro* feebly barbed and measures 18μm (Fig. 1b); seta *le* (Fig. 1a) longer than *ro*, measuring 24 μm and serrated; seta *in* (Fig. 1c) shorter than *le* and *ro*, measuring 15μm, inserted far below, just above the dorsosejugal suture; *ss* (Fig. 1d) bears a swollen brush like head, ciliated, dense cilia present on the outer margin; *ex* absent; surface of the prodorsum distinctly foveolated.

Notogaster

Dorsosejugal suture convex with 3 arches; notogaster oval, bearing immovable pteromorphae anterolaterally, each pteromorph with characteristic anterior notch and bearing dense foveoles; 10 pairs of notogastral setae present, all smooth, slender and simple (Fig. 1c), notogaster bears longitudinal undulating ridges, each ridge reaches the base of pteromorph, entire surface of notogaster ornamented with round foveoles scattered irregularly, imparting somewhat wavy appearance, especially to the posterolateral margin of notogaster; integument also bears punctations, intermingled with foveoles, especially on the lateral and posterior margins.

Ventral Region (Plate 27, Fig. 2):

Infracapitulum not foveolated; mentotectum carries closely set striae, infracapitular setae slender and smooth, epimeral setae also simple and sleder, epimeral setal formula 3-1-2-2; ano-genital plates well separated and each genital plate bears 5 smooth, minute setae arranged as in Fig.2. Minute spherical foveloes scattered on each genital plate; aggenital seate 1 pair, located postero lateral to the gential plates, anal setae 2 pairs, smooth and minute, anal plates also bear foveoles; adanal setae 3 pairs, all slender and smooth, ad_1 post-anal in position, ad_2 para-anal and ad_3 at the anterolateral corner of the anal plate; the lyrifissure *iad* seen on either side of the anal plates, palced para-anally in between ad_2 an ad_3; entire ventral surface including the anogenital plates and epimeral area covered with round foveoles.

Legs

All legs monodactylous.

Etymology

Name is based on the possession of closely set striae on mentotectum.

Materials Examined:

Holotype: ♀; paratype: 9 ♀♀ collected from the retting ground at Beypore, Kozhikode (Dt), Kerala, India on 30.10.2006, coll. E. Julie.

Remarks:

The genus *Trachyoribates* was erected by Berlese, 1908 based on the type species, *T. ovulum*. Of the 29 earlier known species compared, the present specimen shows resemblance to two known species viz., *T.carinatus*

Beck, 1965 from Peru (in the presence of 10 pairs of notogastral setae; presence of atleast 2 well discernible notogastral ridges on ribs)and *T.shibai* described by Aoki, 1976 from Malaysia (in the possession of sensillus bearing a brush like head, prodorsum with foveolae). However, it keeps a separate identity from the known species in the possession of

1. short nature of seta *in*
2. prodorsum with distinct anterior notch
3. lyrifissure *iad* seen on either side of the anal plates, obliquely and placed in between setae ad_2 & ad_3
4. mentotectum carries closely set striae.

Infraorder : Brachypylina Hull, 1918

Superfamily : Oribatuloidea Wolley, 1956

Family : Scheloribatidae Grandean, 1933

Genus : *Scheloribates* Berlese, 1908

Generic Characters

Rostrum without any apophyses; the members possess 10 pairs of notogastral setae, 4 pairs of genital setae; 4 pairs of sacculi and 3 claws.

***Scheloribates praeincisus interruptus* Berlese, 1916**

(Plate 29, Figs.1 & 2)

Colour : Brown

Measurements : Length : 670 – 692 μm

Width : 420-444 μm

Dorsal Region (Plate 29, Fig.1)

Prodorsum

Rostrum triangular with a blunt apex; setae *ro*, *le* and *in* barbed, the latter the longest; translamellar line medially interrupted; (*ss*) with a smooth, slender stalk and a clavate roughened head; *ex* weakly barbed.

Notogaster

Notogaster almost spherical posteriorly, bearing 10 pairs of setae and 4 pairs of saculi, setae very short; fissures *ia*, *im* and *ip* clearly visible.

Ventral Region (Plate 29, Fig.2)

Infracapitulum with 3 pairs of setae, *a, m* and *h*; setae of varying size arranged on the epimeral surface, all of which roughened, epimeral formula 3-2-3-2; genital plates carry 4 pairs of smooth setae; 1 pair of aggenital, 2 pairs of anal and 3 pairs of adanal setae present; fissure *iad* para-anal in position.

Legs

All legs heterotridactylous in nature.

Materials examined

8♂♂ and 6♀♀ recovered from the soil/litter samples collected under a gooseberry tree from Kizhissery, Malappurm (Dt.) of Kerala on 20.12.2004, coll. E. Julie.

Remarks

Characters detected in the present specimen show strong resemblance to *S. praeincisus interruptus* collected and figured by Hammer (1971) from Fiji Island in the nature of prodorsal setae, shape of sensillus and arrangement of notogastral setae.

Infraorder : Brachypylina Hull, 1918

Superfamily : Oripodoidea Jacot, 1925

Family : Protoribatidae Balogh and Balogh, 1984

Genus : *Protoribates* Berlese, 1908

Generic Characters

Movable ptermorhae; presence of a tutorial ridge; 5 pairs of genital setae.

***Protoribates bisculpturatus* Mahunka, 1988**

(Plate 30, Figs. 1 & 2)

Measurements : Length : 556 – 588 μm

Width : 350 – 384 μm

Dorsal region (Plate 30, Fig. 1)

Prodorsum

Tip of rostrum rounded; prodorsal setae *ro*, *le* and *in* ciliated; lamella well developed, seta *in* the longest; fusiform head of *ss* abruptly attenuated; pedotectum I clearly visible in dorsal view; prodorsum punctated.

Notogaster

Surface with scattered pits, punctations present on integument; dorsosejugal suture well developed, straight; pteromorphae, subtriangular in shape, movable; 10 pairs of simple notogastral setae, 4 pairs of area porosae, lyrifissures *ia* and *im* clearly visible.

Ventral region (Plate 30, Fig.2)

Infracapitulum diarthric type; setae *a*, *m* conspicuous and smooth, seta *h* ciliated; apodemes weakly developed, epimeral setal formula 3-1-3-3; 5

pairs of genital setae, 1 pair of aggenital setae, 2 pairs of anal seta; 3 pairs of adanal setae; all ventral setae smooth and simple; lyrifissures *iad* present in adanal position.

Legs

All legs monodactylous.

Material examined

10♂♂ and 7♀♀ recovered from the soil/ litter samples collected from a mixed vegetation at Kizhissery, Malappuram (Dt.) of Kerala on 26.10.2006, coll. E. Julie

Remarks

The present specimen shows resemblance to *P.bisculpturatus* erected by Mahunka, 1988 from Malaysia in the nature of prodorsal setae, fusiform head of sensillus which is apically abruptly attenuated, the presence of scattered pits on the notogaster, nature of ventral setae, etc.

***Protoribates punctata* Grobler, 1991**

(Plate 31, Figs. 1& 2)

Measurements : Length : 541 – 586 μm

Width : 346 – 386 μm

Dorsal Region (Plate 31, Fig. 1)

Prodorsum

Rostrum protruding and truncate at tip. Lamellae rather thick and raised, extending for a distance equal to half the length of prodorsum; seta *ro* inserted a short distance below rostral anterior margin; seta *le* arising from lamellar apex; setae *ro*, *le* and *in* extending infornt of the rostrum all ciliate;

fusiform head of sensillus apically attenuated. Prodorsal integument with scattered pits.

Notogaster

Surface with scattered pits, dense punctations present on integument; pteromorphae subtriangular in shape, movable; 4 pairs of area porosae and 10 pairs of minute and smooth setae; present on notogaster 4 pairs of lysifissres also present.

Ventral Region (Plate 31, Fig. 2)

Infracapitulum diarthric type; setae *a*, *m* conspicuous and smooth, seta *h* ciliated; apdoemes weakly developed, epimeral setal formula 3-1-3-3; 5 pairs of genital setae, 1 pair of aggenital setae, all smooth; 2 pairs of barbed anal setae; 3 pairs of barbed adanal setae; lyrifissure *iad* present in adanal position.

Leg

All legs monodactylous.

Material Examined

8 ♂♂and 10♀♀ recovered from the soil/litter samples collected from Santhigiri Herbal Garden, Thiruvananthapuram (Dt.) of Kerala on 13.09.2006., Coll. E. Julie.

Remarks

The present specimen shows resemblance to *P. punctata* erected by Grobler Mahunka, 1991 in the nature of sensillus presence of dense punctations and pits on the notogaster, 4 pairs of lyrifissure.

Infraorder : Brachypylina Hull, 1918

Superfamily : Otocepheoidea Balogh, 1961

Family : Otocepheidae Balogh, 1961

Genus : *Dolicheremaeus* Jacot, 1938

Generic Characters

Members of this genus possess 10 pairs of notogastral setae, atleast 2 pairs of which flagellate in appearance.

***Dolicheremaeus indicus* Haq, 1978**

(Plate 32: Figs.1, 1a-1c & 2)

Colour : Brownish Yellow

Measurements: Length: 720 μm – 740 μm

Width: 270 μm – 281 μm

Dorsal region (Plate 32, Figs. 1 & 1a-1c)

Prodorsum

Seta *ro* strongly curved and thickly barbed than seta *le*, both *ro* and *le* unilaterally barbed; seta *in* erect, barbed and directed backwards; bothridia (*bo*) directed laterad and the opening of which very small; *ss* elbowed with a fusiform head (Fig. 1c); seta *ex* (Fig. 1b) short and bristle like; median prodorsal condyles (*co.pm*) broadly rounded; lateral prodorsal condyles (*co.pl*) slightly angulate.

Notogaster

Well elongated, fusiform, centromedian region of notogaster well raised than the remaining part; 10 pairs of notogastral setae present, of which the anterior pairs *ta, te, ti* and *ms* with blunt tip while the posterior pairs r_1, r_2

r_3, p_1, p_2 and p_3 with flagelliform tip, all setae barbed; 5 pairs of notogastral fissures seen on the lateral side of the notogaster; notogaster bears punctations.

Ventral region (Plate 32, Figs. 2)

Epimeral setae simple, barbed and arranged as shown in figure, epimeral setal formula 3-2-3-3, setae *2a* & *2c*, *3a* & *3c*, *4a* & *4c* simple and small, *1b*, *3b* and *4c* larger than the remaining setae; 4 pairs of genital setae arranged as shown in figure; 2 pairs of anal setae, both simple; all the 3 pairs of adanal setae barbed and arranged marginally; fissure *iad* placed obliquely, in para-anal position.

Legs

All legs monodactylous.

Materials Examined

5♀♀ and 7♂♂ collected from the soil/litter samples of a mixed vegetation at Kizhissery, Malappuram (Dt.), Kerala on 04.08.2006, coll. E. Julie.

Remarks

The present specimen shows resemblance in most respects to *D. indicus* described by Haq (1978) from Kerala.

Infraorder : Brachypylina Hull, 1918
Superfamily : Otocepheoidea Balogh, 1961
Family : Otocepheidae Balogh, 1961
Genus : *Megalotocepheus* Aoki, 1965

Generic Characters

Members possess a median prodorsal condyle (*co.pm*); notogastral setae *ta* and *te* normally spaced, *te* inserted between *ta* and *ti*; palp 5 segmented.

***Megalotocepheus kizhisseriensis* sp. nov.**

(Plate 33, Figs. 1, 1a, 2 & 3)

Colour : Dark brown

Measurements: Length: 1642 µm (1610-1658µm)

Width : 775µm (780-810µm)

Dorsal Region (Plate 33, Figs. 1 & 1a)

Prodorsum

Seta *ro* erect, densely barbed and measures 197µm in length; seta *le* curved inwards, barbed and 186 µm in length, inserted on the lamella, lamellae lath shaped, elongate and extend to the tip of rostrum; interlamellar area ornamented with foveoles and tubercles, seta *in* measures 173 µm in length, barbed and inserted medially between the lamellae; two rows of foveoles and tubercles present in the space between lamellae; *spa. 1* broad, protrudes beyond the lateral margin of the prodorsum and reaches upto the insertion of seta *ro*; *ss* with a curved stalk which gradually thickens to form a slightly fusiform head; two median wrinkles form a figure almost resembling a key-hole; *co.p1* slightly angular, shorter than *co. pm*; semicircular prodorsal condyles, separated from each other by a short distance; seta *ex* absent; radiating ridges directed anteriorad on the prodorsal surface, one pair each on either side; pedotectum (pd_1) well developed, pd_2 & pd_3 visible in lateral view, pd_4 elongate and triangular in shape.

Notogaster

Notogaster as broad as long; integument of notogaster punctate or granulate, tuberculate, foveolate, the anteriormost part of humeral region densely foveolated; 10 pairs of stiff, barbed setae arranged on notogaster as shown in figure; fissures *ih*, *im* and *ip* present on notogaster.

Ventral region (Plate 33, Fig.2)

Infracapitulum with 3 pairs of barbed setae, seta *a* smallest and *h* the longest; *ap. 1, 2* and *3* well developed, *ap. 4* short; epimeral surface punctated and foveolated, epimeral setal formula 3-1-3-3, seta *1c* thick and barbed while others smooth and of varying length; genital plates surrounded by wrinkles, 4 pairs of moderately long genital setae present, g_1 & g_2 inserted nearby and g_3 and g_4 towards the posterior border; one pair of aggenital setae; 2 pairs of barbed anal setae and 3 pairs of barbed adanal setae present, the latter arranged marginally; ventral plate punctate, faint foveoles of different size also present on the ventral plate.

Legs (Plate 33, Fig.3)

All legs mondactylous, chaetotaxy of leg I: 0-3-4-17; on femur, setae ν, *l´* and *l"* long, thin and weakly barbed; genu bears a solendion σ, setae *d* and *I´* slightly barbed while seta *I"* smooth; tarsus *I* with two solendia, ω_1 flagelliform, ω_2 thicker with bent tip, ε small and curved. Seta *s* will never be barbed.

Etymology

Named after the name of the type locality.

Materials Examined:

Holotype: ♂, paratype: 6♀♀ and 3♂♂, collected from a mixed vegetation at Kizhisserry, Malappuram (Dt.) Kerala, India on 31/08/2007, coll. Julie. E.

Remarks

The genus *Megalotocepheu*s was erected by Aoki (1965) with *M. japonicus* as type species and the genus at present consist of 16 species. Of the 16 species compared, the present specimen shows resemblance to *M. undulatus* Hammer, 1981 in the presence of 2 rows of foveoles at the interlamellar area; shape of sensillus; possession of 10 pairs of stiff, barbed setae and absence of seta *ex*. But the present specimen differs from *M.undulatus* in the following characters:

1. *Spa.I* broad, reaching up to the insertion of rostral seta.
2. The two median wrinkles form a figure almost resembling a key hole.
3. Epimeral setae *Ib,3b, 4a* longest.
4. Adanal and anal setae of the same size.
5. 2 pairs of anal setae.

Infraorder : Brachypylina Hull, 1918

Superfamily : Plateremaeoidea Tragardh, 1926

Family : Pheroliodidae Paschoal, 1987

Genus : *Pheroliodes* Grandjean, 1931

Generic Character

Ventral neotrichy absent (branched ventral setae missing); notogaster mostly flattened or slightly excavated; usually 2-4 pairs of postero-marginal setae present; concentrically arranged scalps often present.

***Pheroliodes ciliata* sp. nov.**

(Plate 34, Figs. 1, 1a-1e & 2)

Colour : Brown

Measurement : Length: 507μm (Range: 485-530 μm)

Width : 278 μm (Range: 270-286 μm)

Dorsal Region (Plate 34, Figs. 1 & 1a-1e)

Rostrum conical and foveolate with few irregular rugae; seta *ro* arising on small tubercle, far behind the rostral tip, thick, densely ciliated, resembling a tail; seta *le* arising more inwards on a curved ridge, curved and longer than *ro*, measuring 42μm; seta *in* minute and thorn like; small curved lath like structure found beneath *in*; seta *ex* not located; bothridium widely open; *ss* with simple curved stalk and a slightly dialted, densely ciliated head; entire prodorsal surface covered with certegumental structure and tubercles; the prodorsal surface divided into various compartments as shown in Figure 1, joined by curved lath like structure, interlamellar area also provided with a curved, lath like structure below seta *in*.

Notogaster

Notogaster clearly visible on removal of trytonymphal scalp; dorsosejugal suture complete and slightly convex; notogaster somewhat spherical in appearance and ornamented variously with foveoles, granulations, punctations, curved lines and ridges as shown in figure, marginal and median zones clearly demarcated on the notogastral surface (Fig.1e); 4 pairs of notogastral setae present, 3 pairs present posteromarginally, of which 1 pair curved inwards as shown in figure, the anterior pair located at the peripheral zone, all resemble prodorsal hairs in appearance; fissures *ia, im* and *ip* clearly discernible.

Ventral Region (Plate 34, Fig. 2)

Infracapitulum carries 3 pairs of small serrated setae; hypostome with a sowed posterior border; epimeral region ornamented with cerotegumental secretions; epimeral setal formula 3-1-4-3, setae short and thin except *3c, 3d, 4a, 4b, 4c*; genital plates with 7 pairs of short and thin setae, 3 pairs, situated near paraxial rim of anal plate, all setae very short and serrate; 3 pairs of thick, short adanal setae present in paranal position.

Legs

All legs tridactylous with large sickle shaped median claw and two thin, baciliform lateral claws.

Etymology

Name is based on the nature of densely ciliated head of sensillus.

Materials Examined

Holotype: ♂; paratype: 9 ♂♂ and 6 ♀♀, all collected from the soil/litter samples of a mixed vegetation at Kizhissery, Malappuram (Dt.), Kerala, India on 12.06.2006, coll. E. Julie.

Remarks:

Grandjean (1931) erected the genus *Pheroliodes* based on the type species, *P.rotundatus*. The genus at present comprises 34 species. A closer examination of the present specimen reveals its resemblance with an earlier species, *P.longiceps* erected by Balogh & Mahunka 1966 in the general appearance of the body, nature of prodorsal hairs,presene of condyle like structures on the scalp etc. However it keeps a separate identity from the known species in the possession of

1. Sensillus with a densely ciliated head
2. A curved lath like structure, below seta *in*
3. Difference in the number & arrangement of genital setae.

Infraorder : Brachypylina Hull, 1918

Superfamily : Tectocepheoidea Grandjean, 1954

Family : Tegeocranellidae Balogh, 1987

Genus : *Tegeocranellus* Berlese, 1913

Generic Characters

Lamellae broad, marginal and covering the prodorsum laterally; interlamellar setae inserted on the median part of the lamellae; deep paired cavities on the anterior part of the notogaster; genital and anal plates long, occupying almost the whole length of the ventral plate; 6 pairs of genital setae; one pair of aggenital; 2 pairs of anal and 3 pairs of adanal setae; legs monodactylous.

***Tegeocranellus laevis* (Berlese, 1905)**

(Plate 35, Figs. 1, 1a-1c & 2)

Colour : Dark brown

Measurements: Length: 281µm - 294µm

Width: 195µm – 198µm

Dorsal Region (Plate 35, Fig. 1 & 1a)

Prodorsum

Anterior margin of prodorsum very broad; lamellae broad, covering the prodorsum laterally; seta *ro* short and bristle like (Fig.1a); seta *le*

originates from the surface of the lamella (Fig.1b), short, thick, dagger shaped; seta *in* minute, inserted on the surface of lamella, above the bothridial cup on the medial part; *ss* directed backward, stalk smooth, which apically dilated to form a clavate head, the latter with small spines (Fig. 1c); prodorsal integument smooth and highly sclerotized.

Notogaster

Dorsosejugal suture convex, anterolateral margin of notogaster with a pair of short wrinkles; 10 pairs of notogastral setae present, *ta* thin and minute, the remaining 9 pairs long; notogastral surface highly sclerotized.

Ventral region (Plate 35, Fig.2)

3 pairs of infracapitular setae present, all thin and smooth; apodemes well developed; epimeral setal formula: 3-1-4-3, epimeral setae thin, smooth and of varying length; genital and anal plates situated close together, genital plates large, carrying 6 pairs of minute, simple and smooth setae, arranged linearly; aggential setae one pair, short and simple; anal setae 2 pairs, short and smooth; adanal setae 3 pairs, ad_2 and ad_3 in para-anal and ad_1 in post-anal position; lyrifissure *iad* placed para-anally, close to ad_2; ventral plate smooth.

Legs

All legs monodactylous.

Materials examined

10 ♀♀ collected from a paddy field at Edavannappara, Malappuram (Dt.), Kerala, India on 29.06.2007, coll. E. Julie

Remarks

The present specimen resembles the type species, *T. laevis* described by Berlese (1913) in the general appearance, nature of prodorsal, notogastral, genital, anal and adanal setae. However, the arrangement of setae on the notogaster and spined head of the sensillus of the present specimen differs from that of *T. laevis.*

REVIEW OF RELATED LITERATURE

Michael (1884, 1888) was the pioneer to undertake biological studies of oribatid mites by rearing a few species like *Damaeus nitens*, *Notaspis bipilis* and *Cepheus palmicinctum* in special culture cells made up of plastic rings mounted on microslides with preferred food items like lichen, decayed wood and cheese. He recorded the duration of their development as 32, 60 and 345 days respectively. Vitzthum (1923) confirmed the affinity of oribatid mites towards fungi and lower plant materials. Jacot (1933a) reported aparity, a phenomenon in which young ones come out after the death of the mother in notaspid oribatids except in the genus *Galumna*. Jacot (1934) studied the life history of some Hawaiian oribatids by culturing them in the laboratory. The meticulous work of Grandjean (1933, 1939) provided valuable information on the changes occurring in the chaetotaxy of oribatid mites during the process of development along with data on the morphological details of different life stages.

Jacot (1937) recommended a new culture cell formed by a glass ring mounted on a microslide for culturing oribatid mites and he succeeded in rearing a few species in special culture cells lined with plaster of paris and charcoal mixture. Forsslund (1939) studied the gut contents of oribatid mites and found a range of fungal hyphae and spores. From India, Anantaraman (1944) reported the vector role of *S. madrasensis* by studying the development of *Moniezia expansa* in the body cavity of the above species. Stunkard (1944) raised *Galumna* sp. from egg to adult under laboratory conditions at a constant temperature of 25^0C and a relative humidity of

approximately 82%. Soldatova (1945) detected the total life span of 3 species of oribatids viz., *S. latipes, S. laevigatus* and *G. obvius* which were found to act as vectors of anoplocephaline cestodes. Kates and Runkel (1948) kept oribatid mites in the laboratory in 50cc weighing bottles containing small pieces of filter paper moistened with a few drops of water.

Riha (1951) was the first who showed that oribatid mites are not just decomposer animals but also could feed on dead animals. Van Der Hammen (1952) gave an illustrated description of the duetonymph of *Fuscozetes fuscipes* along with the morphology of the immature forms of 4 common species. Pauly (1952) traced the process of spermatophore deposition in oribatids and he proposed this as the principal means of sperm transfer in these mites. Cleat (1952) gave a brief account on the postembryonic development of *S. laevigatus* by culturing the species in slender dishes.

Sengbusch (1954) reared 3 species of *Galumna* viz., *G. nervosa, G. elimatus* and *G. longipluma* at a temperature of 25^{o}C. One of the species, *G. nervosus* was found to take an average of 47.1 days to complete its development at a temperature of 25^{0}C. The same species when reared at a temperature of 20^{0}C, took an average of 63.0 days. Rhode (1955) devised culture vials using a mixture of plaster of paris and charcoal in dram vials for rearing oribatid mites.

Pauly (1956) successfully completed the biological studies of 3 species of *Belba*., *B. geniculosa, B. gracilipes* and *B. clavipes* and reported that the first species completed development within 150 days while the latter 2 look only 75 days. He further gave information on the spermatospore production in the members of the family Belbidae. Copulation, a rare

phenomenon in oribatid mites was reported for first time by Grandjean (1956).

Schuster's (1956) observation on oribatid feeding led to the formulation of a nomenclatural framework to describe the feeding patterns of oribatid mites as a whole. He grouped these mites into three categories viz., macrophytophages, microphytophages and panphytophages.

Grandjean (1957) correlated the structure of mouth parts of oribatid mites in relation to feeding activity. He reported rutellum as a modified form of infracapitular seta which would facilitate feeding.

Taberly (1957) observed the production of spermatophores in 17 species belonging to 15 genera and discussed their structural peculiarties. Wallwork (1957) reported the borrowing habit of the adults and immatures of some oribatids on the bark and hard wood of fallen twig. The same author (1958) studied the feeding behaviour of several species of soil inhabiting oribatids in relation to decomposition of litter.

Sengbusch (1958) revealed that the algal species *Protococus* and moss served as excellent food item for culturing a variety of oribatid mites and further traced life history of 8 species of oribatid mites. Stinkova (1959) furnished an elaborate data on the life cycle of *B. boreus* by culturing it on leaves and potatoes and recorded the duration of the life cycle as 120 days.

Wallwork (1960) recorded a higher temperature tolerance in a West African oribatid species when compared to that of a North American oribatid species.

Sengbusch (1961) studied the process of spermatophore deposition and sperm transfer in oribatid mites. Woodring and Cook (1962) conducted

studies on the biology of 3 species of oribatids, viz., *C. cisalpinus*, *S. laevigatus* and *O. neerlandica,* giving details on spermatophore deposition and morphological peculiarities of immatures. They further noted that the period of the life cycle could be lengthened either by providing a minimum or lowering the temperature.

Graves (1960) observed that *Galumna sp*. could feed on live larvae of flies. Fuhrer (1961) reported the association between bacteria and mites. Engelmann (1961) proposed that mites could be used to control fungi and bacteria. Macfadyen (1961) indicated that soil oribatid mites could cause rapid reinfection of soil samples by transporting micro-organisms on and in their body. Evans *et. al*., (1961) identified *Humerobates rostrolamellatus* as the pest of cherries. Bhattacharya (1962) succeeded to rear *Damaeus onustus* upto the deutonymphal stages and recorded the average duration of egg, larva and protonymph as 17.4, 56.57 and 60 days respectively. Further, he offered a variety of food materials to 6 species of mites and found that several species were omnivorous and concluded that the average longevity was an indication of the nutritive value of food. Schuster (1962) confirmed the occurrence of copulation in oribatid mites.

Feeding specificity of different species of oribatid mites was analyzed elaborately by Hartenstein (1962 to 1962f). The author (1962a) recognized 3 types of feeders among oribatid mites viz., primarily wood and leaf feeders, primarily fungivores, but would feed on wood and leaf tissue and strictly fungivores. The same author (1962b) while studying the development of *B. kingi* found that there was a rapid rate of development with a diet *Trichoderma sp*. In the same year (1962c) he offered different types of fungi to *Metabelba montana* and *Eremobelba nervosa* and he showed the

preference of these mites to certain specific types of fungi and he also gave a descriptive account on development, biology and ecology along with gross morphology of immature stages. He reported (1962c) that *Protoribates lophotrichus* could feed specifically upon decaying parenchymatous leaf tissue, rich in living microorganisms and derived most of its sustenance from the latter. He also revealed that, approximately 5 months were required for the development from the adult to the egg stage. He (1962d) revealed that *C. gracilis* could live in the litter layer of soil feeling predominantly upon fungi. The over wintering tritonymph and the adults oviposited from early spring until fall. At least 119 and as many as 149 days were required in the laboratory at 20^0C for the completion of development from egg to adult. A longer period might be required in nature where lower soil temperature could be encountered.

Gasdorf and Goodnight (1963) reported a proportional increase in ligin and decrease in cellulose in the faeces of *Peloribates* sp. and *Hermannia* sp. normal of oribatids. Woodring (1963) reviewed the nutritional and reproductive aspects of oibatid mites and provided a consolidated list of oribatids which could be successfully reared in the laboratory. Sengbusch (1963) recommended some methods for preparing and culturing of oribatid mites. According to Lebrun (1964) litter dwelling forms developed at a faster rate than the humus dwellers. Madge (1965) carried out behavioural studies on *B. geniculosa* and revealed that this species possessed true preferred temperature irrespective of other prevailing physical and environmental conditions.

Jalil (1965) based on his field and laboratory observations, furnished data on the life cycle of *Hermannia scabra*, providing illustrations of the

juvenile stages. Woodring (1965) successfully completed developmental studies of 5 species of oribatids viz., *G. confusa*, *G. parva*, *R. flavus*, *S. parabilis* and *S. nudus* under laboratory conditions.

Wallwork (1965) detected the leaf boring nature of immatures of *O.terebrantis* on the leaf tissue of the aquatic weed, *Eichhornia crassipes*. The extent of damage caused by the mite to the host plant was studied by Silveria Guido (1965). Block (1966) observed seasonal fluctuations in the population of oribatid mites, which as in many cases, would closely be correlated with their reproductive cycle.

Wauthy *et. al*. (1966) expressed that members belonging to the same species would develop enzymatic polymorphism due to nutritional and environmental adaptations. This observation was based on investigation carried out by the authors using 2 subspecies of the oribatid mite, *Quadroppia quadricarinata*. The zoophagous nature of *Pergalumna omniphagous* was established by Rockett and Woodring (1966) by observing its predatory habit on nematodes.

Wallwork (1967) studied the direct and indirect effects of soil oribatids in soil formation, plant productivity and litter decomposition by their vertical translocation of organic matter to deeper soils. He further added that many species of oribatids had a tendency to feed on the faeces of other animals.

Kowal (1969) recorded feeding rate of *Cultroribula juncta* on natural pine-moors by estimating Ca_{45}. Cancela Da Fonseca (1969) contributed information on the biology of *Damaeus quadrihastatus* and the complex nature of its spermatophores consisting of a twisted pedicel and sculptured

head. Arlian and Woolley (1969) described the morphological characteristics of the immatures of *Liacarus cidarus*, recording the various changes occurring in their chaetotaxy during postembryonic development. The same authors (1970) observed the developmental pattern of *L. cidarus* by rearing it on *Cladosporium sp*. of fungus and recorded data on spermatophore deposition, oviposition, duration of incubation period at different temperatures and ecdysis. Woodring (1970) provided a comparative account on the homology and function of the male and female systems of 30 species of oribatid mites, belonging to 22 families. Woolley (1970) pointed out that members of the oribatid families, Oribatulidae and Oppiidae could be reared nearly on any food substance while those of Liacaridae, Tenuialidae and Xenillidae were food specific. Trave (1970) provided morphological description of the juvenile stages of *Neoribates sp*. Baumler (1970) reported that in *H. scabra*, the oviposition occurred during the direct period of the year. Sengbusch and Sengbusch (1970) traced the life history of *O. nitens* at a temperature of 20^0C and compiled data on the life history of 48 species of oribatids. Shereef (1970) assessed the feeding preference of oribatids by providing them two different species of fungi viz., *Pencillum* sp. and *Aspergillus* sp. Mignolet (1971) also estimated feeding preference of oribatid mites by providing various types of fungal diet to these mites. He recorded their response to individual species of fungus. Spain and Luxton (1971) studied the ability of some oribatid mites to digest cellulose and other plant polysaccharides like pectin, chitin etc. Kowal and Crossley (1971) carried out experiments on the influence of temperature on ingestion and egestion rates in oribatids. Bernini (1971) with the aid of E.M. studied the ultra structural details of the alimentary canal of 4 species of oribatid mites viz., *S. laevigatus*,

S. anomalus, Xenillus tigeoribates, Phthiracarus sp. and studied in detail the histology of different regions of gut.

Perkins (1971) observed the duration of development of the waterhyacinth mite, *O. terebrantis* and found that this species required about 10 days for the completion of development from egg to adult stage. Shereef (1971) studies the life history of 5 species of oribatid mites viz., *B. meridionalis, Spatiodamaeus subverticillipes, Palaeacarus kamanaskii, Eremobelba geographica* and *Granuloppia* sp., by providing a fungal diet of *Aspergillus flavus*. He found that the life cycle was much longer in *P. kamanaskii* and in all the species where males were produced, the duration of male life cycle was shorter. Further, he concluded that the presence of female was not always needed for spermatophore deposition. The same author (1971a) conducted comparative studies on the life cycle of oribatid mites from USSR.

Lions (1971) described the morphological details of all the nymphal stages of *Eremaeus cordiformis* collected from soils of France. Butcher *et al*. (1971) provided data on the embryonic development and details of spermatophore deposition in different species of oribatids. Sitinikova (1971) conducted studies on the postembryonic development of *Eupelops torulosus* by culturing the mite under laboratory conditions.

Zinkler (1971) analyzed carbohydrases present in litter dwelling oribatids. His studies showed that macrophytophagous and omnivorous oribatids were able to attack plant structural polysaccharides by carboxy methyl cellulose, xylanase and pectinase which were recognized as very important in primary decomposition. The same author (1972) reported that

microphytophagous feeders could digest only intracellular compounds of algae, fungal mycelia and bacteria with the help of maltase and amylase.

Luxton (1972) reviewed the classification of oribatid mites based on feeding habits. He enlarged the classification substituting the term panphytophages for non specialized feeders. He added further terms like Zoophages (feeding on living animal matter), necrophages (feeding on carrion) and coprophages (feeding on faecal materials). Shereef (1972) made a series of observation on 5 species of orbatid mites, which were cultured on the fungi, *P. martensii* or *Aspergillus flavus* in petridishes and small glass cell. And provided data on their life cycle. The duration of life cycle varied considerably, and in the case of species producing males, the duration of the male life-cycle was shorter than that of the female. He also noticed that *P. kamanaskii* reproduced parthenogenitically. *B. meridionalis* was cultured in glass cells on 12 different species of fungi and further assessed the popultion of all stages in the cells after 104 days. The most favourable diet was *Trichoderma sp*. and the least favourable were *P. viridicatum* and *Mucor ramannianus*.

Tadros (1973) found that oribatid species of the families Oribatulidae and Oppiidae could be reared on more than one food stuff. Pande and Berthert (1973) studied food habits of oribatids inhabiting a Black pine forest and concluded that food habits of immatures varied from that of the adults. Durations of the life cycle of *O.concolor* and *Epidamaeus* sp. were recorded by Salvatore and Alfredo (1973). Lions (1973) reported the occurrence of prelarva in *Plesiodamaeus craterifer, Zetorchestes falzonii*, *Mycobates parmeliae, Dometorina plantivaga plantivaga, Epliohmannia sp*. and *Sphaerozetes sp*. Narsapur (1974) fed *S. laevigatus* and *S. fimbriatus* with the

eggs of *Avitellina lahorea* to study the development of cysticercoids in the body cavity of these mites.

Cordo and De Laoch (1975) studied the pattern of oviposition in *O. terebrantis* and noted that gravid females of this species cut round holes of 0.1mm diameter with their mouthparts and inserted the eggs into aerenchyma cells of the leaf. Luxton (1975) conducted calorimetric studies of oribatid biomass and discussed it in terms of life histories and metabolic rates. Metz and Sharma (1975) gave morphological and biological descriptions of *O.durhamensis* collected from North Carolina. Seniczak (1975) also performed similar work, on 3 species of *Oppia* viz., *O. subpectinata*, *O. bicarinata* and *O. neerlandica*.

Weigmann (1975) conducted laboratory and field studies on the life cycle of *H. subglabra*, *P. peltifer* and *Ameronothrus schneideri*. Cancela Da Fonseca (1975) provided description on the deposition of spermatophores and feeding aspects of few oribatid species viz., *D. verticillipes*, *H. gibba* and *S. magnus*.

Haq (1976) conducted feeding experiments on 20 species of oribatid mites and concluded that the wide range distribution of panphytophagous species would reflect their ability to digest different varieties of food available in their habitat. Haq and Prabhoo (1976) employed suitable staining procedures for analyzing the gut contents of 10 species of oribatid mites collected from field and found that they fed on decaying parts of higher plants as well as microflora and were therefore assigned to the category of panphytophages. The authors observed that no 2 species agreed perfectly with each other in their feeding habits. Cordo and De Loach (1976) carried

out biological studies of *O. terebrantis* and provided data on the behaviour of immatures and adults of the mite in Argentina. Sankaran (1976) recommended this species as one of the effective biological agent for the control of waterhyacinth.

Shereef (1976) made observations on the postembryonic development of *O. sticta* and *Multioppia wilsoni* on their preferred food, *A. flavus* and informed that males took lesser time (11-18 days) to complete life cycle when compared to the females (16-21 days).

Lebrun (1977) compared the incubation periods in *D. onustus* at a given mean temperature applied either constantly or variably with less or well marked amplitudes. Wallwork (1977) gave description of structure of the ovipositor, and mechanism of egg laying in the oribatid mite, *Machadobelba symmetrica*. Shereef (1977) provided morphological information on 2 more oribatid species viz., *Plakoribates multicuspidus* and *Xylobates souchnaiensis*. Webb (1977) gave details on the general biology and life cycle of *S. magnus* from Southern England. Michael (1977) gave a brief review on the existing data on the oribatid life histories and related the information to their physical and biological environment.

Bhattacharya *et al.* (1978) studied the effect of temperature on the development of *O. nodosa* and found that total duration of development varied with respect to the alterations in temperature and very low temperature like 8^0C could induce dormancy in many species. Seniczak (1978) gave information on the juvenile stages of *Achipteria coleoptrata* and noted their resemblance to the nymphs of *A. nitens* and *Parachipteria willmanni*. Bellido (1978) gave an elaborate account on the external characteristics of the immature stages including the prelarva of *Carabodes willmanni*.

Behan and Hill (1978) described feeding habits of 25 species of oribatid mites. They estimated the direct and indirect effects of oribatid mites on decomposition process. The author further added that 50% of oribatids adopted 'eurytyptic' feeding habits which proved advantageous for their survival. Lebrun (1978) provided a detailed description about the activities of soil mites in various ecosystems particularly soil fertility, biogeochemical cycles, humification, bio-indication and in the detection of residual concentration of pesticides. Reddy *et al*., (1978) studied the influences of food on the developmental period of *G. flabellifera*. They further reported that gut microflora of immatures of *A. coleoptrata* were more active and possessed the ability to digest cellulose, lignin, chitin and pectin. Seniczak and Stefaniak (1978) reported that microflora of alimentary tract in *O. nitens* depended on quality of food taken. They also described that alimentary tract microflora were clearly distinct from that of the feeding habitat.

Haq (1979a) observed that adults of *G. flabellifera orientalis* fed on decomposed leaves of *Artocarpus* sp. while larvae preferred fungal feeding. He further studied the postembryonic development of the same species and reported that the mite took an average of 25 days to complete its development at a temperature of 31 ± 1^0C. The occurrence of parasitic protozoans in the alimentary tract of oribatid mites was reported by Purrini *et al*., (1979). Luxton (1979) presented a detailed review on the nutritional biology of oribatid mites. He compiled data on the rate of food processed by these mites. Krantz and Lindquist (1979), while studying the evolution of phytophagous mites, speculated that edaphic saprophagous and mycophagous mites become pre- adapted to phytophagy due to the lack of major ecological barriers.

Travenicek (1979) described the different factors influencing the deposition of spermatophores and mechanism of sperm transfer in oribatid mites while conducting studies on 9 species of Liacarid mites.

Mitchell (1979) studied population energetics of 5 taxa of oribatid mites (*Ceratozetes kananaskis, C. gracilis, Scheloribates* sp. *Eremaeus* sp., and *Eupterotegaeus rostratus* in an aspen woodland soil in the Canadian Rockers. Standing crops varied between 76.9 and 13.8 mg/m^2. Using data from a life table the secondary production of *C. kananaskis* was estimated to be 24.8 mg/m2/yr (260j/m2.yr). Adult population metabolism was estimated by gas chromatography and which ranged from 8.3 to 32.3 cm^3 02/m2.yr. When these values were extrapolated to the total oribatid community and compared with litter input, a utilization of only 0.43% was found. The energetic role of oribatid mites was concluded to be small.

Seniczak (1980) described the morphological peculiarities of life stages of *Trichoribates trimaculatus* and *T. novus* and observed similarities between the immatures of both the species. The same author (1980a) studied the juvenile stages of the members of Scheloribatidae. Shereef and Zaher (1980) described the morphological and biological details of *O. bayoumi*.

Rockett (1980) studied nematophagy in *Nothrus* sp., *Fuscozetes* sp., *Ceratozetes* sp. and *Pergalumna* sp. The author reported that this feeding habit occurred more frequently among superior oribatids. Haq and clement (1980) conducted comparative studies on the developmental duration of 4 species of oribatids, viz., *L. ornatissimus, A. longisetosus, G. flabellifera* and *G. longipluma*. The same authors (1981) explained spermatophore deposition and mechanism of its transfer in *Pelokylla malabarica*.

Andrie and Voegtlin (1981) made observation on the biology of *Camisia carolli*, an abundant species found on Douglas fir in the Western Cascade Mountains of Oregeon. Vikram Reddy (1981) illustrated the various indispensable functions performed by different groups of acari. The author stressed the importance of mites in nutrient cycling, energy flow, bioindication, decomposition and soil aeration. Luxton (1981, 1981a-1981c) gave a brief introduction to the field population, developmental biology, vertical distribution and seasonal variation in the population diversity of oribatid mites.

Krantz and Baker (1982) described the fine structure and configuration of plastron mechanism of an aquatic oribatid mite, *Hydrozetes* sp. and compared it with the peritrematic plastron mechanism of 2 gamasid mite species that also invaded aquatic habitats.

West (1982) investigated the life history of 3 species of subaractic oribatid mites. Haq (1982) concluded that the rate of reproduction was enhanced by preferred food and grouped 10 species recovered from litter samples in to three major feeding categories, viz., microphytophages, macrophytophages and panphytophages. He also made assessment of carbohydrates present in the gut of these species. Clement and Haq (1982a) reported the fungus *Pestalotia* sp. as the preferred food of the oribatid species, *P. malabarica* and found that the food item accelerated the rate of spermatophore deposition and egg laying by this mite.

Ramani and Haq (1982) studied the phytophagous nature of *P. bengalensis* on the tuber crop *D. alata*. Waitzbauer (1983) described the process of spermatogenesis in *H. gibba*. Behan and Hill (1983) conducted a survey on the feeding habits of 16 species of oribatid mites from uncultivated

and cultivated blanket bog of Glenamoy, Ireland through gut content analysis and reported that 15 species were panphytophages and acted as regulators in the process of mobilization of minerals, dissemination of fungal spores and as temporary store house of nutrients. Hagan and Norton (1983) explored the impact of human disturbance of the habitat on the richness of oribatid fauna. The authors revealed that sites with highest calcium content had higher species richness.

Clement and Haq (1984) gave a detailed account of the breeding biology of *P. malabarica* and noted that it took an average of 18.2 days to complete the life cycle at a temperature of 30$\pm$ 1^0C on a fungal diet of *Pestalotia* sp. The postembryonic development of *P. bengalensis* inhabiting the leaves of *D. alata* was observed at a temperature of 20$\pm$ 1^0C and a relative humidity of 80% by Haq and Ramani (1984), who further recorded duration of development as 26.7 days. Nannelli and Bernini (1984) traced the postembryonic development of *C. pegazzonoae* and described the morphological and ecological aspects of its immature stages. Balakrishnan and Haq (1984) reported that the oribatid genus *Hydrozetes* and species *G. flabellifera* orientatlis as vectors of cestode parasites.

Purrini and Bukva (1984) elucidated the presence of microorganisms like bacteria, fungi and protozoans in the gut and body cavity of many species of oribatid mites. Wolf and Rockett (1984) isolated several species of bacteria from the alimentary tract of two species, *Rhysotitra* sp. and *Pergalumna* sp. The authors noted that the microorganisms in the oribatid gut changed with species and their habitat.

Schatz (1985) studied the life cycle of *Oromurcia sudetica* by creating fluctuating temperature and observed similarities in the results of both

laboratory and field studies. An elaborate account on the biology of *Adoristes ovatus* dwelling inside the pine litter was provided by Gourbiere *et al*. (1985). Norton (1985) observed that oribatid mites could directly affect soil structure by ingesting particulate food and producing discrete faecal pellets. According to him saprophagous and mycophagous oribatid mites possessed an active gut microfauna which changed with diet change. Cancela Da Fonseca (1985) revealed the profound effect of food characteristics on the spatial distribution of oribatid mites in a particular microhabitat.

Haq and Ramani (1987) reported the association of 21 species of oribatid mites with the weed plants, *C. odorata* and *E. crassipes*. The authors stressed the role of oribatid mites in the control of these weeds. Association of oribatid mites with moss was studied by Lawrey (1987). His studies revealed that moss provided food, concealment, camouflage and dispersal facilities for these organisms. Reutimann (1987) worked out the quantitative aspects of the feeding behaviour of some oribatid mites like *P. boneatis*, *N. horasricus*, *D. diversipilus* and *Podoribates longior*. Purrini (1987) reported the high rate of infestation of soil oribatids by several species of protozoans in polluted locality.

Bhattacharya and Bhattacharya (1985) identified three different response patterns for the oribatid species of a field polluted by the industrial wastewater on the basis of the shift in the dominance status. They found that *S. fimbriatoides, X. indicus* and *G. flabellifera* were considered to be the most impact-sensitive potential bio-indicator species of soil pollution. Ramani and Haq (1987) conducted biological studies of *S. decarinatus*, a common inhabitant of the terrestrial weed, *C. odorata*. They observed (1987a) the

influence of different temperature on the duration of development of this species.

Haq (1988) studied the biology of oribatid vectors belonging to the families Scheloribatidae and Galumindae. Neena and Haq (1988) studied the feeding specificity of 6 species of soil oribatids and observed similar feeding trends in field and laboratory except in one species, viz., *Bicyrthermannia duodentata*. Sheela and Haq (1988) conducted a survey on the oribatid mites associated with *E. crassipes*. The authors reported the presence of leaf parts in the gut of the mites. While studying the biological aspects of *Mucronothrus nasalis*.

Kaneko (1989) studied the duration of life cycle as well as the reproductive pattern of 4 species of oribatids viz., *Eohydroppia magnus, Ischeloribates lanceolatus, Quadroppia quadricarinata* and *Archoplophora villosa* collected from mull soil type.

While discussing some unusual behaviour pattern exhibited by oribatid mites, Haq (1989) showed the dependence of mites on food source of animal origin by predation and ingestion of cestode eggs.

Sannyal and Das (1989) found many species of oribatid mites attacking the apical portion of the roots of pineapples. Alberti *et al*. (1989) provided a summary on the available data on spermatophore structure among oribatid mite using light and electron microscopic studies.

Fernandez *et al*., (1991) studied the fine structure and histochemistry of spermatophores and spermatozoa of oribatid mites. Alberti *et al*. (1991) gave a detailed study on the functional and systematic aspects of the spermatophore and spermotozoa of oribatid mites.

The extreme adaptability of oribatid mites to occupy newer habitats was brought to light by Ramani and Haq (1991). The authors reported that mites originally adapted for soil life could lead an arboreal life when their habitat was destroyed. The potential of *M. degradatus* and *X. rhomboides* in the degradation of higher plant materials was revealed by the same authors (1991a).

Haq *et al*. (1991) reported the presence of fungal hyphae in the gut of *S. fijiensis*. Neena and Haq (1991) studied the influence of a few species of fungi on the postembryonic development of *O. kuhnelti* in the laboratory at a temperature of 30$\pm$ 2^0C and a relative humidity of 82-85%. Their studies revealed that the mite completed its life cycle in 14.15 to 16.70 days on their preferred food *Pencillum* sp. The same authors (1991a) reported the occurrence of a large number of protozoans in the gut and body cavity of 10 species of oribatid mites. Sumangala and Haq (1991) reported that *G. cuneata* took 58-60 days to complete its life cycle when fed on *E. crassipes*, while it required only 39-44 days when fed on fungal diet. Haq (1991) observed that members of Scheloribatidae were able to survive on almost any type of food and could live in association with a variety of plants. The same author (1991a) reported that mites infected with nematodes were reluctant to consume food. Lebrun *et al*. (1991) described the different life history strategies exhibited by oribatid mites. Norton and Palmer (1991) studied the distribution mechanism and evolutionary significance of parthenogenesis in oribatid mites. Dennis *et al*. (1991) concentrated their studies on mite-plant association from the Eocene of Southern Australia. Ganga and Jayanthi (1991) studied the life history of *Orthogalumna terebrantis* an exotic oribatid mite introduced for biological control trials

against water hyacinth, under laboratory conditions. The mite completed its life cycle in 25-27 days. Eggs were laid within leaf lamina and the feeding of the larval and nymphal stages caused yellow linear mines on the leaf, Adults were observed to live for 78.75 days, and a female laid the average of 58.5 eggs.

Haq and Shereef (1992) reared *Galumna uniqua* on five different species of fungi. The biology of another species of the genus viz., *G. triquetra* was traced by Shereef and Haq (1992) by rearing it on the preferred food, *C. geniculata* at a mean temperature of 28^0C and a relative humidity of 80% and the same species took an average of 34.3 days to complete its life cycle. Palmer and Norton (1992) noticed that the oribatid mite taxon Desmonomata reproduced by thelytokous parthenogenesis and observed males as non-functional.

Haq (1992) gave an elaborate report on the beneficial aspects of oribatid mites, highlighting the potential of these mites in biodegradation, bioindication and natural predation. Sumangala and Haq (1992) noticed different stages of development of *O. terebrantis* in a single leaf of *E. crassipes*. According to Neena and Haq (1992, 1992a) Mycophagy, the habit of feeding on fungal tissues was common among oribatids.

Nematophagy in oribatid mites was reported by Ravindran and Haq (1993). The authors showed that *G. flabellifera* and *X. seminudus* fed on the plant parasitic nematode *Hoplolaimus* sp. collected from rhizosphere of banana roots. Norton *et al.* (1993) described the different reproductive ways exhibited by oribatid mites.

Role of oribatids in soil ecosystems was reviewed by Haq (1994). The report highlightened the influence of these mites in the maintenance of soil

fertility. Smrz (1994) reported behavioural and histological responses of oribatid mites under the conditions of extreme humidity combined with microorganisms. Wrensch *et al*., (1994) studied the cytogentics of holokinetic chromosomes and inverted meiosis in mites. Sumangala and Haq (1995 and 1995a) studied the detailed reproductive strategies of *O. teretriantis*. They found that the mite took 21-23 days for completing its development.

Siepel and Maaskamp (1994) studied the effect of representatives of five feeding guilds of oribatid mites on microbial respiration during decomposition of organic matter.

Block and Convey (1995) worked out the biology, life cycle and ecophysiology of the Antarctic mite, *Alaskozetes antarcticus*. Rihani *et al.* (1995) studied the food preference and the decomposing activity of 3 oribatid mites, *Steganacarus magnus, A. coleoptrata* and *D. verticillipes*, using 12 different substrates.

Haq (1996) established microbial involvement in the feeding habits of oribatid mites. The same author (1996a) studied nutritional diversity of oribatid mites, which showed predation, parasitism and phytophagy. Crossley (1997) attempted to evaluate the energetics of oribatid mite population based on their contribution in mineral and nutrient cycling Skubala's (1997) investigations showed that oribatid mites could thrive equally well on post industrial dump containing Zn and Fe. Marie *et al*. (1997) examined the phenomenon of obligate thelytoky in oribatid mites and recommended an alternative hypothesis for the induction of thelytoky. The authors further studied its relevance to the observed diversification of thelytokous oribatid mites.

The importance of oribatid mites in the decomposition of organic matter and their influence in the edaphic trophic chain of two forests under Mediterranean condition was worked out by Andre and Binche (1998). Studies carried out by Connell *et. al*., (1998) revealed that soil oribatids had a low degree of food resource specialization.

Food preference in various oribatid mites was analyzed by Maraun *et al*. (1998). Maraun *et al*., (1998a) worked out the effect of panphytophagous oribatid mites on the recovery of microbial community in F-layer material of soil, which was disturbed by human activities.

Behan and Paoletti (1999) gave a detailed account on general ecology, biology and life history of oribatid mites inhabiting the organic horizons of soils. They suggested that oribatid mites with low metabolic rate, slow development and low fecundity couldn't respond rapidly to resource scarcity. Haq (1999) reared oribatid vectors in culture vials by offering preferred food and eggs of tapeworm.

Ramani (1999) carried out biological studies on the widely prevalent oribatid mite, *Xylobates seminudus*, which consumed 13 out of the 17 food items offered, in the laboratory. The entire life cycle was found completed with in 18.75-23.00 days. Fernandez (1999) described the tritonymph and adult stages of *Oripoda benegasi*.

Schuster *et al*. (2000) artificially infected 6 species of adult oribatid mites and 2 immature stages with eggs of *M. expansa* and studied their vector role. Kuriki (2000) studied life histories of oribatid mites in sphagnum mines. Sexuality and asexuality in oribatid mites were studied on a molecular basis by Maraun (2001). The same author (2001a) carried out a through study on

the sexual and parthenogenetic oribatid mites and derived evolutionary and phylogenetic conclusion.

Hubert *et al*. (2001) reared panphytophagous oribatid mites, *S. laevigatus, Achipeteria coleoptrata* and *G. elimata* under laboratory conditions on the green bark algae, *Desmococcus vulgaris,* grass and herb litter *H. lanatus, Hypecicum maculatum* and *Acetosella vulgaris* including fungi growing on litter, and filter paper. Food preference, defecation, gut contents and types of food boli were studied in order to assess the consumption and digestion of the offered diets.

Smrz (2002) described microanatomical and microbiological characteristics of the quiescent state of an oribatid mite, *Scutovertex minutus*. Schneider *et al.* (2004) summarized the existing knowledge on the feeding biology of oribatid mites. Schneider and Maraun (2005) conducted a laboratory food choice experiment and offered a number of various dark pigmented fungi to different species of oribatid mites. They found that only some of the dark pigmented fungi were preferentially ingested and others were of intermediate food quality. Their studies revealed that melanin alone was not responsible for deciding the feeding preference of oribatid mites.

Anibal *et al*. (2007) estimated the consumption rates of a *Pergalumna* sp. when feeding on 2 major pest nematodes, *Meloidogyne javanica* and *Pratylechus coffeae*, under laboratory conditions. They adopted a new method, in which live nematodes were offered to mites and subsequently consumption was quantified based on the sclerotized, well preserved structures in the mite fecal pellets. The assay was evaluated during 5 days, at 25^0C and 96% relative humidity, with three replicates for each nematode species. Every replicate consisted of a group of 4 mites isolated in an arena,

to which 400 nematodes were transferred daily. The daily produced fecal pellets were mounted in Hoyer's medium for examination under a microscope. The nematode buccal stylets and cephalic frame works were counted to estimate the number of nematodes consumed.

Ramani (2007) studied the belief feeding and tunneling habit of oribatid mites on the fiber crop *Pandanus kaida* Kurz. Studies of Saporito *et al*. (2007) indicated that oribatid mites represented a previously unsuspected repository of a wide variety of alkaloids and a significant dietary source for the alkaloids found in poison frogs.

Julie *et al.* (2007) reported the role of *S. praeincisus* interruptus in the dispersal of the fungus, *Trichoderma harzianum*. Julie and Ramani (2007) conducted studies on the role of oribatid mites in the degradation of highly recalcitrant solid wastes on found setting grounds. The same authors (2009a) studied the deposition of spermatophores and sperm transfer in an oribatid mite, *S. praeincisus interruptus*.

MATERIALS AND METHODS

I. EXTRACTION OF LIVE MITES

One of the essential requirements for biological studies of any organism is to acquire sufficient collection of live specimens from their natural habitat. For making detailed biological studies of higher oribatid mites, soil samples from various litter accumulated areas were collected. Collected samples were subjected to extraction under a modified Berlese-Tullgren funnel apparatus in the laboratory (as described in chapter IV). Live mites for biological studies were extracted into collecting vials containing water/moistened leaf/wood pieces. The process of extraction was carried out for a period of 2-3 days depending upon the moisture content of the samples. After extraction, the contents of the collecting vials containing the extracted animals were spread in petridishes and allowed to dry for 10-15 minutes in air. Live mites were picked up with a moistened camel hair brush under a stereomicroscope and transferred in to individual culture cells for subsequent rearing.

II. REARING OF MITES

1. Preparation of Culture Cells:

Rearing of selected species of oribatid mites was carried out in the laboratory in plastic chambers based with plaster of Paris- charcoal mixture (4:1). Plastic chambers of varying diameter and height were selected for the preparation of culture cells. Four parts of plaster of paris and one part of activated charcoal were thoroughly mixed and made in to a slurry with the addition of adequate amount of water .The above mixture was poured into

individual plastic container. A small drop of thymol was also added to prevent fungal infestation. While pouring the mixture, care was taken to avoid trapping of air bubbles and to achieve a uniform spreading of the mixture. The surface of the medium was made smooth and even and the culture cells were allowed to set and dry for 3-4 days. The culture cells were closed with respective lids and small pin holes were made on the lids to ensure air circulation.

2. Procuring Test Food Items:

(a) Fungi:-

Pure cultures of different species of fungi were procured from institutions like Indian Institute of Spices Research, Kerala Agricultural University, Thrissur and Department of Botany, University of Calicut. Many sub cultures were prepared in the laboratory on PDA medium, from these pure cultures.

(i) Preparation of PDA Medium (Potato Dextrose Agar Medium)

200 gm of potato were pealed off and boiled in 500ml of water. It was filtered and made up to 1000 ml and poured into a conical flask and sterilized. After sterilization, the medium was poured into petridishes and test tubes which were sterilized. On solidification of the PDA medium, each species of fungus was inoculated on to the medium, with the help of a platinum loop, in an asceptic condition.

(b) Leafy/Woody Particles of Litter and Pneumatophores

Fallen leaves or twigs from different collection sites were collected in polythene bags, properly labelled and were brought to the laboratory. Leaves of *D. lanceolaria*, *A. hirsutus*, *A. occidentale*, *X. xylocarpu*s, *M. elenji*,

E. officinalis, *B. arundinacea***,** *A. ilicifolius* and decayed pneumatophores in various stages of decomposition were collected. Three or four dried leaves of the same plant were stapled together and then cut into squares of 0.5 cm and kept soaked in distilled water. Leaf discs prepared in this way were used as food for rearing the mites**.** Decayed pneumatophores collected from mangrove ecosystem were washed, dried and kept soaked in distilled water**.**

(c) Filter Paper:

Filter paper (Whatman No.1) was cut into squares of 0.5 cm and such squares were soaked in water and kept in rearing chambers containing different species of oribatid mites.

(d) Coconut Pith:

Retting is a procedure where the coconut husks are decomposed in either salt water/freshwater encouraging the growth of micro-organisms. At this stage the coir fibers separates from the husk leaving behind residues which is known as coir pith (Plate 37, Fig. 1-4).

Fresh coconut pith collected from the retting grounds were kept in polythene bags and brought to the laboratory. This was dried in an oven at 103^0C for 1-2 days and stored in desiccators for subsequent use as test food item.

(e) Animal Waste:

Fresh cow dung was collected and sun dried. For rearing the mites, traces of dried dung were soaked in distilled water and offered to the selected species of oribatid mites as test food item.

3. Culture of Oribatid Mites:

From the extracted live mites, individuals representing 20 common and abundant species were segregated species wise and transferred to the prepared culture cells. These mites were then offered different food items mentioned above in order to acclimatize them under laboratory conditions and to maintain their culture for further feeding studies. Utmost care was taken to maintain optimum conditions of hygiene, temperature, moisture and humidity within the culture cells. Regular observation of these culture cells was made thrice a day. The preferred food of each species was identified by conducting gut content analysis of field collected specimens and laboratory food choice test.

III. QUALITATIVE ANALYSIS OF FEEDING HABITS

An analysis of feeding habits of the various species of oribatid mites selected for the current study was made by conducting gut content analysis of field collected mites as well as food choice test. Apart from these the structural details of the gnathal appendages (mouth parts) were also analyzed for correlating their functional attributes in relation to feeding.

A. Analysis of Gut Contents of Field Collected Mites

In order to evaluate the natural food preference of the various species of mites, gut content analysis of field collected specimens was carried out. Live mites extracted through Berlese funnels were washed in distilled water and kept in culture vessels without supplying any food. Such mites were then transferred to microscopic slides. Food boli and gut contents present inside the body of these mites were dissected out under a stereomicroscope by exerting slight pressure with the blunt end of a dissecting needle. The ingredients thus dissected out were spread out evenly in glycerin and examined

under a research microscope after proper staining. Identification of gut contents was carried out following Johansan (1940), Prasad and Prasad (1979), Gahan (1984), Dwivedi and Singh (1990) and Sanderson (1994). Help from specialists was also sought for confirmation of identity. The following stains were used for the preparation of slide mounts of the gut contents.

1. Safranin : 2.25gm of safranin dissolved in 225ml of 95% alcohol. This was used for staining fungal mean hyphae, spores.
2. Basic fuschin : 1gm of Basic fuschin was dissolved in 100 ml of 95% alcohol and then diluted with 10ml distilled water. This was used to stain vascular system of higher plants.
3. Cotton blue : 20% solution of cotton blue was used to stain fungal mycelia.
4. Orange G : 0.5% orange G solution in 95% alcohol was used to stain fungal hyphae.
5. Fast Green : 0.2% solution of fast green in 90% alcohol was used to stain cellulose wall of parenchymatous cells.

Besides the analysis of gut contents of live field collected mites, preserved mites were also subjected to dissection for the recovery of gut contents/ food boli, as described above. Quite often, faecal pellets laid by field collected mites were also stained and slide mounted for the identification of ingredients.

Based on the results of gut contents analysis, the selected 20 species of the mites were assigned to different feeding groups. Mites which disclosed the presence of higher plant materials in their gut/faecal pellets were considered as macrophytophages, while those which revealed fungi, bacteria, etc. were categorized as microphytophages and those which showed the

prevalence of both lower and higher plant materials were regarded as panphytophages.

B. Laboratory Food Choice Test

Of the 20 species which were subjected to gut content analysis, 10 species which showed the prevalence of fungi, woody and leafy litter etc. were selected for further study of laboratory food choice test, to locate their most preferred food items. For this, the mites were reared in separate culture cells, individually by providing different food items like different species of fungi, coconut pith, filter paper, animal dung, etc. (Table 6). Each food item was offered individually at the center of the culture cell. Regular observation was made regularly three a day. Each feeding test was repeated 5 times for drawing conclusions on the nature of preference to individual food item. Feeding preference to a definite type of food item was evaluated based on the following criteria.

1. Presence of the mites near/adjacent/ or among the food item.
2. Observing the general behaviour feeding activity of mites in cultures.
3. Presence of feeding marks produced on the food surface in the form of feeding holes/ burrows on leaves, skeletonization of leaves, tunnels on wood pieces, nibbling signs on the fungal material, etc.
4. Presence and number of faecal pellets laid on/around food materials or on substratum.
5. Production of eggs/spermatophores in the culture cells/ on or around food item and subsequent appearance of immature stages in the culture cells.
6. Positive signs of feeding by the immature stages leading to completion of life cycle.

C. Structural Analysis of Gnathal Appendages

Gnathal appendages of the above 10 species of oribatid mites were dissected out in glycerin and kept in slightly warm lactic acid for 20-30 minutes and then transferred to microslides. They were properly spread out and mounted in Hoyer's medium. The pedipalps, chelicerae and rutella which constitute the major grasping and masticating appendages of oribatid mites were examined in detail under a research microscope for studying their functional role in feeding. Sketches of mouth parts were drawn and photographs were taken using a Canon digital camera attached to Zeiss research Microscope.

IV. QUANTITATIVE ANALYSIS OF FEEDING HABITS: ANALYSIS OF MICRONUTRIENTS

1. Evaluation of nutrient composition of soil samples

The potential of oribatid mites in enriching soil fertility and productivity was analysed quantitatively by recording the levels of 3 important micronutrients viz., Nitrogen (N), Phosphorous (P) and Potassium (K) present in the soil samples. Soil samples collected from different sites viz. Site 3 characterised by *B. arundinacea* and *M. elengi,* Site 23 with *F. racemosa, J. beddomei, A. galangal, V. negundo, E. prostrata, A. indica, I. mauritiana, H. indicus, V. cineria, S. asoca* and Site 24, a biowaste accumulated area, Site 13 a retting ground bordered by *C. nucifera, A. officinalis, A. ilicifolius* and pith deposits., Site 17 with *X. xylocarpus, M. elengi,, D. lanceolaria, M. indica and A. occidentale* and Site 16 with mangrove vegetation like *A. officinalis, Acanthus ilicifolis, Exceorcaria agallocha* were subjected to micronutrient analysis. The collected samples of soils from the above sites were thoroughly extracted for 72 hours in order to

remove all faunal members and then transferred to earthen flowerpots. In experimental samples, 150 live adults of *p. ciliata* sp. nov., *P. punctata*, *M. kizhisseriensis* sp. nov., *D. indicus* and *S. praeincisus*, litter and soil samples from the sites selected for the study were present. While in control samples litter and soil sample from the selected sites were present. Soil samples in both experimental and control samples were adequately watered frequently and kept undisturbed for a period of about 6 months. These pots were covered with fine mesh to prevent the invasion by other organisms. After a period of 6 months, the soil samples of both experimental set ups and respective controls were subjected to chemical analysis for determining the quantities of N,P,K. Chemical analysis was carried out in the District Soil Testing Laboratory, Thikkodi following Jackson (1967).

2. Quantitative Assessment of Oribatid Potential in Degradation of Coconut Pith: Assessment of feeding impact of oribatid mites in the enhancement of micronutrients in pith

The potential of oribatid mites in the degradation of highly recalcitrant solid wastes like the coconut pith was made by quantitative estimation of micronutrients present in the pith before and after feeding by selected species like *P. punctata*. For the purpose, pure pith samples were collected from the retting grounds which were treated as experimental and control sets separately. For each set, 10-12 gm of samples were taken and dried in an oven at 103^0c for a period of 1-2 days. Such oven dried samples were kept in separate bottles .For the experimental purpose, 2 gm of the dried sample was taken in a fresh culture cell in to which 25 live specimens of *P. punctata* were introduced. The sample was adequately moistened with distilled water and kept for 3/6 months. The control set was also prepared similarly, but without the mite specimens. The faecal pellets from the experimental

samples were collected separately in every alternate days dries and stores in stoppered sterilized bottles. The stored faecal pellets were subjected to micronutrient analysis in the sophisticated Test and Instrumentation Center, Cochin University.

The analysis of Nitrogen and Carbon was carried out with Carbon Hydrogen Nitrogen Sulphur (CHNS) analyser and that of K and P was done with the Inductively Coupled Plasma- Atomic Emission Spectrometry (ICP-AES) system.

The quantitative difference in the various elements present in the experimental and control samples were recorded and analyzed statistically by applying 't' test for 0.01 level of significance. The differences in the quantities of the various elements were taken as an index for the assessment of feeding potential of the oribatid mites. 't' value was calculated following –

$$\text{Critical Ratio, } t = \frac{M_1 - M_2}{\sqrt{\frac{\sigma_1^{\,2}}{N_1} + \frac{\sigma_2^{\,2}}{N_2}}}$$

where,

M_1 = Mean of the experimental sample

M_2 = Mean of the control sample

σ_1 = Standard deviation of experimental sample

σ_2 = Standard deviation of control sample

N_1 & N_2 = Number of experimental and control samples

V. STUDIES ON POST EMBRYONIC DEVELOPMENT

1. Selection of Species

In the present work, studies on the developmental biology of a few selected species of oribatid mites which were proved to be important in

biodegradation of organic litter were carried out. After a careful scrutiny of the results obtained through gut content analysis and laboratory feeding experiments, members of 5 species viz. *C. ajaii* sp. nov., *R. philippinensis, T.(Rostrozetes) striata* sp. nov., *S. praeincisus interruptus* and *P. punctata* were selected for detailed developmental studies.

2. Rearing of Mites for Developmental Studies

Adult individuals (30-50 numbers) of each of the above 5 species were introduced into each culture vessel. The preferred food item, as evidenced through feeding studies mentioned earlier was then placed in the centre of each culture cell vessel. After introducing the mites and the respective food, the culture vessels were closed with lids bearing minute holes for exchange of gases. Culture vessels were properly labelled and left undisturbed. Extreme care was taken to maintain optimum hygienic condition by checking the culture twice daily. The daily cleaning operation consisted of replenishing food, addition of water, if necessary, preventing fungal attack, careful removal of accumulated wastes etc. The culture vessels were kept in an incubator to maintain a constant relative humidity of 70 percent and temperature of 30 ± 1^0C during the entire period of investigation.

3. Study of Life Stages of Oribatid Mites

Culture vessels were routinely examined to study the biology of each species. Thorough search was made on the culture base and among/ on the food material provided to detect the spermatophores, if any, or eggs laid. Ovipositional behaviour of females and the behaviour of males during spermatophore deposition were also studied carefully. When eggs were detected, they were transferred to separate culture vessels with maximum

care. A minimum of 10 eggs were introduced into each culture cell. Further development of the eggs was followed closely. A detailed study of the eggs and incubation, hatching, larval and nymphal stages, intervening quiescent and moulting phases etc. was carried out. Appropriate photographs of the various life stages were taken using Canon digital camera attached to an Axioskop 2 plus Zeiss Trinocular Research microscope. Permanent slide mounts of the various life stages of each species were prepared and examined under a Meopta Research microscope to study the morphological details of the life stages. Drawings were made using a camera lucida attached to a Meopta research microscope. Measurements were taken using an ocular micrometer. Details regarding the duration of development of F_1 generation as well as duration of individual stages were recorded and tabulated.

OBSERVATION

I. QUALITATIVE ANALYSIS OF FEEDING HABIT

A. Analysis of Gut Contents

Results of the gut content analysis of the 20 species of oribatid mites collected during the present study enabled to procure knowledge on their feeding habits under natural conditions. As represented in Table 5, all the species with the exception of *P. ciliata* sp. nov. disclosed the presence of varied food items like fungal hyphae/ spores and remnants of leafy/woody components of litter in various stages of digestion, pollen grains etc. along with some unidentified particles in highly advanced stage of digestion. Individual species exhibited qualitative/quantitative difference in gut contents, as some species showed predominance of fungal hyphae, while leafy or woody matter could be recovered in abundance from the gut of certain other species. Species like *S. praeincisus interruptus*, *T.* (*Rostrozetes) foveolatus, T.(Rostrozetes*) *striata sp. nov.* etc. revealed the presence of fungal and leafy components in almost equal proportions.

Species like *P. bisculpturatus*, *P. punctata*, *M. kizhisseriensis* sp. nov. etc. showed equal preference to fungal and woody ingredients, though they consumed leafy particles also. *P. ciliata* sp. nov. was the only species which showed a deviation in the nutritional habit .As shown in Table 5, the gut contents of this species disclosed a total absence of fungal hyphae/spores and the species was recognized as a sole dependent on higher plant materials like the leafy and woody components of litter and pollen grains. In all the species studied, a good proportion of the gut contents was found to comprise

materials in a highly advanced stage of digestion/fully digested condition and hence could not be identified properly (Plate 44, Figs. 3-4). The proportion of such unidentified material also varied considerably from species to species.

Presence of green coloured algal cells was detected in 6 species viz., *R. philippinensis, P. genitae* sp. nov., *S. praeincisus interruptus*, *T. laevis* and *A. pellucida*. The gut contents of *T.*(*Rostrozetes*) *striata, S. praeincisus interruptus, P. bisculpturatus, P. punctata*, *M. kizhisseriensis* sp. nov., *D. indicus*, *P. ciliata* sp. nov., *A. pellucida* and *G. (Indogalumna*) *intermedius* sp. nov. were found to comprise woody elements like tracheids and sclerites. The gut contents of *P. bisculpturatus*, *P. punctata*, *M. kizhisseriensis* sp. nov., *D. indicus* and *P. ciliata* sp. nov. were found to be predominated by woody materials. Though traces of woody elements were present in the gut of *S. praeincisus interruptus*, large quantities of leafy components and fungal conidia and hyphae could also be observed. Traces of moss cells were also detected in this species. The feeding habits of the two species of *Protoribates* appeared similar under natural conditions as evidenced by the detection of woody, leafy and fungal elements in their gut. The natural diet of *Indogalumna* and *Allogalumaa* included primarily fungi, but often their gut showed the presence of leafy and woody remnants, pollen grains etc. along with various unidentified components in advanced stage of decomposition.

Members of the genus *Trachyoribate*s viz., *T. (Rostrozetes) foveolatus* and *T. (Rostrozetes*) *striata* sp. nov. revealed a natural preference to both fungal matter and leafy litter particles. Woody components were also recovered from the gut of the former species, but proportionately fewer in quantity. Fungal matter appeared to be the most preferred food item for *B. brazilozetoides*, though traces of leafy particles also could be detected in its

gut. A similiar trend was noted in the case of *X. santhigiriensis* sp. nov. also. The gut of *B. cajamarcensis* revealed the occurrence of semidigested fungal hyphae, moderate quantities of unidentified particles and traces of leafy particles. Fungal matter in abundance, along with traces of algal remants could be detected in the case of *R. philippinensis*. Fungal spores and hyphae were the major constituents in the gut of *A. spotus* sp. nov. and *C. ajaii* sp. nov. Moderate occurrence of fungal spores and lower concentration of algal cells and leafy particles could be visualized in the gut of *I. philippinensis*.

B. Laboratory Food choice test

Results of the food choice test carried out under laboratory conditions by providing selected food items are displayed in Table 6. As shown in the table, the feeding response of the 10 species varied considerably as different levels of preference to test food items could be observed. Most of the species were proved as voracious feeders on one or a few of the food items provided in the laboratory and were even observed to deposit eggs and spermatophores (Pate 40, Fig.1) on one or more of the above food items. Intense feeding by immature stages was also observed in certain cases. With the exception of *P. cliata* sp. nov., all the 9 species displayed positive signs of fungal feeding. The preference of individual species to the specific fungal food varied considerably. Though most of the species exhibited a general preference to the fungal diet, substantial variation could be recorded with respect to individual species of fungus. *C. ajaii* sp. nov. was proved to be the most efficient fungal feeder, actively devouring all the 6 species of fungi offered in the laboratory. The second position was shared by 3 species, *B. brasilozetoides*, *S. praeincisus* i*nterruptus* and *R. philippinensis*, all of which showed higher preference to 4

species of fungi. Members of Otocepheidae like *M. kizhisseriensis* sp. nov. and *D. indicus* showed preference to 2 species of fungi.

High degree of specificity was found exhibited by the various oribatid species to the individual species of fungus. Though all the 6 species of fungi offered during the laboratory feeding test were found to be consumed by the members studied, the feeding intensity varied considerably. Accordingly, 2 species of fungi, *C. geniculata* and *A. alternata* were proved to be highly preferred by most of the species studied. The above 2 fungal species were found highly palatable to 9 out of the 10 species studied.

Voracious feeding on *T. harzianum* was exhibited by *C. ajaii* sp. nov., (Plate 38, Fig.1), *R. philippinensis*, *B. brasilozetoides* and *S. praeincisus interruptus* while *T. (Rostrozetes*) *foveolatus* showed a moderate feeding trend. A similar observation was made in the case of *T. viridae* also. *P. capscii* could be recognized as a highly preferred food to *C. ajaii* sp. nov. Most of the species consumed the PDA medium also, which adhered to the different fungal species. Such feeding activity most often led to the deposition of a large number of eggs and spermatophores by the species.

As represented in Table 6, leaf litter of 8 species of plants viz. *D. lanceolaria, A. hirsutus, A. occidentale, X. xylocarpa, M. elengi, E. officinalis, B. arundinacea* and *A. ilicifolius* also were consumed by all 10 species of oribatid mites studied. *D. lanceolaria* was found highly preferred by *P. punctata, M. kizhisseriensis* sp. nov., *D. indicus* and *P. ciliata* sp. nov. The litter of *A. hirsutus* was moderately consumed by 4 species viz. *P. punctata, S. praeincisus interruptus* and *G.* (*Indogalumna) intermedius* sp. nov. The litter of *A. occidentale* was intensely fed by *S. praeincisus*

interruptus, *P. punctata*, *P. ciliata* sp. nov. and *M. kizhisseriensis* sp. nov., *M. kizhisseriensis* sp. nov., and *P. ciliata* sp. nov. *G. (Indogalumna) intermedius* sp. nov., and *P. punctata* showed higher preference to litter of *X. xylocarpa* also. *S. praeincisus interruptus* and *P. punctata* also showed higher preference to *E. officinalis* litter.

The other components provided to these mites were decayed pneumatophore, cow dung, coconut pith and filter paper. Cow dung was found accepted by all the members studied and high feeding potential was shown by *P. punctata* and *S. praeincisus interruptus*. Coconut pith has a very high water holding capacity and is very stable because of the presence of high percentage of lignin (Plate 45, Figs. 1-3), which takes decades to decompose. The pith was found consumed by all the members and higher preference was shown by *R. philippinensis*, *P. punctata* and *T.* (*Rostrozetes*) *foveolatus*. Filter paper was also found consumed by all the members and it was highly preferred by *P.punctata*, *G.* (*Indogalumna) intermedius* sp. nov. and *D. indicus*.

The fungal feeding species were found producing definite feeding marks, through their excessive grazing activity on the fungal cushions (Plate 38, Fig.6). The high rate of feeding resulted in the deposition of large number of faecal pellets, which were usually laid on the culture substratum, cells, or even on or around the fungal matter provided. Fungal diet also supported the production of sufficient numbers of spermatophores, eggs and life stages under laboratory conditions (Plate 40, Figs.1&2). Generally the spermatophores were found deposited at the base of culture cells, walls and lids of culture cells close to the food, under the food item and even on the food item offered.

Feeding activity of the individuals of comparatively large sized species like *P. punctata*, *M. kizhisseriensis* sp. nov., *D. indicus*, *P. ciliata* sp. nov. etc. on the litter components led to the rapid skeletonization of leaf tissues (Plate 39, Fig.5). Owing to the progressive feeding activity of the juveniles and adults of the above species, leaf pieces developed small holes initially, followed by the formation of cavities and tunnels on the midrib of the leaf tissues in the litter. Such feeding tunnels often were found packed with faecal pellets, eggs and immature stages also. Continued feeding resulted in the transformation of the midrib into narrow strips and traces which also got vanished subsequently, leaving behind the faecal accumulations. Members of smaller species like *B. brasilozetoides*, *C. ajaii* sp. nov., *R. philippinensis*, *T. (Rostrozetes) foveolatus* etc. consumed the soft parts and then proceeded to the veinlets and veins and finally transformed the entire leaf pieces/ other food items into heaps of faecal pellets which were found accumulated at the base of the culture cells (Plate 39, Figs. 5-7).

C. Structural Analysis of Gnathal Appendages (Plate 42, Figs.1a-4b; Plate 43, Figs. 5a-10)

Analysis of gnathal appendages often served as an efficient tool in categorizing nutritional status of oribatid mites. As a general rule, structure of gnathal appendages could be regarded as a better reflection of feeding modes and accordingly, attempts were made here to study in detail the gnathal appendages of 10 species of oribatid mites representing the major feeding groups included in the present study. The gnathal appendages of all the oribatid species were found of the chelate-dentate type, consisting of rutella, chelicera and the pedipalp. Of these, the first two could be recognized

as the main masticator organs while the third served as a sensory organ, also helping in grasping.

In *S. praeincisus interruptus*, *P. punctata*, *T. (Rostrozetes) foveolatus* etc. the labiogenal articulation appeared diarthric with multidentate chelicerae and rutella. In all these species, rutellum was broad and sclerotized with 3 distinct notches (Plate 42, Fig.1a & 2a; Plate 43, Fig. 6a). Chelicerae were strong and well developed. Rutellum in *G.* (*Indogalumna*) *intermedius* sp. nov. appeared as thin, and some what narrow but with dense sclerotization. Chelicerae were long, thin, strong and well scleoritized. Both digits carried two well scelerotised teeth (Plate 43, Figs. 1b & 2b; Plate 41, Fig.66). *B. brazilozetoides* (Plate 44, Figs. 1&2), *R. philippinensis* and *C. ajaii* sp. nov., possessed more or less triangular rutella with more sharp notches distally. The labiogenal articulation was diarthric type in all the species. Chelicerae of these species were narrow, elongated and with 3-4 teeth (Plate 42, Figs. 4a & 4b; Plate 43, Figs. 5a & 5b).

In the otocepheid members, rutellum appeared broad, ending in 3 blunt notches (Plate 43, Fig. 7a). Chelicerae was strong, thick and broad. Digitus mobilis carried three and digitus fixus carried two teeth (Plate 43, Figs.7b& 8).

In *P. ciliata* sp. nov., the macrophytophagous member, the rutella appeared to be strong and flat, with blunt teeth. It was more or less rectangular with weak sclerotization. The chelicerae of *P. ciliata* sp. nov. also appeared broad with round base, but were comparatively short. The movable digit had four teeth while the fixed digit had three teeth (Plate 43, Fig.10).

II. QUANTITATIVE ANALYSIS

(1) Analysis of nutrients present in soil samples (Experimental and Control) of the Various Sites

A qualitative increase was obtained in the concentration of N.P.K. as a result of feeding by oribatid mites. The results of statistical analysis of the data obtained in chemical analysis of soil samples following 't' test are presented in (Table 7-9; Plate 46, Figs. 1-3).

In site 3, experimental sample had 3.41% of N, 139ppm of P, and 238ppm of K while the control sample showed 2.51% N and 114.8ppm and 182.8ppm of P and K respectively. The 't' value showed 260.38 for N, 79.213 and 148.38 for P & K respectively. In Site 13 experimental sample had 2.18% of N and 39.54ppm of P and 727.80ppm of K while control sample showed 1.28% of N and 25.48ppm and 156ppm of P&K respectively. Site 16, experimental sample showed 0.57% of N and 10.530ppm of P and 141.90ppm of K, the control sample showed 0.39% of N and 9.19ppm of P and 122ppm of K. In site 17, experimental sample had 2.04% of N, 11.4ppm of P and 210ppm of K, while control sample had 1.73 % of N and 10.2ppm of P, 188 ppm of K. In site 23, experimental sample had 2.8% of N and P=74.28ppm and K=248ppm, control sample showed 2.56% of N and P 45.12 and K 232ppm. In site 24, experimental sample had 3.19% of N and P and K were 147 and 783ppm respectively, control sample showed 3.01% of N and 108.1ppm of P and 613ppm for K. There exist significant difference between experimental sample and control sample, since the p-value is less than 0.01.

(2) Analysis of coconut pith

Results of micronutrient analysis using ICP-AES showed that experimental sample comprised of faecal pellets of *P. punctata* which fed on coir pith had 662.55ppm and 471.58ppm of K and P respectively against the respective elements to the tune of 195.8 ppm and 108.6ppm in the control samples (Table-11; Plate 47, Fig. 2). The p value is less than 0.01 which exerts a significant difference between the two samples. This showed that both K and P showed an increase in concentration owing the feeding activity of *P. punctata*. Similarly, the percent composition of N and C also showed an enhancing trend owing to oribatid feeding by using CHN analyzer. The concentration of N in experimental sample is 0.24% and C 16.15%, while the control sample of N is 0.10 and 5.25% of C (Table 12; Plate 47, Fig. 1). The p value is less than 0.01 which shows a significant difference between the experimental and control sample.

III. STUDIES ON POST EMBRYONIC DEVEOPMENT

1. Postembryonic Development of *Corynoppia ajaii* sp. nov. on *Trichoderma harzianum* (Table 12; Plate 48, Figs. 1-9)

Unlike various other related species, *C. ajaii* sp. nov. never deposited any spermatophores in the culture cells. This was confirmed through repeated observation carried out in the laboratory by maintaining the stock culture for 2-3 years.

Oviposition

Newly emerged adults initiated oviposition in culture cells within 8-10 days after their emergence. Oviposition was usually found confined to concealed microhabitats like the small holes on the culture base, under

surface of food substratum, the gap between the walls of culture cells etc. Oviposition in exposed condition was very rarely observed in this species. Prior to oviposition, the adult females were found actively wandering inside the culture cells with their ovipositor protruded in search of secure sites. On the availability of such preffered sites,the females remained stationary, inserting ovipositor to extrude the eggs. The whole process was completed within 10-20 minutes. Freshly laid eggs were oval in appearance, glittering white and solitary.

Incubation and Hatching

The incubation period lasted for 4-5 days. With the advancement of incubation, a prominent shining white patch developed along the posterolateral sides of the egg shell. Subsequently eggs turned milky white in colour and the white patch gradually developed into a postero-lateral slit. With the intermittent wriggling movements of the emerging larva inside, the slit got widened and the white transparent hexapod larva emerged out from the egg case, by making backward movement. The larva appeared highly lethargic soon after hatching and then showed sluggish movement. Gradually, the larva resumed normal movement and feeding activity after 5-10 minutes.

Duration of Life Stages

The active larva was found nibbling on the hyphae and spores of *T. harzianum* for 1-2 days. This was recognized as the active period of the larva, at the end of which it became sluggish, stopped feeding and assumed a swollen appearance. With in another 2-2½ hours, the larva became completely immobile. This inactive phase was recognized as the I quiescent phase. The preferred sites for quiescence were the areas adjacent to the food

pieces or those lying in between the walls of the culture cells. Larval quiescence extended for 1 day and which was terminated by the moulting process. Larval moulting was initiated by the development of a posterolateral slit on either side of the notogaster and each slit gradually extended posteriorly to meet medially. After 30 minutes, the prodorsum of the emerging nymph was found protruded through the slit, as a consequence of its wriggling movements. Progressive up and down movements of the moulting instar resulted in the lifting off of the dorsal half of the exuvium and ultimately the protonymph emerged out, leaving behind the exuvium. The whole process required 1-2 hrs for completion. The newly moulted nymph remained stationary for 10-15 minutes near the exuvium and initiated wandering in search of food. On reaching the fungal food, it started nibbling on the hyphae and spores of *T. harzianum*. The protonymph was slightly larger than the larva and could be easily distinguished from the latter by the possession of 4 pairs of legs. The active period of the protonymph lasted for 2-3 days and then it entered into the second quiescent phase of 2-3 days duration. Subsequent moulting of the protonymph led to the emergence of the deutonymph which was larger than the previous stage. The feeding period of the deutonymph lasted for 2-3 days, and after which it passed through a quiescent phase (III quiescent) of 1-2 days of duration. On subsequent moulting, the tritonymph got emerged, which was the largest of the juvenile stages. Tritonymph was also transparent and was observed to feed voraciously on the fungal diet for 2-3 days. It then entered in to the IVth quiescent phase, the duration of which lasted for 2-3 days. On the 2nd or 3rd days of this last quiescent phase, the colour of the nymph got changed to light pinkish-brown. Subsequent to this colour change, moulting of the tritonymph took place and the adult emerged. The newly emerged adult

appeared shining and pale golden brown in colour and it remained stationary for 2-3 hours near the exuvium. Later, the entire exuvium was found devoured by the adult and then it wandered inside the culture cell, in search of its preferred food. After 2 days of emergence, the colour of the body of the adult got changed into dark brown.

Under laboratory conditions of 30°C and 70% RH, *C. ajaii* sp.nov. completed its development from egg to adult within 17-21 days. The newly emerged females initiated oviposition within 8-10 days inside the culture cell. Thus the duration of F_1 generation was 25-31 days.

Morphological description of life stages of *Corynoppia ajaii* sp. nov. (Table 13-18; Plate 49, Figs. 1-8)

Egg

Measurements : Length: 127 -139 μm

Width : 57 - 62 μm

Egg small, oval, white and transparent with smooth texture.

Larva

Measurements : Length : 150 -158μm

Width : 74 – 82 μm

Dorsal Region

Prodorsum:

Prodorsum elongated, broader at the base and narrower towards the rostral apex; seta *ro* smooth, measuring, 10μm in length; setae *le* and *in* phylliform in shape; sensillus (*ss*) with an elongated, clavate head with minute barbs.

Notogaster

Dorososejugal suture wavy and interrupted at several points: notogaster elongated, a total of 12 pairs of phylliform setae, each seta with a circular microsclerite at its base; lyrifissures *ia, im* present dorsally.

Ventral Region

Infracapitulum smooth; 3 pairs of minute and smooth setae *h, m* and *a* present; epimeral setal formula 2-1-2, all setae very short and smooth; claparede organ clearly seen; genital plates absent; anal aperture bordered with wavy margins, anal area devoid of any setae; fissure *iad* present.

Protonymph

Measurements : Length : 186-192 μm

Width : 82 - 98 μm

Dorsal Region

Prodorsum:

Prodorsum broad at the base and broadly conical towards rostral apex. seta *ro* measuring 13 μm and setae *le* and *in* same as those of the previous stage; sensillus with clavate head bearing more prominent barbs; posterior lateral margins slightly concave.

Notogaster

Notogaster oval with a continuous dorsosejugal suture, 15 pairs of setae arranged on the notogaster, setae ps_1, ps_2 and ps_3 added anew, all phylliform; fissures *ia* and *im* laterally placed.

Ventral Region

Infracapitulum with 3 pairs of small and smooth setae *a*, *m* and *h*; epimeral region well developed with a setae formula of 3-1-2-1, all epimeral setae small and smooth; genital plates appeared with a pair of minute smooth setae and a pair of suckers; adanal plate appeared at this stage, but devoid of any setae.

Deutonymph

Measurements : Length: 209 – 229 μm

Width : 101 – 109 μm

Dorsal Region

Prodorsum:

Posterolateral margin same as the previous stage; seta *ro* simple, measuring 15 μm; all other prodorsal setae phylliform, *ss* with more prominent barbs present.

Notogaster

Notogaster elongated with a total of 15 pairs of setae, of which ps_2 and ps_3 seen ventrally, all setae phylliform in shape; lyrifissures *ia* and *im* present.

Ventral Region

Gnathosoma with 3 pairs of minute setae *h*, *m* and *a*; epimeral plates well developed, with setation 3-1-2-2; genital plates with 2 pairs of setae g_1 and g_2, the skin around the anogenital area exclusively folded; anal plates developed, but without any setae, 3 pairs of barbed adanal setae, ad_1, ad_2 and ad_3 located, exterior to the anal plates.

Tritonymph

Measurements : Length: 236 – 248 μm

Width : 126 – 135 μm

Dorsal Region

Prodorsum:

Prodorsum comparatively narrower, rostral apex slightly pointed with a pair of thin, simple seta (*ro*) measuring 16 μm; setae *le* and *in* same as the preceding stages. *ss* with clavate head bearing a thick barbs.

Notogaster:

Dorsosejugal suture wavy in appearance; notogaster with 15 pairs of phylliform setae; lyriffissures *ia* and *im* as in the previous stage.

Ventral region

Infracapitulum well developed with 3 pairs of short, smooth setae, *h*, *m* and *a*; epimeral region with setation 3-1-2-2; genital plates elongated, bearing 4 pairs of smooth setae and 3 pairs of suckers, a pair of aggenital setae present posterior to the genital plates; anal plates with 2 pairs of setae an_1 and an_2; adanal area possess 3 pairs of barbed setae.

2. Postembryonic development of *Ramusella philippinensis* on decayed pneumatophores (Table 19; Plate 50, Figs. 1-7)

R. philippinensis never deposited any spermatophores in the culture cells though repeated observation was made by maintaining the stock culture for 2-3 years.

a. Oviposition

Adult females oviposited on the food items provided or in the pits present on the surface of the base of culture cells. The eggs were solitary and never found in clusters but always placed adjacently, in a small area.

b. Incubation and Hatching

Incubation period ranged from 3-4 days. On the third day of incubation, a tiny, white patch appeared on the egg shell. This patch darkened and became prominent afterwards. Later, the egg got split along this patch, releasing the larva.

c. Duration of Life Stages

Soon after hatching, the larva remained immobile for a few minutes and afterwards initiated movements and showed the signs of feeding. The active feeding period of the larva could be recorded as 1.5 to 2 days. The physical activities of the larva were found restricted towards the end of this period and the larva gradually became inactive and swollen in appearance, sluggish in habit and stopped feeding activities. This swollen, immobile posture was marked as the I quiescent phase and which extended for a day, and it was terminated by the process of moulting. The initiation of moulting was marked by the appearance of a lateral slit, on either side of the notogaster, which gradually got widened. Subsequent up and down movements of the body of the moulting individual, resulted in the casting off of the exuvium. The entire process was found completed within 30-35 minutes. The newly moulted protonymph remained stationary for some time, near exuvium, and then moved away in search of food. The protonymph exhibited active signs of feeding on decayed pneumatophores for a period of

2-2.5 days and entered into the II quiescent phase of 1-1.5 days duration. On moulting, the deuto nymph emerged which actively fed for a period of 2-2.5 days, after which it became quiescent. The III quiescent phase extended for 1-1.5 days and then it moulted in to the tritonymph. The tritonymph actively fed on the decayed pneumatophores for 2-3 days, and then became quiescent (IV quiescent phase) for 1-2 days.On subsequent moulting, the adult individual emerged and it appeared pale yellow in colour. Its colour changed to deep yellow on the second day of emergence. Adults and the immature stages of this species were found wandering inside the culture cells. The newly emerged females, after 7-8 days started oviposition. All the eggs hatched were developed into females under laboratory conditions, thereby confirming the parthenogenetic mode of reproduction.

Thus the results of the study indicated that the development of *R. philippinensis* from egg to adult could be completed with in 14.5-19 days and the duration of F□ generation was 21.5-27 days.

Morphological description of life stages of *Ramusella philippinensis* (Table 20-25; Plate 51, Figs. 1-8)

Egg

Measurements : Length: 115-128µm

Width : 46 - 56µm

Egg small, oval, white and transparent.

Larva

Measurements : Length : 144-150 µm

Width : 64 – 68 µm

Dorsal Region

Prodorsum

Prodorsum broadly conical seta *ro* plumose basally with tapering tip; seta *le* thin, roughened and placed medially; seta *in* resembles *le* in nature and inserted between *bo*; seta *ex* simple; bothridial cup (*bo*) circular from which the *ss* originates, the latter barbed with a clavate head.

Notogaster

Notogaster more or less oval with a smooth wrinkled, integument; 10 pairs of barbed setae present on notogaster; porose microseterites present at the bases of setae, c_2, *la,* and *lp*; lateroabdominal gland situated below the level of *lm*; fissures *ia* and *im* clearly visible.

Ventral Region

Infracapitular region smooth; setae *h*, *m* and *a* very small; epimeral setae smooth, setal formula 2-1-2, genital area lacking; anal plates not developed; fissure *iad* well developed.

Protonymph

Measurements : Length: 154-162μm

Width : 70 – 82 μm

Dorsal Region

Prodorsum

Seta *ro, le* and *in* same as that of the previous stage with slight increase in length; seta *ex* thin and simple; *ss* with clavate head with thick barbs.

Notogaster

Notogaster with 12 pairs of setae, the lyrifissures *ia* and *im* seen clearly.

Ventral Region

Infracapitular setae show increase in length; number of epimeral setae increased in number with setation 3-1-2-1-; 1 pair of setae added on the genital plates, 1 pair of suckers also added; aggenital setae not developed; anal plates with no setae.

Deutonymph

Measurements : Length: 161 – 169μm

Width : 90 – 99μm

Dorsal Region

Prodorsum:

Seta *ro* slightly increased in length than the earlier stages; seta *in* and *le* also increased in length; seta *ex* simple and thin; *bo* circular, from which the *ss* originates, later with densely barbed, clavate head.

Notogaster:

Notogaster with 15 pairs of setae, Ps_1, Ps_2, Ps_3 appeared anew; lyrifissure *ia, im* present as in the previous stage.

Ventral Region

Infracapitular setae increased in length; addition of setae occurred on the epimeral area, resulting in a setation 3-1-2-2, all seta smooth; 1 pair of setae and 1 pair of sucker added on the genital plate; aggenital setae not developed; 1 pair of anal setae; 3 pairs of smooth adanal setae.

Tritonymph

Measurements : Length: 212 – 220 μm

Width : 105 – 132 μm

Dorsal Region

Prodorsum

Prodorsum elongated and broader at the base; seta *ro* as the previous stage, with slight increase in size, all other prodrosal setae same as the previous stage.

Notogaster

Notogaster enlarged considerably, setae with 15 pairs, shape of notogastral setae same as the earlier stages; lyrifissures *ia* and *im* clearly visible.

Ventral region

Epimeral setae same as the previous stage; number of genital setae increased to 4 pairs, an additional pairs of suckers also detected and 2 pairs of genital setae present on each genital plate; a pair of aggenital setae; anal plate with 1 more pair of seta; number of adanal setae same as the previous stage.

3. Postembryonic development of *Trachyoribates (Rostrozetes) striata* sp. nov. on *Curvularia geniculata* (Table 26; Plate 52, Figs. 1-8)

Results of food choice test helped to attribute panphytophagous habit to *T. (Rostrozetes) striata* sp.nov. However, the current observation on the postembryonic development of this species was made by rearing it on the

fungal species, *C. geniculata* under laboratory conditions, at a temperature of 30^0C and RH of 70%.

Oviposition

Eggs were first detected 15-20 days after the release of adult mites into the culture cells. This species was found to oviposit deep into the feeding holes and tunnels formed on the fungal cushions. Oviposition in exposed condition was a rare process in this species. Freshly deposited eggs were solitary, oval, white, shiny and translucent with a smooth texture.

Incubation and Hatching

The incubation period of *T. (Rostrozetes) striata* sp. nov. was comparatively longer, ranging from 10-16 days. As the incubation period advanced, the eggs became turgid and 5-6 hours before hatching, the eggs attained an amber colouration.

At the termination of incubation period, the egg became light brown in colour and hatching occurred through the formation of a longitudinal slit medially on the surface of the egg. With the frequent movements of the emerging larva, the slit widened and the hexapod larva escaped from the egg case. The larva remained inactive for 10-12 minutes and then it started moving and feeding.

Duration of Life Stages

The active period of the small, white larva appeared to vary from 3-5 days after which it entered in to the I quiescent period of 2-3 days duration. At several instances, the larvae were found preferring the underside of the fungal matter and the deep cavities dug out within the fungal cushion for attaining quiescence. The I quiescent stage was terminated by moulting. At

the time of moulting, a posterolateral slit became evident on the notogaster of the quiescent stage which gradually widened. With the subsequent movements of the legs and backward pulling of the body, the protonymph finally came out. After a feeding period of 3-4 days, the protonymph entered into the II quiescent stage, the duration of which varied from 4-5 days. The moulting of this stage resulted in the emergence of the deutonymph which was characterized by its large size. The deutonymph fed voraciously on *C. geniculata* for 4-6 days and then it underwent the III quiescent stage, leading to the emergence of the tritonymph which was the largest among the instars. Tritonymph was a very active feeder for 7-10 days and the culmination of this stage was marked by the IV quiescent period of 8-10 days. At the termination of this prolonged quiescent period, the emergence of the adult took place. The newly moulted adult was light brown in colour and it remained stationary, near the moulting skin for a few hours and then resumed its normal activity of feeding.

Thus, the postembryonic development of *T. (Rostrozetes) striata* sp. nov. completed with in 51-59 days (Table 12). Eggs were laid with in the culture cell when the newly emerged adult females attained 15-20 days of maturity. Thus the F_1 generation of the species was found requiring 66-71 days.

Morphological description of life stages of *Trachyoribates (Rostrozetes) striata* sp. nov. (Tables 27- 32; Plate 53, Figs.1-8)

Egg

Measurements : Length: 146 – 169 μm

Width : 79 – 92 μm

Dorsal Region

Prodorsum

Freshly deposited eggs appeared oval, white and transparent with a smooth texture, later became turgid and developed amber colouration at the time of hatching.

Larva

Measurements : Length: 230 – 248 μm

Width : 106 – 122 μm

Dorsal Region

Prodorsum

Prodorsum more or less triangular with a blunt rostrum; seta *ro* barbed, measuring 12 μm in length; lamellar ridge present and continued upto to the base of the lamellar seta, seta *le* barbed measuring 15μm in length and inserted in a slightly depressed area, lying just above the lamellar ridge; interlamellar ridge not continuous; seta *in* the thickest and shortest of prodorsal setae, measuring 10μm in length, roughened and with blunt tip; sensillus (*ss*) small, with a finely club shaped head; prodorsum finely punctate.

Notogaster

Dorsosejugal suture wavy and interrupted at several points; notogaster elongated, having wrinkled skin which became more distinct towards the posterior region, forming intricate reticulation; an incomplete dorsolateral ridge of wrinkled skin present laterally on each side; a total of 12 pairs of small, smooth setae present, of which h_1, h_2 and h_3 comparatively longer, the

latter inserted ventrally; each seta with a circular microsclerite at the base; lyrifissure *ia, im* and *ip* present dorsally and *ih* seen ventrally.

Ventral region

Mentum separated from the genae by an almost straight, labiogenal articulation; infracapitulum smooth; 3 pairs of minute and smooth setae *h, m* and *a* present; epimeral setal formula 2-1-2, all setae very short and smooth; genital plates absent; anal aperture bordered with wavy margins, latter devoid of any seta, area around the ps_1 segment highly wrinkled; triangular opening of lateroabdominal gland (*gla*) seen near the posterolateral margin, at the level of fissure *ih*.

Protonymph

Measurements : Length: 247 - 266 μm
Width : 147 – 157 μm

Dorsal Region

Prodorsum

Prodorsum wider at the base and converged into a conical rostrum; the lateral margins of the prodorsum with 2 small, blunt protruberances at the level of bothridium which became more pronounced than that of the larval stage; apart from the lamellar ridge, another lateral ridge like structure present which continued apically; seta *ro* measures 16μm and *le* 18μm both roughened; seta *in* 13μm, shortest among the prodorsal setae; bothridium (*bo*) almost circular; sensillus (*ss*) with a clavate, roughened head, seta *ex* present.

Notogaster

Notogaster oval with a discontinuous dorsosejugal suture, 15 pairs of setae arranged on the notogaster, setae ps_1, ps_2 and ps_3 added afresh, of which

ps_2 and ps_3 inserted ventrally, seta h_1 became stout and curved inwards, h_2 and h_3 became barbed, ps_1, ps_2 and ps_3 also long and barbed; fissures *ia* and *im* laterally placed; the dorsolateral ridge became more distinct in the form of skin foldings.

Ventral region

Labiogenal articulation diarthric type; gnathosoma well developed, bearing 3 pairs of small and smooth setae *a*, *m* and *h*; epimeral region well developed with a setal formula 3-1-2-1, all epimeral setae small and smooth; genital plates appeared with a pair of minute smooth setae and a pair of suckers; adanal plate appeared at this stage, but devoid of any setae, setae ps_2 and ps_3 inserted ventrally; the posterior region of the notogaster wrinkled and porose with a highly folded integument; fissures *ip* and *ih* present at the anterolateral margin of adanal plate.

Deutonymph

Measurements : Length: 273 – 298 μm

Width: 156 – 182 μm

Dorsal Region

Prodorsum

Prodorsum more or less conical; posterolateral margin of the prodorsum slightly bulged at the level of bothridia; all prodorsal setae serrated; setae *le* and *ro* measure 18 μm each; prodorsum possess two ridges, one medially and the other one posteriorly; the posterior ridge arose from the dorsosejugal suture and terminated at the base of lamellar seta (*le*), the prodorsum completely porose in nature.

Notogaster

Notogaster with a highly wrinkled integument, elongated with a total of 15 pairs of notogastral setae, of which ps_2 and ps_3 seen ventrally, all setae small and smooth except h_3 and ps_1-ps_3, setae h_1 and h_3 stout and strongly curved; lyrifissures *ia*, *im* and *ih* well discernible dorsally while *ip* and *iad* detected ventrally.

Ventral Side

Gnathosoma with 3 pairs of minute setae *h*, *m* and *a*; epimeral plates well developed, bearing 8 small, glabrous setae arranged in the order 3-1-2-2; genital plates with 2 pairs of setae g_1 and g_2, the skin around the anogenital area exclusively folded; anal plates developed without any setae, 3 pairs of sparsely barbed adanal setae ad_1, ad_2 and ad_3 located, exterior to the anal plates.

Tritonymph

Measurements : Length: 297 – 316 μm

Width : 176 - 196 μm

Prodorsum

Prodorsum comparatively smaller; the posterolateral margins gently curved; rostral apex blunt with a pair of thin long seta (*ro*) measuring - μm; lamellar ridge weakly developed, lamellar setae (*le*) slightly larger than *ro*; seta *in* shortest measuring 15μm and barbed; (*ss*) small; prodorsum completely porose.

Notogaster

Roughly circular in outline and broadest medially; 15 pairs of notogastral setae present, of which ps_2 and ps_3 seen ventrally, setae h_1 and h_2 smooth and curved, the remaining setae finely barbed unlike that of the deutonymphal stage; lyrifissures i*a, im, ih, ip* and *iad* present as in the previous stage.

Ventral side

Infracapitulum well developed with 3 pairs of short, smooth setae, *h, m* and *a*; epimeral region well demarcated, epimeral setal formula 3-1-3-2; genital plates oval, bearing 4 pairs of smooth setae and 3 pairs of suckers; a pair of aggenital setae (*ag*) present posterior to the genital plates; anoadanal plates with wavy margin, possessing 2 pairs of anal setae, an_1 and an_2 adanal area possesses 3 pairs of long, barbed setae; anal plates foveolated.

4. Postembryonic Development of *Scheloribates praeincisus interruptus* on *Trichoderma viridae* (Table 33; Plate 54; Figs. 1-7)

Unlike the earlier three species discussed above, *S. praeincisus interruptus* was recognized as a bisexual species, with the mode of reproduction being sexual in both field and laboratory conditions.

Spermatophore deposition

The males deposited stalked spermatophores in large numbers on and around the food items, culture base, walls of culture cells and so on. A single male laid 30-40 spermatophores and spermatophore deposition was initiated by the males 4-6 days after their emergence. The spermatophores laid in the culture cell looked like dew drops having a globular shining heads on thin erect stalks. The head of each spermatophore measured 26-30μm in length

and 23-25μm in width and the stalk had a length of 42-46μm. Prior to the deposition of spermatophores, the males remained stationary for some time in the culture cells. Then exhibited a few rhythmic up and down movements, raising their body and dropping behind the spermatophore on the culture substratum. Closer and continuous observation revealed the changes undergone by the spermatophores from the time of deposition.They retained an erect posture with glittering appearance for the first one or two days and afterwards seen loosing their glittering appearance and the upper portion of the stalk was slightly bent. Presence of females and regular supply of food and moisture condition enhanced the production of spermatophores. When the adults were transferred to new, clean culture cells with plenty of food and adequate moisture, spermatophore production also was found increased. Spermatophore deposition lasted for 15-20 days.

Intake of Spermatophores and Oviposition

The females of *S.praeincisus interruptus* while wandering inside the culture cells showed their genital flaps widely opened, so as to take up the globular head of the spermatophores through the genital opening, leaving behind the stalks intact. Such females initiated oviposition, 6-7 days after the intake of spermatophores.Females oviposited on and around the food items. Eggs were also found in the small pits on the culture base and on the walls of the culture cells. The eggs were small, glittering, creamy white and with a porose surface when viewed under higher magnification.

Incubation and Hatching

The incubation period lasted for 4-5 days. Prior to hatching, eggs became transparent .The hatching period varied from 1-1.5 hours. The

initiation of hatching was marked by the gradual development of weakened area, on the outer membrane which gradually turned into a longitudinal slit. The colour of the egg also changed from cream white to pale red. The slit gradually progressed in length laterally on either side, through which the wriggling movements of the larva could be seen. The thrushing movements of the larva inside the egg shell helped further widening of the slit and subsequent emergence of the larva.

Duration of Life Stages

The active period of the larva lasted for 3-4 days and at the end of which it became sluggish and swollen. Then it moved to a suitable place in the culture cell and remained motionless. This stage was recognized as the I quiescent phase which was terminated by the process of moulting. The quiescent phase lasted for 1-2 days. Moulting was a gradual process, taking 1-2 hours for completion. The initiation of moulting was marked by the appearance of a posterolateral slit on either side of the notogaster. The slits of the two sides extended to meet posteriorly in due course. Subsequently, the last pair of legs was found protruded through the slit which helped to provide a firm grip on the substratum. With the progressive up and down movements and a simultaneous pushing of the body, the moulting skin got separated leading to the emergence of the protonymph. The newly emerged protonymph remained stationary for some time and then resumed its normal activity. The protonymph was larger than the larva and easily distinguishable by the possession of four pairs of legs. The duration of feeding period of the protonymph varied from 3-4 days and then it entered into the II quiescent phase which lasted for 1 to 2 days. After the second moulting, the

deutonymph got emerged, which appeared more active and larger than the previous stage. The gut of laboratory reared deutonymphs as well as the field collected species often carried two to three food boli, indicating active feeding. The active period of the deutonymph ranged from 4-5 days and then it entered into the III quiescent phase which lasted for 1 to 2 days. Further moulting resulted in the release of the tritonymph. The tritonymph was the largest among the immature stages and its colour ranged from light yellow to pale brown. Tritonymph also exhibited voracious feeding in the laboratory and it nibbled on the preferred food item. The active period of the tritonymph varied from 5-6 days and then it entered into the IV quiescent phase for 2-3 days before the final moult into the adult. Thus, the development from egg to adult was found completed within 27-31 days. The newly moulted adults were light brown in colour and attained sclerotisation after 1 to 2 days of their emergence. The newly moulted males started depositing spermatophores within 4-5 days while newly moulted females initiated oviposition after 6-7 days after the intake of spermatophores. Thus under the laboratory conditions, the duration of the development of F□ generation of *S. praeincisus interruptus* ranged from 33 to 38 days.

Morphological description of life stages of *Scheloribates praeincisus interruptus* Berlese, 1916 (Table 34-39; Plate 55, Figs.1-8)

Egg

Measurements : Length: 147-171 μm

Width : 72-85 μm

Eggs small, oval, glittering and transparent, the surface of which porose under higher magnification.

Larva

Measurements: Length: 181 – 190 μm

Width : 124 – 129 μm

Dorsal Region

Prodorsum

Prodorsum elongated with a flattened rostrum, 2 lateral protruberances exterior to bothridia; prodorsal setae thin, bearing barbs; setae *ro* and *le* equal in length, measuring 28 μm each, while seta *in* shorter, reaching 26 μm in length; behind the insertion of seta *ro* a curved ridge present on either side; another curved ridge located below the bothridial cup (*bo*) on either side; bothridium small and sensillus with clavate head, bearing irregularly arranged barbs; prodorsal integument porose.

Notogaster

Notogaster with 11 pairs of setae; setae c_2, c_3, h_1 and h_2 possess barbs, c_3 and h_1 longer than others, measuring 21μm each, h_2 slightly shorter measuring 19 μm, the remaining setae small, thin, finely attenuate, more or less of the same length; porose microseterites present at the bases of setae c_2, *la* and *lp*; lateroabdominal gland situated below the level of seta *1m*; fissure *ia* and *im* clearly visible.

Ventral region

Infracapitular region smooth; labiogenal articulation diarthric type; setae *h, m* and *a* very small; epimeral setae smooth, setal formula 2-1-2; genital area lacking; anal plates not developed; fissure *iad* well developed.

Protonymph

Measurements : Length: 205 – 221 μm

Width : 140 – 149 μm

Dorsal Region

Prodorsum

Rostral tectum entire; prodorsal setae increased in length; setae *ro* and *le* of equal length, measuring 35μm each, the curved ridge below the insertion of seta *ro* disappeared and another ridge appeared below seta *le*; the head of the sensillus (*ss*) more pronounced with distinct barbs; integument of the prodorsum porose as in the previous stage.

Notogaster

Notogaster enlarged considerably with large number of wrinkles; the number of notogastral setae increased to 12 pairs, the newly added setal pair being h_3; c_3 longest, measuring 23μm in length and with short barbs; fissures *ia* and *im* present; porose microsclerites detected at the bases of setae c_2, *la*, *lp* and h_2; lateroabdominal gland enlarged.

Ventral region

Infracapitular setae increased in length; addition of setae occurred on the epimeral area, resulting in a setation of 3-1-2-1, all setae smooth, *1b* longer than the others; genital plates made their appearance with 1 pair of suckers and setae; aggential setae not developed, anal setae not detected; each adanal plate bears a single smooth seta; fissure *iad* retained its position as in the larval stage.

Deutonymph

Measurements : Length: 453 – 459 μm

Width : 253-267 μm

Dorsal Region

Prodorsum

Most of the prodorsal characters retained as in the protonymphal stage; prodorsal setae became more elongated; seta *ro* measures 40μm; setae *le* measuring 42 μs and *in* 47μm; the prodorsal ridge below seta *le* not detected in this stage; sensillus (*ss*) resembles that of the protonymph; the porose nature of the integument retained.

Notogaster:

Increase in size of the notogaster noted; dorososejugal suture more distinct than the previous stage; addition of 2 pairs of setae ps_1 and ps_2 occurred on the notogaster; the length of seta c_2 increased to 30 μm; porose microsclerites detected at the bases of setae c_2, *la*, *lp*, *dm* and h_2; lateroabdominal gland lightly sclerotized; the remaining characters of the notogaster resemble those of the previous stage.

Ventral region

Infracapitular setae show increase in length and developed barbs; *h* the longest, *a* the smallest, *m* intermediate; epimeral setal formula 3-1-3-1, *1b* and *3b* longer than the others; 1 pair of setae added on the genital plates, 1 pair of suckers also added; aggenital setae not developed; anal plates with a pair of small setae; on the adanal plates 3 pairs of setae detected, all of which arranged para-anally; fissure *iad* as in the protonymphal stage.

Tritonymph

Measurements : Length: 587- 601μm

Width : 392 – 398 μm

Dorsal Region

Prodorsum

Prodorsum broader than that of the deutonymph, seta *ro* shows only slight increase, reaching 43μm while *le* measures 53μm; seta *in* shows the maximum length, measuring 63μm; the curved ridge below *le* reappeared in the tritonymph; nature of sensillus (*ss*) similar to that of the preceding stage.

Notogaster

The length and width of the notogaster increased; the number of setae increased by the addition of 1 pair (ps_3) resulting in a total of 15 pairs; seta c_3 shows a marked increase in length reaching 43μm; setae c_2, *la*, *lp*, h_2 and h_3 possess porose microsclerites at their base, only c_2 and c_3 bear barbs, the others smooth; lateroabdominal gland sclerotized and brownish.

Ventral region

Epimeral setae increased in number, epimeral setation 3-1-3-2, seta *1b* and *3b* larger than the rest; number of genital setae increased to 3 pairs, an additional pair of suckers also detected on each genital plate; a pair of aggential setae (*ag*) appeared in the tritonymph, posterolateral to the genital plates; on each anal plate a new seta (an_2) added; all the 3 pairs of adanal setae retained in this stage also; fissures *iad* and *ih* detected as in early stage.

5. Postembryonic development of *Protoribates punctata* on coir pith (Table 40; Plate 56, Figs. 1-8)

Laboratory feeding experiments carried out on *P. punctata* revealed this species as a voracious feeder of coir pith on which it could successfully complete several generations. This species also was recognized as a bisexual species in both field and laboratory conditions.

Spermatophore deposition

Postembryonic development of *P. punctatus* also initiated with the deposition of spermatophores by males. Males laid innumerable number of spermatophores singly on and around the food items, 5-8 days after their emergence. The spermatophores of *P. punctatus* appeared as dew drops, stalked, bearing globular shining heads. The spermatophore head measured 46- 51 μm in length and 35-38 μm in width. Stalk of spermatophores measured 69-73μm. A single male laid 15-25 spermatophores per day. At the initial stage of the process, the males remained stationary for some time and exhibited a few rhythmic up and down movements and subsequently raised their body, leaving behind the spermatophores on the substratum. Spermatophore deposition lasted for 25-30 days.

Spermatophore Intake and Oviposition

The females wandered inside the culture cells with their genital flaps widely opened so as to take up the globular heads of the spermatophores through the genital opening.Several such deheaded spermatophore stalks could be observed in the culture cells/walls of culture cells. The females which actively took up spermatophores started oviposition after 8-9 days. Concealed places in culture chambers were the preferred sites for oviposition. Freshly laid eggs appeared oval in shape and translucent.

Incubation and Hatching

The incubation period lasted for 5-6 days. As the incubation period progressed, there appeared an area of weakness at the anterior pole, which developed into a slit and got extended in either directions laterally to the posterior pole. Prior to this observation, the egg got changed to reddish to pale brown in colour. The egg case lastly cleaved in to two halves, leading to the emergence of a hexapod larva. The larva appeared highly lethargic soon after hatching and initially it showed sluggish movement and resumed normal activities and feeding after 10-20 minutes.

Duration of Life Stages

The active feeding period of the larva lasted for 2-3 days. At the end of its active feeding period, gradually it became swollen in appearance, sluggish in habit and stopped feeding. This inactive phase was recognized as the I quiescent phase. The duration of the quiescent phase was the same as that of the active period. The end of quiescence was marked by the moulting process which lasted for 2 hours. Moulting of the larva was found completed following the same pattern and it was found initiated by the development of a posterolateral slit on either side of the notogaster and each slit gradually extended to meet medially. After about 45 minutes, the prodorsum of the emerging nymph was found protruded through the slit, as a consequence of its wriggling movements. Progressive up and down movements of moulting instar resulted in the lifting off of the dorsal half of the exuvium and the release of protonymph, leaving behind the exuvium. The protonymph emerged was slightly larger than the larva and was an octapod. Newly moulted nymph remained stationary for 15-25 minutes near the exuvium and initiated wandering in search of food. On reaching the food item i.e., the

coconut pith, the protonymph started feeding. The active period of the protonymph lasted for 3-4 days and then it entered in to second quiescent phase of 2.25-3.00 days duration. Subsequent moulting of protonymph led to the emergence of the deutonymph which was larger than the previous stage. The feeding period of the deutonymph lasted for 3 to 5 days, and after which it passed through a quiescent phase of 3-4 days duration. On subsequent moulting of the III quiescent phase, the tritonymph emerged, which was the largest among the juveniles. Tritonymph was creamy yellow in colour with brown legs and was observed to feed voraciously on the pith for 4-6 days. On the 3rd or 4th day of its quiescent phase, the colour of the nymph got changed to light brown. Subsequent to this colour change, moulting of the tritonymph took place and the adult emerged. The newly emerged adult was less sclerotized. Within 2-3 days of emergence, the colour of the body of the adult got changed into dark brown.

Under laboratory conditions at 30°C and 70% RH, *P. punctatus* completed its development from egg to adult within 29.5 -34 days. The newly emerged males started deposition of spermatophores within 4-6 days and the newly emerged females initiated oviposition after 8-9 days of active feeding on pith. Thus, the F_1 generation was completed within 37.5-43 days.

Morphological description of life stages of *Protoribates punctata* Grobler (Table 41-46; Plate 57, Figs. 1-8)

Egg

Measurements : Length: 180 -197 μm

Width : 89 – 96 μm

Egg small, oval, the surface of which appears porose under higher magnification.

Larva

Measurements : Length : 281 –290 μm

Width : 174 – 189 μm

Dorsal Region

Prodorsum

Prodorsum elongated with a rounded rostrum, setae thin bearing barbs; seta *ro* measuring 32 μm, *le* measuring 34μm while seta *in* shorter measuring 29 μm in length; bothridium small and sensillus with fusiform head; prodorsal integument porose.

Notogaster

Notogaster with 11 pairs of setae; setae c_1, c_3, h_1 and h_2. c_1 measuring 29 μm and h_1 measuring 22μm, h_2 measuring 18μm, all other setae more less of the same length; porose microseterites present at the base of setae c_2, *la* and *lp*; lateroabdominal gland situated below the level of seta *lm*; fissures *ia* and *im* clearly visible.

Venteral region

Infracapitular region smooth, labiogenal articultion diarthric type; setae *h, m* and *a* very small; epimeral setae smooth, setal formula 2-1-2 genital area lacking; anal plates not developed; fissure *iad* well developed.

Protonymph

Measurements : Length: 305 – 321 μm

Width : 240 – 249 μm

Dorsal Region

Prodorsum

Prodorsal setae increased in length; seta *ro* measuring 36 μm, seta *le* 38, seta *in* measuring 32 μm; head of the sensillus (*ss*) more fusiform; integument of the prodorsum as in the previous stage.

Notogaster

Notogaster enlarged with large number of wrinkles; the notogastral setae increased to 12 pairs, the newly added setal pair being h_3; c_3 measuring 26 μm in length; fissures *ia* and *im* present; porose microsclerites detected at the bases of setae c_2, *la*, *lp* and h_2; lateroabdominal gland enlarged.

Ventral region

Infracapitular setae increased in length; addition of setae occurred on the epimeral area, resulting in a setation 3-1-2-1, all setae smooth; genital plates made their appearance with 1 pair of suckers and setae; aggenital setae not developed, anal setae not present; adanal plate bears a single smooth setae; fissure *iad* retained its position as in the larval stage.

Deutonymph

Measurements : Length: 553 – 559 μm

Width : 354 – 385 μm

Dorsal Region

Prodorsum

Prodorsal setae became more elongated; seta *ro* measures 42μm, seta *le* 43μm, seta *in* measuring 48μm; sensillus (*ss*) resembles that of the protonymph; the porose nature of the integument retained.

Notogaster

Increase in size of the notogaster observed; dorsosejugal suture straight, more distinct from the previous stage; addition of 2 pairs of setae ps_1 and ps_2 occurred on the notogaster, the length of seta c_2 increased microsclerites at the bases of setae c_2, *la*, *lp*, *dm* and *h*;

Ventral region

Infracapitular setae show increase in length *h*, the longest, *a* the smallest, *m* intermediate; number of epimeral setae increased with setation 3-1-2-2; 1 pair of setae added to on the genital plates, 1 pair of suckers also added; aggenital setae not developed; anal plates with a pair of small setae; on the adanal plates with 3 pairs of setae detected; fissure *iad* as in the protonymphal stage.

Tritonymph

Measurements : Length: 687 –702 μm

Width : 492 – 498 μm

Dorsal Region

Prodorsum

Prodorsum broader than that of the deutonymph, seta *ro* measuring 46 μm while be measuring 58μm; seta *in* shows the maximum length, measuring 68μm; nature of sensillus (*ss*) similar to that of the preceding stage.

Notogaster

The length and width of the notogaster increased, the number of setae increased by the addition of 1 pair (ps_3) resulting in a total of 15 pairs; seta

c_2, *la*, *lp*, h_2 and h_3 possesses porose microsclerites at their base, latero abdominal gland sclerotized and brownish.

Ventral region

Epimeral setae increased in number, addition of setae observed on the third epimere resulting in a setation 3-1-3-2; number of genital setae increased to 3 pairs, an additional pair of suckers also detected on each genital plate; a pair of aggenital setae appeared; on each anal plate a new seta (an_2) added; all the 3 pairs of adanal setae retained in this stage also; fissures *iad* and *ih* detected in early stage.

DISCUSSION

Brachypyline oribatid mites exert diverse feeding trends which enable them to play significant role in bioprocessing of organic litter through their mechanical break down, microbial inoculation and also stimulation of micro flora.

A qualitative and quantitative assessment of the brachpyline oribatid mites present in 25 vegetationally contrasting sites distributed in 6 districts of Kerala, viz., Wayanad, Kozhikode, Malappuram, Thrissur, Idukki and Thiruvananthapuram was carried out during the study period. The study was based on random sampling of oribatid mites from localities with varied floral characteristics based on which these could be categorized as forest ecosystems, river banks, coir retting areas, waterlogged area, mangrove ecosystems, agricultural lands, secondary shrub tingles, biowaste accumulated regions, and isolated litter accumulated areas. Results of sampling disclosed a great deal of structural variation in the oribatid species diversity and density in all the localities surveyed. The variation observed in the oribatid diversity and density could be attributed to the topography of the soil, floral composition and presence of organic litter. A good number of brachypyline oribatid mites could be collected, of which only 57 species belonging to 36 genera, 20 families and 14 superfamilies were considered in the present study.

The collection sites selected for the current study exhibited profound variation with respect to their variation in vegetational and geographical peculiarities. This was quite evident in the case of Wayanad District where the soil samples collected from the 3 sites viz., Kalpetta, Sultan Battery and

Muthanga Reserve Forest revealed the presence of 40 species of brachypyline oribatid mites.

Muthanga Reserve Forest with 9 varied vegetational and geographic peculiarities enabled to procure 40 species of brachypyline oribatid mites. Muthanga Reserve Forest with 9 different type of vegetation, disclosed the maximum number of species, supporting 38 species belonging to 22 genera, 15 families and 12 superfamilies. The predominance of oribatid mites in forest floors and other areas of litter accumulation had been pointed out by earlier investigators (Hartenstein, 1962a; Hayes, 1963; Wallwork, 1976; Ramani and Haq, 1991; Hansen, *et al*., 1998; Kaneko and Salamanca, 1999, Jain *et al*., 1999; Haq, 2001, 2002; Julie and Ramani, 2008). Absence of oribatid mites in site 10, a water logged area without litter accumulation observed during the present study contradicts the results of some earlier observations (Krantz and Baker, 1982; Walter and Proctor, 1999) on freshwater habitation in families Trhypochthoniidae, Ameronothridae, Malaconothridae etc. Amphibious habit has also been assigned to several taxa (Wallwork, 1981; David and Peter, 2004) of oribatids.

The species diversity of oribatid mites in the Kozhikode District with 5 sites selected was highly contrasting, comprised of the mangrove vegetation, river bank and retting grounds. A total of 12 species belonging to 10 genera, 7 families and 4 superfamilies could be collected from the various sites selected in this district. The decrease in faunal diversity observed during the present study could be a reflection of the polluted nature of the soil through accumulation of waste materials and also heavy metals. Such a drastic decline in oribatid density was reported already as a result of organic pollution and heavy metal accumulation (Zaistev, *et al*., 2001). A general

decrease in the floral and faunal composition was noted in the site which could be correlated with the prevalence of low pH and oxygen, high BOD, chlorine and alkaline condition, generally met with in the retting sites (Remani, *et al*., 1989). The species diversity was found comparatively very low in mangrove soils (Julie and Ramani, 2007). Mangrove fauna are generally exposed to various ecological problems like conditions of anoxia, high salinity and frequent tidal inundation. Probably, such challenging ecological conditions must have exerted an adverse impact on the faunal diversity of these mites, which are generally very sensitive indicators of altered ecological conditions in their immediate microhabitat. In this condition, only those forms which could withstand the alterations in pH conditions alone would be able to establish successfully (Karasaw and Hijii, 2004; Julie *et al.*, 2009). Wallwork (1976) could not notice any direct relationship between the number of species present in a site and the number of individuals per species. During the present study, although the species diversity was found decreased, numberical abundance of various species appeared very striking (Julie and Ramani, 2009). Such abundance would be a reflection of the better survival ability of the species.

Oribatid species which survive in mangrove soils are generally equipped with various adaptive modifications in their morphological feaures, like monodactly, long clear, decrease in the length of sensillus, etc. (Karasaw and Higii, 2004).

Results of the present study also revealed a general dominance of monodactylous species with longer claw, which might be considered as an adaptation to overcome highly challenging situations like the regular tidal flooding. Monodactylous condition with stronger and longer claws would

impart a firm grip to the substratum like the decomposing leafy and woody remnants of the soil ecosystem.

The soil samples collected from the 4 sites in the Malappuram District revealed the presence of a total of 28 species. Of these, one site (site 17) with mixed vegetation supported a total of 24 species, representing 19 genera, 14 families and 9 superfamilies. The availability of preferred food in the form of rich and varied litter types would have offered favourable conditions for the population build-up and abundance of oribatid species in this site. In general, accumulation of litter leads to an increase in the organic content of soil. As a rule, the percentage of organic matter is considered as an index to assess the population density of soil organisms (Haq, 1994, 2006). This was evidenced in the present study also which helped to recover abundant bachypyline populations from these sites. Many investigators have established a positive correlation between the organic matter of the soil and oribatid population density (Madge, 1965; Loots and Ryke, 1966; Fujikawa, 1970; Haq, 1994,2006; Migliovini and Bernini, 1999; Gonzalez and Seastedt, 2000). Site 18, which was a homeyard with *E. officinalis* and *T. indica* as the major vegetation, disclosed 13 species belonging to 10 genera, 9 families and 6 superfamilies. The litter accumulation at the site was prevented by constant-human intervention like the practice of regular cleaning and burning of leaves. As a result, the site experienced very low litter accumulation. A combination of all these would have led to the destruction of a major share of soil inhabitants including oribatid mites. The recovery of low yield of oribatid population can be attributed to the above factors. This substantiate decline in oribatid population noted during the present study in the above site and this is in confirmation with that of Badejo *et al*., (1999) who reported that density of oribatid mites in a fallow that was burnt annually decreased

over the year. Sites 19 and 20 disclosed the minimum number of 2 species belonging to 2 genera, 2 families and 2 superfamilies. Site 19 which was a water logged area bordered by *B. arundinacea* and site 20, a semi water-logged area of paddy field bordered by *P. odoratissimus*. These two sites were characterized by low litter and hence with a decreased organic content of the soil. This substantiates the already established fact that oribatid populations thrive only in litter accumulated areas. This was especially true in the case of paddy field, which remained water logged during the period of cultivation and then in a dried condition with litter after harvest Tian *et al.* (2000) had observed that abundance and diversity of oribatids in paddy fields were lower than that of typical forest ecosystem. Wallwork (1976) reported that repeated mechanical disturbance of the substratum could cause unstable microclimatic conditions in the profile and also abrasive effects which could produce high mortality among soil animals. This was found true in the present work also in which the minimum representation of oribatid mites could be noted. The detrimental effect of mechanical disturbances on soil animals had been reported by earlier investigators (Sheals, 1956; Edwards and Lofty, 1969; Aleinikova and Utrobina, 1975; Ghilyarov, 1975; Shaddy and Butcher, 1977; Lebrun, 1978; Hulsmann and Wolters, 1998). Ito and Aoki (1999) and Badejo *et al*. (1999) suggested that oribatid population was strongly suppressed by human intervention in the form of activities like cultivation.

The single sites each at Thrissur (site 21) and Idukki (site 22) districts revealed the presence of 12 and 14 species of oribatid mites respectively. These sites were characterized by having single plant species each and hence represented as areas of mono-culture practice. Wallwork (1976) reported that crop type may influence the distribution of those members of the soil fauna

which are specially associated with particular food plants. Monoculture will eliminate those animal species which are associated with particular food plants. It is clear from the observations made in the present study that only those oribatid mites which could utilize the respective plant litter alone survived in these habitals. The soil surface had a low and medium accumulation of the corresponding plant litter in the 2 sites. In the Thiruvananthapuram District, the 3 sites contributed a total of 30 brachypyline species. Sites 23 and 24 supported 27 species each while site 25 revealed the presence of 15 species. This indicates that the distribution and abundance of oribatid mites are largely influenced by soil texture especially the organic content and vegetation. Soils rich in organic carbon content are known to support high diversity of these mites (Curvy, 1978; Hagvar, 1984; Battigelli *et al.*, 1994; Behan, Pelletier, 1999).

In the current work, the superfamily Oripodoidea exhibited the maximum family diversity, accommodating members of 4 families viz., Caloppiidae, Haplozetidae, Scheloribatidae and Protoribatidae. Three superfamilies viz., Amerobelboidea, Tectocepheoidea and Otocepheiodea comprised members of 2 families each while the remaining 10 superfamilies supported members of a single family. The families Haplozetidae and Oppiidae showed the maximum generic diversity, supporting 6 genera each. The members of the family oppiidae appeared of small size but were very active. Such active forms undertake long migratory movements both in the vertical and horizontal directions in the soil layers (Wallwork and Rodriguez, 1961; Wallwork, 1976; Winchester *et al*., 1991). While performing such migratory movements, these species carry the spores/hyphae of various fungi, bacteria and other microbes on their body setae, mouthparts etc. and

inoculate the litter accumulated in the different layers with these microbial spores. Thus they help in the initiation of the degradation in soil ecosystem. The families Scheloribatidae and Galumnidae were represented by members of 3 genera each while Basilobelbidae and Carabodidae included members of 2 genera each. *Scheloribates* was recognized as the most diverse genus, represented by members of 7 species. The second position was achieved by *Galumna* which included members of 5 species. The families Scheloribatidae and Galumnidae are regarded as the most diverse families (Hunt, 1994; Badeso and Ola-Adams, 2000). Members of *Scheloribates* and *Galumna* which are specifically adapted to thrive in extreme conditions and enjoy a wide variety of food resources owing to their active nature and ability to perform vertical and horizontal migratory movements in the soil ecosystem (Wallwork, 1976).

The results of the survey enabled to recognize *T. (Rostrozetes) foveolatus* as a widely distributed species, as it was recovered from 14 out of the 25 sites surveyed. The panphytophagous nature of this species enables it to switch from one type of food to any other type, depending on its availability. The feeding range of the species appears wide, including fungi, higher plant materials and even substances of animal origin. The species is known to feed dry skin in corpses/carcasses. Hence, the species has the ability to adjust with different habitats in extreme environmental conditions. This explains the occurrence of the species in 14 out of 25 sites surveyed.

S. praeincisus interruptus occupied the second position, which could be collected from 11 sites. *Scheloribates*, in general comprises very active forms with a wide range of tolerance to various environmental factors. Their humidity requirements are minimum (Seniczak, 1980a) and are capable of

surviving in a wide variety of habitats (Hartenstein, 1962a; Krivolutsky, 1979; Haq and Ramani, 1987; Sheela and Haq, 1988; Badejo *et al.*, 1999; Park-Hong *et al*., 2000; Schuster *et al*., 2000). The third species in this regard was *B. brazilozetoides* which was found distributed in 10 sites. Tiny nature of their body would permit them to excavate through the smallest pores available in the soil profile for browsing food. *T. laevis, P. seminudus, P. punctata, S. praeincisus rotundiclava, P. asejugalis* and *O. kuehnelti* showed their presence in 9 sites. The active nature of all the above species would permit quick migration to newer habitats on exhaustion of food in the particular niche. Such quick migratory habits would assist them in finding new and preferred food in one or the other habitat leading to their wide distribution pattern in the soil ecosystem.

Quite often, species show much limited distribution trend, as reported earlier (Wallwork, 1967) when faunal comparison between communities revealed variation in species composition. This was quite evident in the present study also in which certain species like *M. kizhisseriensis* sp. nov., *P. ciliata* sp. nov., *A. pellucida* and *G.* (*Indogalumna*) *intermedius* sp. nov. were found unique to their respective sites. Certain species like *T. laevis* was recognized as hydrophilic during the present study, as it was recovered from semi-aquatic/water logged habitat. *Tegeocranellus* was already designated as a semi-aquatic genus (Behan, 1997) along with various other genera under the family Ameronothridae.

Several aquatic species have been reported under the genus *Ameronothrus*, which show a predatory habit on rotifiers (David and Peter, 2004). In the present study, no attempt was made to trace the feeding habit of *T. laevis* in its natural aquatic habitat. Further studies are warranted along this

line. Oribatid mites exhibit a wide variety of nutritional habits (Schuster, 1956; Hartensten, 1962a; Woodring, 1963; Shereef, 1971; Luxton, 1972; Haq and Prabhoo, 1976; Haq, 1982, 1994, 1996a, Muraun *et al*., 1998a). This imposes selection in pattern of their distribution, each species being better adapted to specific habitat which will offer their preferred food in plenty. Results of gut content analysis of the 20 species of oribatid mites collected during the present study revealed that all the species with the exception of *P. ciliata* sp. nov. could thrive in their natural habitat on varied food items like fungal hyphae/spores and remnants of leafy/woody components of litter, pollen grains etc. Some unidentified particles in highly advanced stage of digestion also could be observed in the gut of most of the species. The diverse feeding trends and wide distribution pattern of these mites helped to consider them as a panphytophagous group (Luxton, 1972; Haq, 1982, 1984, 1987, 1992, 1994, 1996). Panphytophagy represents a feeding category which is determined by the possession of a combination of several characters of morphological and physiological significance. Possession of this type of diverse feeding trends helps them to explore more habitats to enjoy wider distribution as noted earlier (Luxton, 1972; Behan and Hill, 1978; Haq, 1991a and 2001). In *P. ciliata* sp. nov., the single macrophytophagous member noted during the study was found feeding on higher plant materials alone. The rutella of the species appeared to be strong and flat, with blunt teeth. The chelicerae of the species also appeared broad with round base, but were comparatively short. The movable digit had 4 teeth while the fixed digit had 3 teeth. The above morphological adaptation of mouthparts of the species helps it to lead a macrophytophagous habit in its natural environment. Results of the food choice test provided better evidence to reveal the variations in the feeding process of the different species in relation to the

difference in fungal diet. Accordingly, 2 species of fungi, *C. geniculata* and *A. alternata* were proved to be highly preferred by most of the species studied. The above 2 fungal species were found highly palatable to 9 out of the 10 species studied.

Preferential feeding on dark pigmented fungi among oribatid mites was already reported (Schneider and Maraun, 2005). High feeding preference to *T. harzianum* was exhibited by species like *C. ajaii* sp.nov., *R. philippinensis*, *B. brasilozetoides* and *S. praeincisus interruptus* while *T.* (*Rostrozetes*) *foveolatus* showed a moderate feeding trend. A similar observation was made in the case of *T. viridae* also. Hartenstein (1962a) and Pherson and Beattie (1979) recorded that the microphytophagous community could generally accept *Cladosporium* and *Trichoderma* species of fungi. Luxton (1972) reported that 20% of the mites could consume this food. Most of the species studied currently consumed the PDA medium also on which fungal cultures were made and which got adhered to the different fungal species. Such feeding activity mostly led to the deposition of a large number of eggs and spermatophores. This was particularly advantageous to species which could thrive equally well on various fungi and such a diet would be ideal for mass rearing of the species under laboratory conditions.

Litter of *D. lanceolaria* was found highly preferred by species like *P. punctata*, *M. kizhisseriensis* sp. nov., *D. indicus* and *P. ciliata* sp. nov. The leaf litter of *A. hirsutus* was found moderately consumed by 4 species viz., *P. punctata, S. praencisus interruptus* and *G.* (*Indogalumna*) *intermedius* sp. nov. The litter of another plant, *A. occidentale* was also found., fed by members like *S. praeincisus interruptus, P. punctata, P. ciliata* sp. nov. and *M. kizhisseriensis* sp. nov. This undoubtedly proved the significant role of brachypyline species in the degradation of leaf litter present in the soil.

Cow dung was found accepted by all the members studied and high feeding potential was shown by species like *P. punctata* and *S. praeinscisus interruptus*. Otake and Kumasaka (1993) discussed the significance of similar feeding trends in the decomposition of dung and found *Scheloribates* spp., *Trichogalumna* spp., *Galumna* spp., *T. velatus*, and *O. nova* as the dominant species out of the 30 species studied. The above observation helped to establish coprophagy among oribatid mites. Coconut pith was found consumed by all the members and higher preference was shown by *R. philippinensis*, *P. punctata* and *T. (Rostrozetes) foveolatus* (Julie and Ramani, 2007). Continued feeding activity of the immatures and adults of these species by confining themselves within the interior of the pith resulted in the formation of small cavities, burrows and holes filled with faecal pellets, eggs and immatures as reported earlier in *Heptacarus hirsutus* (Haq and Konikkara, 1988) on drift wood elements. Filter paper was also found consumed by all the members and it was highly preferred by *P. punctata, G. (Indogalumna) intermedius* sp. nov., and *D. indicus*. This is clear indication of cellulose in their gut (Luxton, 1982; Haq and Konikkara, 1988) synthesis of which is known to be a function of symbiotic microbes residing in the gut of these oribatid mites (Seniczak, 1982; Haq, 2006).

Thus, the results of feeding studies enabled to establish diverse feeding habits in most of the species. Feeding activity of comparatively large sized species like *P. punctata, M. kizhisseriensis* sp. nov., *D. indicus, P. ciliata* sp. nov. etc. on the litter components led to rapid skeletonization of leaf tissues of the litter. Owing to the progressive feeding activity of the juveniles and adults of the above species, leaf pieces initially developed small holes, which were followed by the formation of cavities. On exhaustion

of tissues of lamina, the fed leaves appeared as skeletonized, leaving behind small veinlets, veins and midrib. Later, the species were found boring and tunneling the midrib and veins also. Such feeding tunnels often were found packed with faecal pellets, eggs and immature stages also. Continued feeding resulted in the transformation of the midrib into narrow strips and traces, which also got vanished subsequently, leaving behind the faecal accumulation. Similar feeding trends were reported in other oribatid members like Liacaridae and Phthiracaridae also by Riha (1951); Murphy (1953), Schuster (1956), Haq (1984, 1987, 2006, 2007), Haq and Konikkara (1988) and Ramani and Haq, (2001). Members of smaller species consumed the soft parts and then proceeded to the veinlets and veins and thus finally transformed the leaf pieces/other food items to faecal pellets. This clearly disclosed the high potential of these species in the degradation of litter leading to the release of energy into the soil ecosystem. Quite often, the immature stages of adults these species voraciously consumed the faeces of mites also. Wallwork (1967) attributed coprophagy as the common habit among the immatures of wood tunneling species and designated it as highly advantageous as it affords a ready food source for the young ones in a highly restricted environment.

The digestive process taking place in the gut of any organism leads to the breakdown of complex food into simple absorbable units. This happens in the digestive tract of oribatid mites also. Normally, the highly lignified, cellulose containing plant and other organic litter consumed by these mites get degraded by the action of cellulase in their gut (Haq and Konikkara, 1988; Haq, 1996; Ramani and Haq, 2001). After absorption and assimilation, the undigested remants are released in to the soil ecosystem as faecal pellets.

These faecal pellets substantially would help to increase the nutrient pool of the soil ecosystem. This could be established repeatedly in the case of oribatid mites studied currently. This warrants the extreme necessity of introducing oribatid mites in agriculture for better crop improvement, degradation of highly recalcitrant solid waste, like the coconut pith etc. Increase in chemical composition of litter components after consumption by oribatid mites can be taken as an index of oribatid potential in bio-processing of organic residues (Haq, 1996; Haq 2007). Chemical analysis conducted during the present study showed a general increase in the concentration of 3 elements tested viz., Nitrogen, Phosphorous and Potassium in the soil samples in which selected species of oribatids were introduced and allowed to feed on the selected types of litter for a specific period. This established the potential of oribatid mites in the enhancement of soil fertility through breakdown of litter components in their gut and subsequent release of nutrients in the form of faecal pellets in to the environment. Earlier information regarding this crucial role played by oribatid mites is rather scanty. Yet a few earlier workers (Schuster, 1956; Wallwork, 1958; Hartenstein, 1962a; Hayes, 1963; Berthet, 1964; Luxton, 1966; Kowal and Crossley, 1971; Hammer, 1972) had stressed the bioprocessing ability of oribatid mites. Relevance of these mites in the recycling of a few essential nutrients like calcium and potassium has been brought to light through some isolated studies (Cornaby *et al*., 1975; Gist and Crossley, 1975; Werner and Dindal, 1987). Norton (1984) reported that the feeding activity of oribatid mites leads to an increase in nitrogen content of organic litter. In the present study, the potential of oribatid mites in the degradation of solid wastes like coconut pith was evaluated through quantitative estimation of micronutrients present in the pith before and after feeding by selected species like

P. punctata. The results of analysis showed an increase in the micronutrients in faecal pellets against the respective micronutrients in the (original pith). Haq (1996, 2006) conducted quantitative analysis of certain macro and micronutrients in selected items of plant litter after consumption by oribatid mites and reported a general increase in concentration of nitrogen and phosphorous in all the materials tested. Ramani and Haq (2001) showed that feeding activity of *H. rimosus* and *Lohmannia* sp. increased the nutrient status of the litter of *A. integrifolia*. The above authors found that both macro and micronutrients increased. These observations in the light of the present findings signify the utilization of oribatid mites in promoting soil fertility and productivity in general, and the degradation of solid wastes, in particular.

The intense feeding activity of oribatid mites on the pith helped to fragment the pith into single fibers and heaps of faecal pellets. Continued feeding activity of the immatures and the adults of this species confining themselves to the pith resulted in the formation of small cavities, burrows and holes filled with faecal pellets, eggs and immatures. The total conversion of pith faecal pellets by these mites in both laboratory and field conditions confirms their ability to release cellulolytic enzymes in their gut (Haq, 1996; Ramani and Haq, 2001). The faecal pellets of these mites were proved highly rich in nutrient status (Horword and Butt, 2000) and on addition to soil, create a highly fertile environment for plant growth. Thus, this study clearly established the potential of oribatid mites in the acceleration of decomposition of even highly recalcitrant organic pollutants like coconut pith (Julie and Ramani, 2007) which would otherwise get decomposed at a very slow rate.

Reproductive trends in oribatid mites generally vary, usually with respect to their morphological and physiological characteristics and

requirements. Commonly, oribatid mites follow two means of reproduction viz., parthenogenesis and sexual reproduction. The phenomenon of parthenogenesis, though has been established in various taxa of oribatids, like the familieis Camisiidae, Nanhermaniidae, Nothridae Malaconothridae, Trhypochthoniidae etc., the results of the present study could not provide any confirmative account in this regard. Sexual reproduction in these mites commonly involves the production of spermatophores. Of the 5 species of oribatid mites considered for post embryonic development, spermatophore deposition could be detected only in 2 species viz., *S. praeincisus interruptus* and *P. punctata*. The remaining 3 species, *C. ajaii* sp. nov., *R. philippinensis* and *T.* (*Rostrozetes*) *striata* sp. nov. were found producing parthenogenetic lineages alone even when the most favoured food items were made available, to the species.

The deposition of spermatophores in oribatid mites was reported in a number of species by various authors (Pauly, 1956; Taberly, 1957; Sengbusch, 1958, 1961; Woodring and Cook, 1962a; Rockett and Woodring, 1966; Shereef, 1972, 1977; Haq and Clement, 1981; Fernandez, 1981; Waitzbauer, 1983; Kummel and Dobner, 1986; Fernandez *et al*. 1991). The time respective required by *S. praeincisus interruptus* and *P. punctata* for the deposition of spermatophores after attaining adulthood was 4-6 days and 5-8 days. The rate of deposition of spermatophores by *S. praeincisus interruptus* was 30-40 spermatophores/day and that of *P. punctata* was 15-25 spermatophores. Presence of females, was recorded to have a positive influence on the deposition of spermatophores as in oribated mites (Shereef, 1972; Haq and Clement, 1981). However, despite this, the results of the present study could not establish any such influence in any of the species studied, thereby contradicting the earlier observation.

Oribatid mites are reported to exhibit different patterns of oviposition. Generally, deposition of aggregated and solitary eggs has been reported. Sengbusch (1954) reported the deposition of aggregate eggs in 3 Galumnoid members like *G. longipluma, G. elimatus* and *G. nervosus*. Woodring and Cook (1962) and Clement and Haq (1984) also noted egg clusters in *S. laevigatus* and *P. malabarica* respectively. Deposition of solitary eggs was reported by several investigators like Cordo and De Loach (1976) in *O. terebrantis*, Haq and Ramani (1984) in *P. bengalensis* and Clement and Haq (1984) in *P. malabarica*. *P. omniphagus* was found to deposit both solitary and aggregate eggs depending on seasonal variation as reported by Rockett and Woodring (1966), while *Liacarus cidarus* and *Uracrobates indicus* deposited both solitary and aggregate eggs intermittently as noted by Arlian and Woolley (1969) and Ramani and Haq (1988) respectively. In the present study, all the 5 species laid solitary eggs alone and no egg cluster could be observed.

A change in the colouration of eggs prior to eclosion was reported in certain oribatid species. The colour change may be correlated with the development of amber pigmentation. Such colour change was observed in the eggs of *G. elimatus* (Sengbusch, 1954), *O. nitens* (Sengbusch and Sengbusch, 1970) and in *L. cidarus* (Arlian and Woolley, 1970). The eggs of *S. praeincisus interruptus*, *P. punctata* and *T. (Rostrozetes) striata* sp. nov. also exhibited a similar colour change, thereby supporting the above observation.

The occurrence of prelarval stage was noted in several species of oribatid mites (Grandjean, 1956; Webb, 1977; Clement and Haq, 1984 and Schuster, 1988). However, no prelarval stage was observed in any of the 5 species selected for postembryonic development.

Generally, the feeding efficacy of the immature stages of oribatid mites is comparatively greater than that of the adults (Wallwork, 1967; Cordo and DeLoach, 1976; Haq and Ramani, 1984). The nymphal stages of the species studied were proved highly voracious feeders on their respective favourable items of food given. This suggest that the role of immatures in the turn over of nutrients is comparatively greater than that of the adult mites.

The durations of F_1 generation of *C. ajaii* sp. nov., *R. philippinensis, T. (Rostrozetes) foveolatus, S. praeincisus interruptus* and *P. punctata* were 25-31, 21.5-27, 66-71, 33-37 and 37.5 – 43.5 days respectively. Based on this, it is assumed that these species could complete 6-11 annual generations. However, in the field, the number of generations will be slightly lower, owing to the action of various biotic and abiotic factors operating in the soil ecosystem.

During the process of ontogeny in oribatids, a general increase in the number and size of setae on different regions of the body occurs. However, the number of setae on the notogaster shows a regressive trend during the transformation from tritonymph to adult (Arlian and Wolley, 1970; Haq, 1978; Seniczak, 1980a). In the present study, both *S. praeinscisus interruptus* and *P. punctata* showed an increase in the number of notogastral setae commencing from larva to tritonymph. In both, the tritonymphs possessed 15 pairs of setae. However, during the final moult, 5 pairs of setae were found lost in both species. The size of the setae also got reduced considerably. However in *C. ajaii* sp. nov. and *T.* (*Rostrozetes*) *striata* sp. nov., a progressive trend was observed in the number of notogastral setae from the larval to the protonymphal stage and which remained stationary until the completion of the tritonymphal stage. In *R. philippinensis* a progressive trend

was observed in the number of notogastral setae from the larval to the deutonymphal stage. At the final moult, setal regression was observed in all the 3 above species and the adult individuals possessed lesser number of notogastral setae when compared to nymphal stages. All the species were found highly heterogenic, in which the immatures had no resemblance with the adults. Oribatid mites generally undergo anamorphic development, in which body segments are added terminally at certain points in the life cycle (Norton, 1990). This involves, with few exceptions, addition to the larval complement of two segments around the anus, one first present in the protonymph and the other in the deutonymph. The increase in the number of setae, is a reflection of the addition of segments. In brachypyline oribatid mites, a contrasting development is met with, which is somewhat analogous to the holometabolous development of higher insects. In these mites, in addition to anamorphosis and ontogenetic changes in setation, usually a striking change is seen in overall appearance between the tritonymphs and adult instars, with the adult usually being much more, externally ornamented and heavily sclerotized than the tritonymph. Such changes could be clearly seen in the current study also. As in holometabolous insects, this type of metamorphosis not only affects appearance, but may also correspond to changes in feeding preferences and habitat-selection. An indepth study concentrating more on breeding biology is essential to confirm the significance of such morphological changes between the adults and immatures.

SUMMARY

Kerala is enriched with varied floral elements providing bountiful food resources not only to the plant parasitic forms but also to the members of the soil fauna, when the floral rudiments reach as litter in the soil. Oribatid mites which are known to be free living detritus feeders are abundant in such litter accumulated areas. The detection of panphytophagy in majority of species studied earlier indicates that in Kerala soils, mites take part a much significant role in degradation. Mites play earth-shattering role in the usual transaction of organic residues in the soil ecosystem due to their speckled activities. They render an innovative service to mankind aiding in the process of biodegradation thereby helping in the nutrient cycling and energy flow. Another spectacular area of mite activity is in the bioindication of soil conditions. This incredible ability is acquired through their extreme sensitivity to the physico-chemical characteristics of their immediate surroundings. Above all, most of the Brachypyline oribatid mites are panphytophagous in nature, feeding on a wide range of food resources comprising both lower and higher plant materials and which exert an energetic influence on soil humification process, leading to enrichment of soil fertility. They show uniform worldwide distribution and high adaptability to survive and replenish in altering environmental conditions. The present study was envisaged with a view to carry out an in-depth study on the systematic and biological details of some brachypyline taxa of oribatid mites, which exert a terrific impact on soil humification and nutrient cycling, leading to enrichment of soil fertility. In the present study, attention was also focused to assess the potential of these mites to degrade highly recalcitrant

materials like the coconut pith, left behind after coir retting process. Quantitative studies were also carried out to analyse the due to the feeding activity of oribatid mites, towards the enrichment of the fertility status of soil.

The first part of the thesis was focused to gather information on the habitat, distribution pattern, species diversity, abundance and systematic details of the most common and locally important taxa of brachypyline oribatid mites. The above objective was achieved through intermittent sampling of soil/litter samples covering different seasons from varied habitats like forest ecosystems, river banks, coir retting areas, water logged area, mangrove ecosystems, agricultural lands, secondary shrub jungles, biowaste accumulated and isolated litter accumulated areas, distributed over 6 districts of Kerala viz., Wayanad, Kozhikode, Malappuram, Thrissur, Idukki and Thiruvananthapuram. 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 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/PVA 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 Camera lucida attached to a Meopta research microscope.

The results of the survey yielded 57 species of brachypyline oribatid mites belonging to 36 genera, 20 families and 14 superfamilies. The 14 superfamilies of brachypyline mites recorded during the study were Oripodoidea, Amerobelboidea, Tectocepheoidea, Otocepheoidea, Gustavioidea, Carabodoidea, Licneremaeoidea, Microzetoidea, Oppioidea,

Galumnoidea Phenopelopoidea, Plateremaeoidea, Trizetoidea and Zetomotrichoidea. Among the 20 families, Haplozetidae and Oppiidae showed maximum generic diversity, supporting 6 genera each. The families Scheloribatidae and Galumnidae were represented by members of 3 genera each, while Basilobelbidae and Carabodidae included members of two genera. The rest of the families were found represented by a single genus each.

Scheloribates was recognized as the most diverse genus represented by members of 7 species. The second position was achieved by *Galumna* which included members of 5 species. The third position was shared by *Eremulus* and *Protoribates*, comprising 4 species each, followed by *Pergalumna* with 3 species. The genera *Dolicheremaeus, Ischeloribates, Trachyoribates* and *Brachioppia* were represented by a single species each there by disclosing the minimum diversity.

Results of the quantitative and qualitative distribution pattern of the various oribatid species recovered during the study provided substantial evidence to confirm the influence of vegetational characteristics on the faunal composition of brachypyline oribatids. This was quite evident in the Wayanad District, where Kalpetta, Sultan Battery and Muthanga Reserve Forest with 9 varied vegetational and geographical peculiarities were the sites surveyed which enabled to procure 40 species of brachypyline oribatid mites. Out of the 19 sites surveyed, site 10 was a fully water logged area with no evidence of litter accumulation and which was found devoid of any oribatid species. The species diversity of oribatid mites in the Kozhikode District was comparatively low with a total of 15 species as the 5 sites selected in the District were highly contrasting, comprised of the mangrove vegetation, river

banks and retting grounds. The soil samples collected from 4 sites in Malappuram District comprising mixed vegetation, water logged area, paddy field, homeyard etc. yielded a total of 28 species. The single site at Thrissur District occupied by *A. heterophyllus* with low litter accumulation yielded a total of 6 species. Similarly, the single site at Idukki District with medium litter accumulation revealed the presence of 14 species. In the Thiruvananthapuram District, the 3 sites surveyed comprising herbal garden, area of biowaste accumulation and mixed vegetation, yielded a total of 33 species. Results of the survey enabled to recognize *T.* (*Rostrozetes*) *foveolatus* as a widely distributed species, as it was recovered from 14 out of 25 sites surveyed. *T. laevis* showed preference to semi-water logged area. Some of the species like *M. kizhisseriensis* sp. nov., *P. ciliata* sp. nov., *A. pellucida* and *G.* (*Indogalumna*) *intermedius* sp. nov. were unique with respect to their sites. The immature stages of most of the species were also present in abundance in all the sites surveyed.

In the systematic part of the thesis, detailed morphological descriptions of 20 species of brachypyline oribatid mites were included along with appropriate figures. The above 20 species were found representing 18 genera, 13 families and 8 superfamilies. Of these, 8 species representing 8 genera, 6 families and 6 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.

The second part of the thesis envisages studies on the biological aspects of selected species of brachypyline oribaitid mites, comprising both feeding and breeding parameters. The occurrence of oribatid mites in a

multitude of micro-conditions of the soil is mainly determined by their ability to consume the available food items present in their natural habitats. This has led to the development of a variety of feeding responses among oribatid mites. To ascertain the food preference of field collected oribatid mites, gut content analysis of 20 species was performed. Food boli and gut contents of live mites were dissected out on microscopic slides, spread out evenly in glycerine and observed under a research microscope. Appropriate stains were applied for better observation. Results of gut content analysis of the 20 species of oribatid mites collected during the present study revealed that *P. ciliata* sp. nov. was the only species which showed a deviation in the nutritional habit. Remaining species showed the presence of varied food items like fungal hyphae, spores and remants of leafy/woody components of litter in various stages of digestion, pollen grains etc. along with some unidentified particles in highly advanced stage of digestion. Food choice test was conducted under laboratory condition by providing an array of test food items comprised of varied species of fungi, leaf litter of different plants, coconut pith, decayed pneumatophores, cow dung, filter paper etc. Ten out of the 20 species considered for gut content analysis were subjected to food choice test. Of these, *P. ciliata* was proved as macrophytophagous species while the other 9 species were categorized as panphytophagous.

The potential of oribatid mites in enriching soil fertility and productivity was analysed quantitatively by recording the levels of 3 important micronutrients viz., Nitrogen, Phosphorous and Potassium present in the soil samples. Soil samples collected from 6 sites with varied vegetational composition were subjected to micronutrient analysis. The collected samples of soils from the above sites were thoroughly extracted for

72 hours in order to remove all faunal members and transferred to earthen flower pots. In experimental samples, 150 live adults, *P. ciliata* sp. nov., *P. punctata*, *M. kizhisseriensis* sp. nov., *D. indicus* were introduced in to the soil sample containing litter collected from the study sites. While control samples contained only the soil and litter collected from the study sites. Soil samples in both experimental and control samples were adequately watered frequently and kept undisturbed for a period of about 6 months. These pots were covered with fine mesh to prevent the invasion by other organisms. After a period of 6 months, the soil samples of both experimental set ups and respective controls were subjected to chemical analysis for determining the quantities of N, P, K. Chemical analysis was carried out in the District Soil Testing Laboratory, Thikkodi. Results of chemical analysis conducted in the present study showed a general increase in the concentration of 3 elements tested viz., Nitrogen, Phosphorous and Potassium in the experimental soil samples where the mites were released. Preliminary studies on the potential of these mites in the degradation of highly recalcitrant wastes like the coconut pith on retting ground have provided very promising results. An analysis of oribatid potential in the degradation of coconut pith was made by quantitative estimation of micronutrients present in the pith before and after feeding by selected species like *P. punctata*. For the purpose, pure pith samples were collected from retting grounds which were treated as experimental and control sets separately. For each set, 10-12gm of samples were taken and dried up in an oven at 103^0C for a period of 1-2 days. Such oven dried samples were kept in separate bottles. For the experimental purpose, 2 gm of the dried sample was taken in a fresh culture cell into which 25 live specimens of *P. punctata* were introduced. The sample was adequately moistened with distilled water and kept for 6 months. The control

set was also prepared similarly, but without the mite specimens. The pith from the control sample and faecal pellets were collected separately laid by *P. punctata* offer feeding the pith and subjected to micronutrient analysis in the Sophisticated Test and Instrumentation Center, Cochin University. The analysis of N and C was carried out with CHNS analyzer and that of K and P was done with the ICP-AES system. Results of micronutrient analysis showed that the faecal pellets of *P. punctata* which fed on coir pith showed an increase in concentration against the respective elements in the control sample containing only the coir pith.

Population density of any organism depends greatly on their reproductive potential. Since oribatid mites form a major component of soil mesofauna, an understanding of the reproductive strategies is highly essential. Hence in the present work, breeding biology of 5 species of panphytophagous brachypyline oribatid species viz., *C. ajaii* sp. nov., *R.philippinensis., T.* (*Rostrozetes*) *striata* sp. nov., *S. praeincisus interruputs* and *P. punctata* were selected for developmental studies. 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, duration of F_1 generation etc. Morphological details of each stage were studied and presented through illustrations and drawings. Two mode of reproduction were shown by the species. Spermatophores were laid in abundance in culture cells by the males of *S. praeinscisus interruptus* and *P. punctata.* Other 3 species showed parthenogenetic mode of reproduction since in no instance, male progeny was found developed and the entire population of the mite comprised of only females. This was proved

by the results of field sampling also. The egg after incubation hatched out into a hexapod larva, followed by an inactive quiescent phase which subsequently moulted into the next active phase. The duration of development varied with respect to variation in individual species. The above 5 species, viz., *C. ajaii* sp. nov., *R. philippinensis*, *T.* (*Rostrozetes*) *straita* sp. nov., *S. praeincisus interruptus* and *P. punctata* completed their life cycle from egg to adult from 17-21, 14.5-19, 51-59, 27-31 and 29.5-34.5 days respectively. The duration of F_1 generation of the above species were 25-31, 21.5-27, 66-71, 33 to 38 and 37.5-43.5 days respectively.

Detailed study on the comparative morphology of the life stages of the 5 species showed an increase in the number of notogastral setae from larva to tritonymph in *S. praeincisus interruptus* and *P. punctata* could be observed. However, during final moult 5 pairs of setae were lost in both the species. But in the other 3 species, *C. ajaii* sp. nov. and *T.* (*Rostrozetes*) *striata* sp. nov., a progressive trend was observed in the number of notogastral setae from the larval to the protnymphal stage and then it was retained until the completion of the tritonymphal stage. In *R. philippinensis* a progressive trend was observed in the number of notogastral setae from the larval to the deutonymphal stage. At the final moult, setal regression was observed in the adult species. The number of epimeral, genital, anal and adanal setae increased from larva to adult. In all the 5 species, the larva was always a hexapod, devoid of genital plates and suckers.

Thus, the present study helped to identify and contribute 8 new species coming under 8 genera, 6 families and 6 superfamilies, to science. The results of feeding studies brought out the biodegradative potential 10 species of brachypyline oribatid mites, on a variety of food items. One of the

most interesting observations made during the study was the potential of oribatid mites to feed and survive on highly recalcitrant solid waste, coconut pith. Further the study also revealed an increase in the nutrients after the feeding of coconut pith by selected species like *P. punctata*. Quantitative studies were carried out to analyse the positive impact resulted due to feeding activities of oribatid mites towards the enrichment of fertility status of soil.

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PLATE 12

Family Diversity of the Brachypyline Superfamilies in the Study Sites

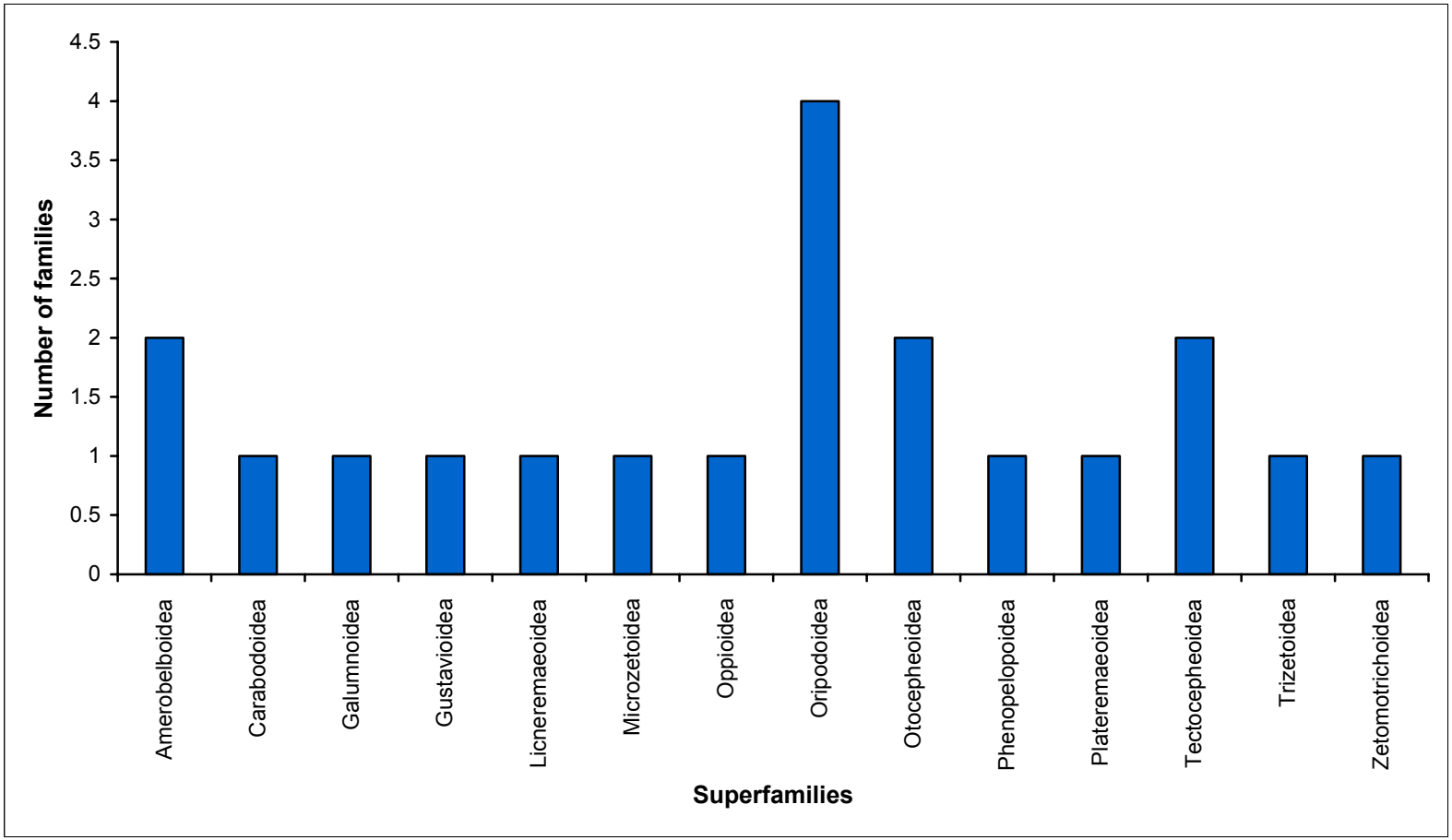


PLATE 13

Species Diversity of Brachypyline Oribatid Mites in the Study Sites

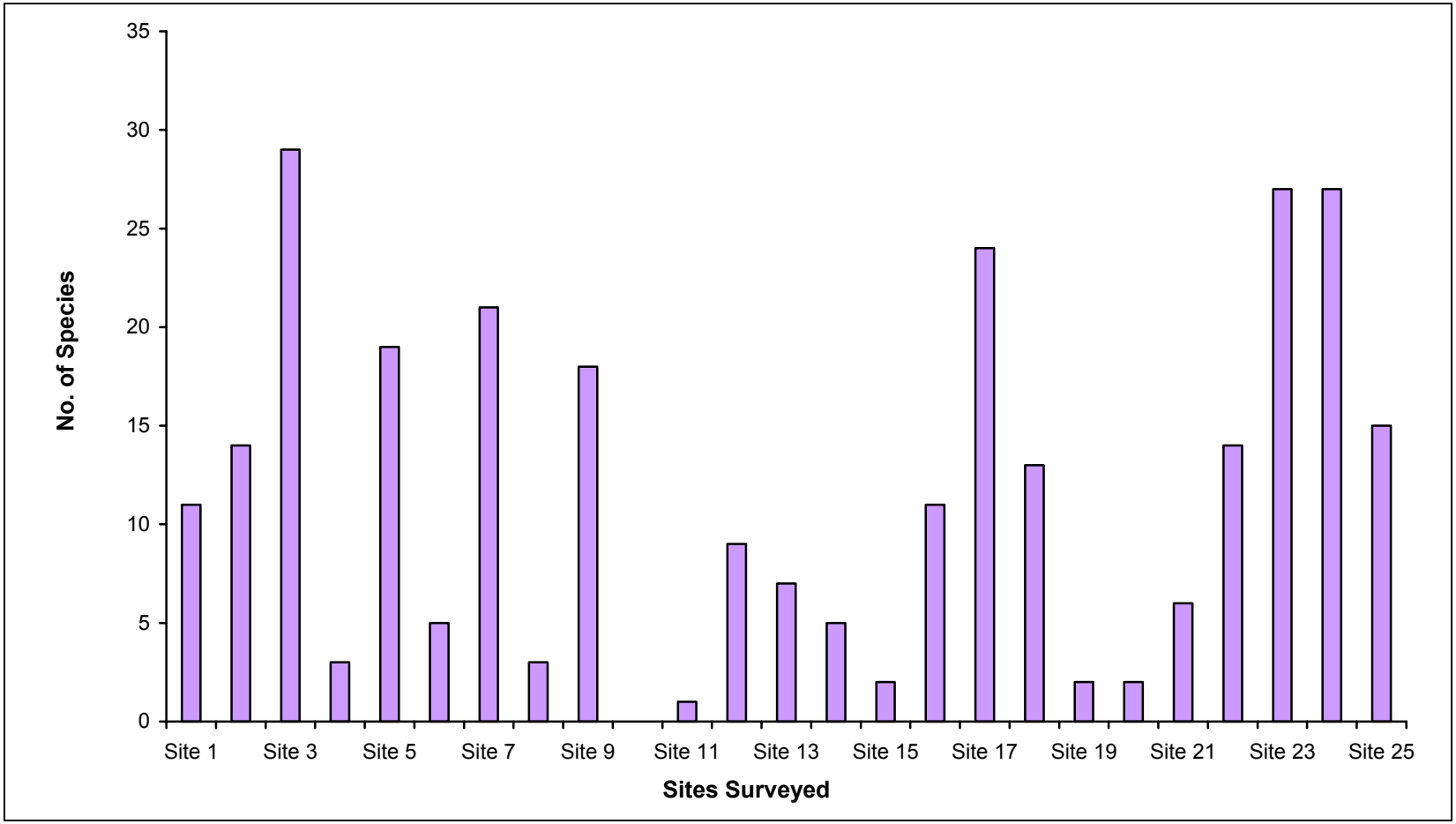


Plate 14
Generic and Species Diversity of Brachypyline Oribatid Families in the Study Sites

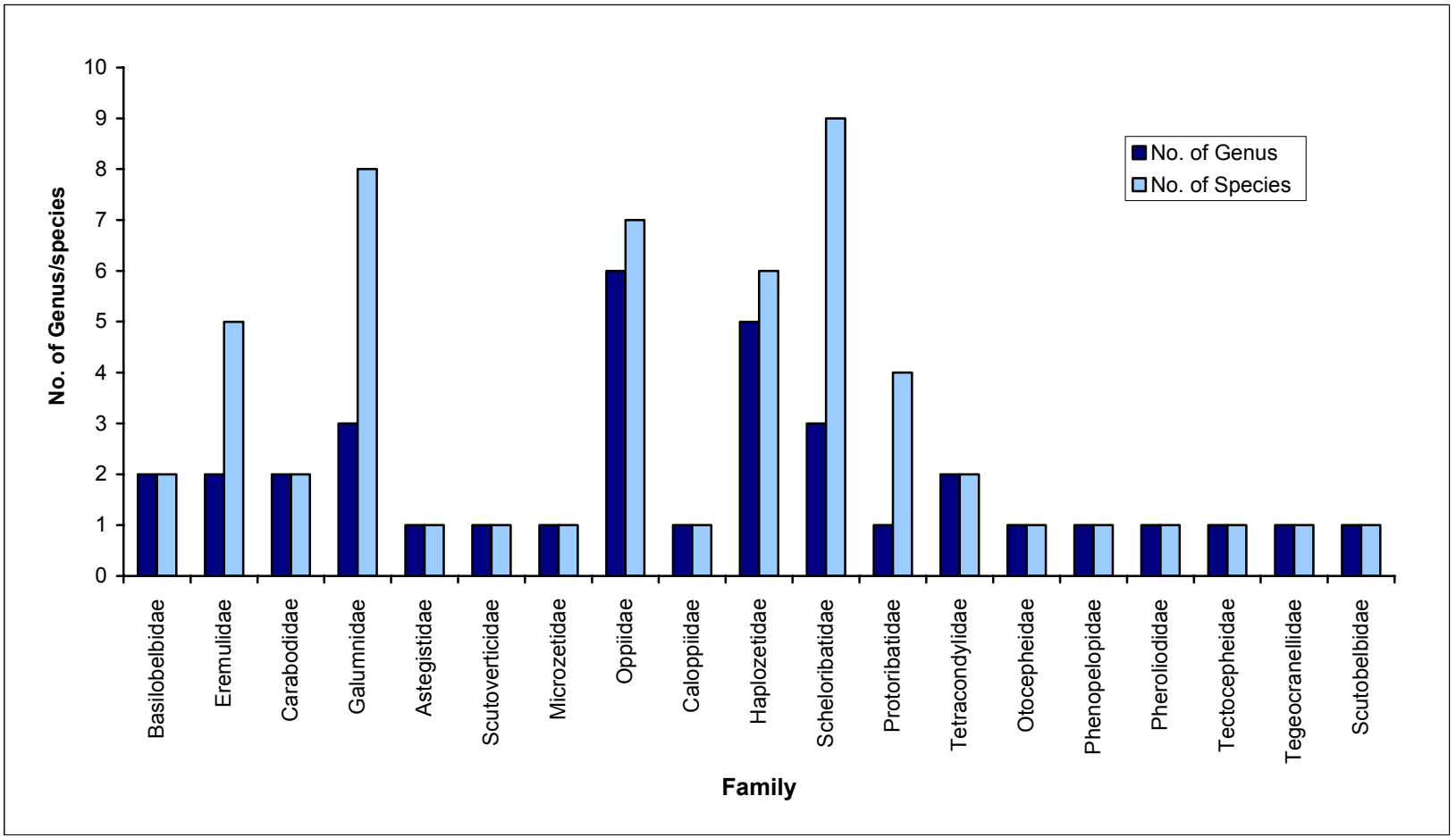


PLATE 46

Figure 1:Quantitative Difference in Phosphorous Content in Soils Due to Oribatid Feeding at Various Sites (in ppm)

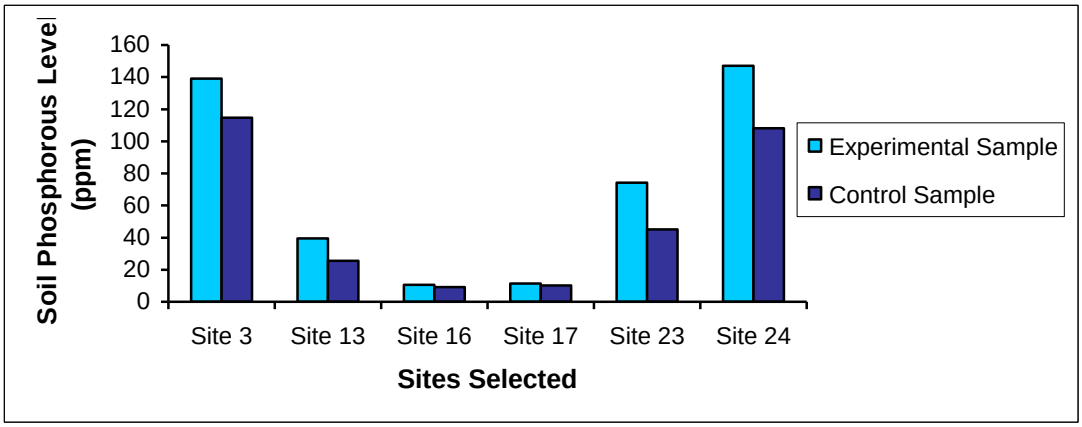


Figure 2: Quantitative Difference in Potassium Content in Soils Due to Oribatid Feeding at Various Sites (in ppm)

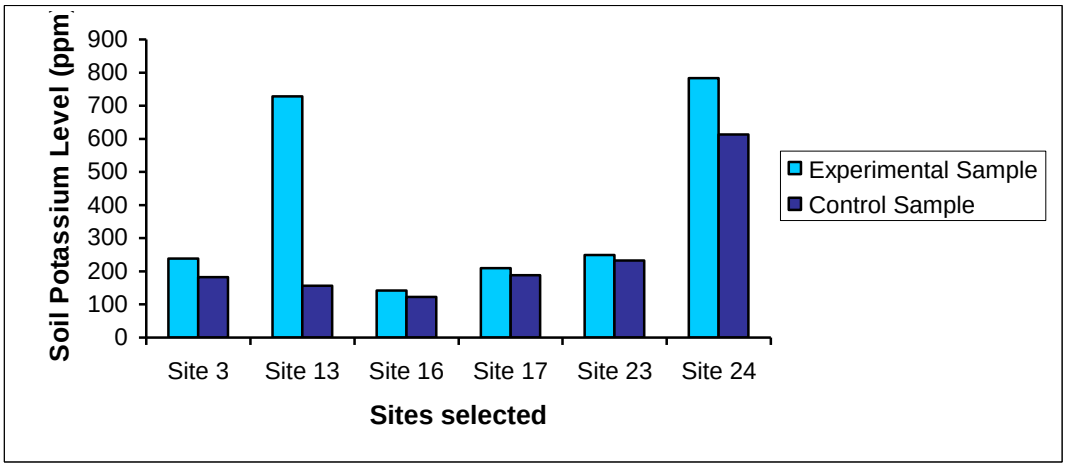


Figure 3: Quantitative Difference in the Nitrogen Content in Soils Due to Oribatid Feeding at Various Sites (in %)

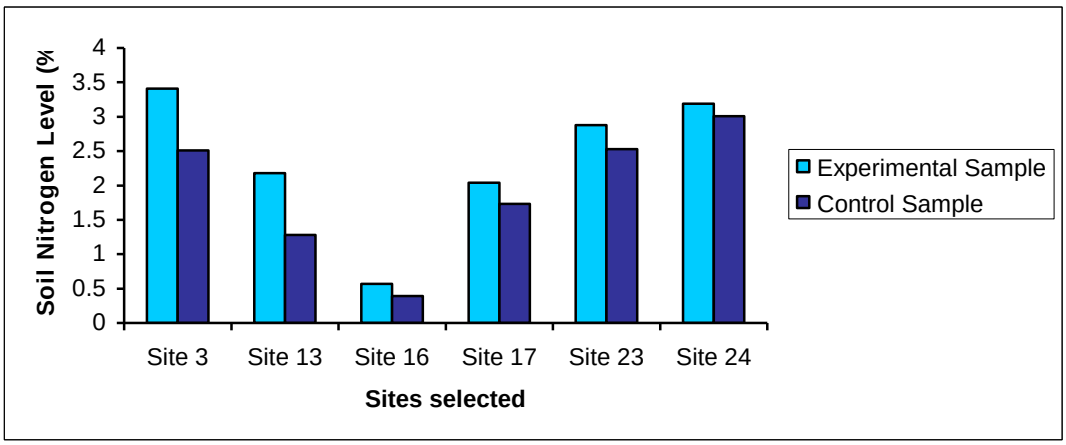


PLATE 47

Figure 1: Quantitative Difference in Nitrogen and Carbon Levels in Pith Samples Owing to Oribatid Feeding (in %)

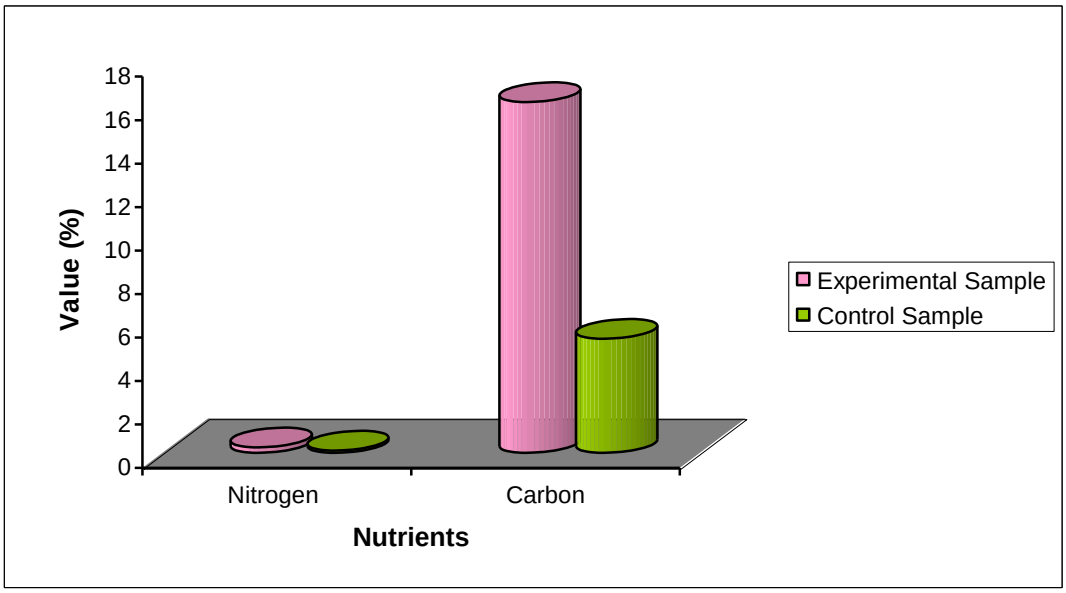


Figure 2: Quantitative Difference in Phosphorous and Potassium Levels in Pith Samples Owing to Oribatid Feeding

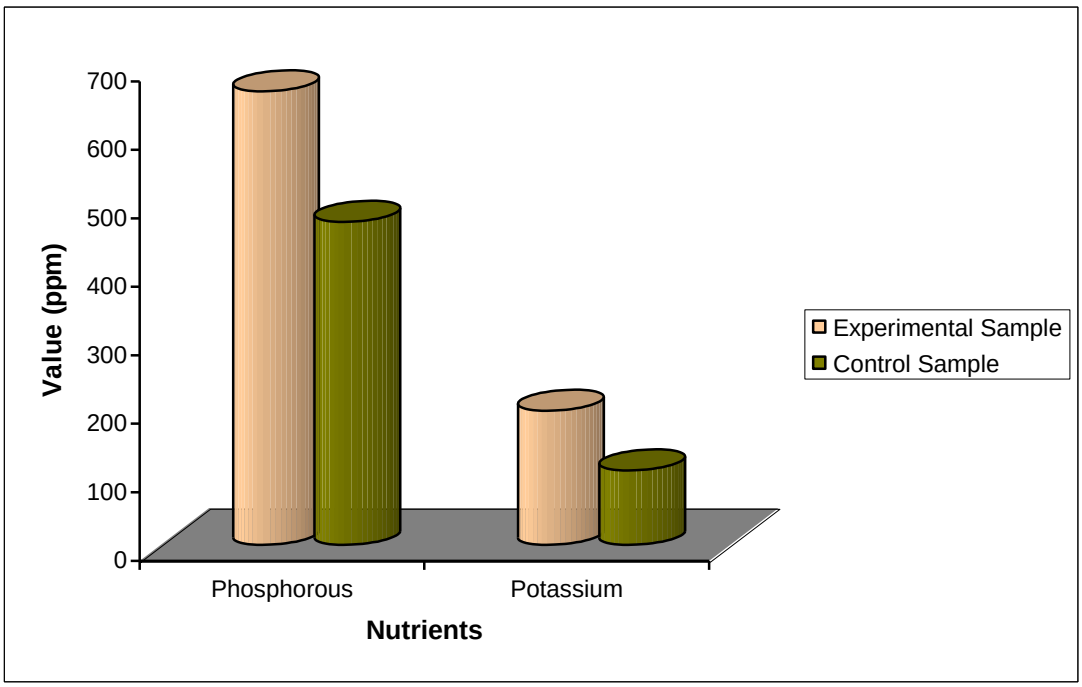
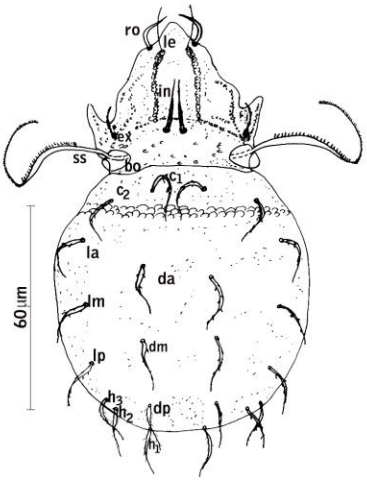


PLATE 1



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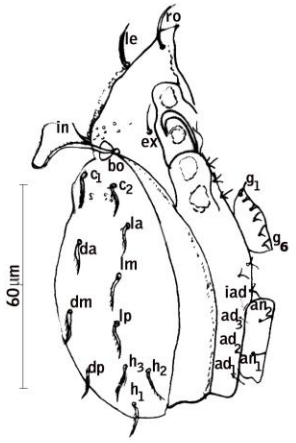

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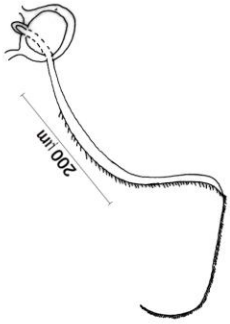
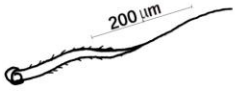
1(c)

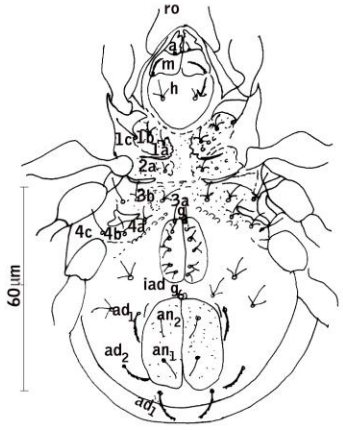


1(d)



1(e)

PLATE 2



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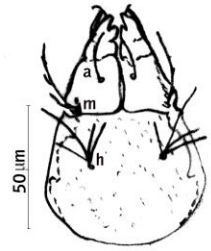
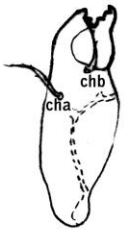


3a



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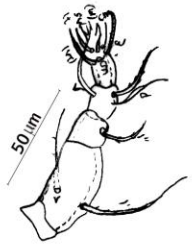

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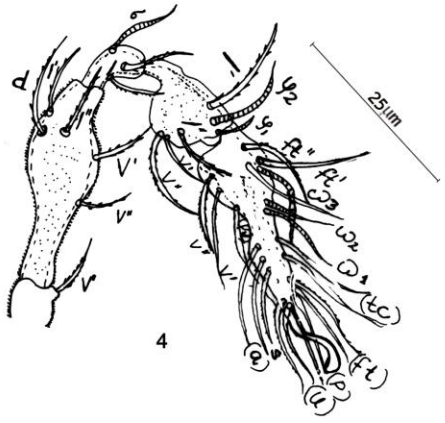

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PLATE 3

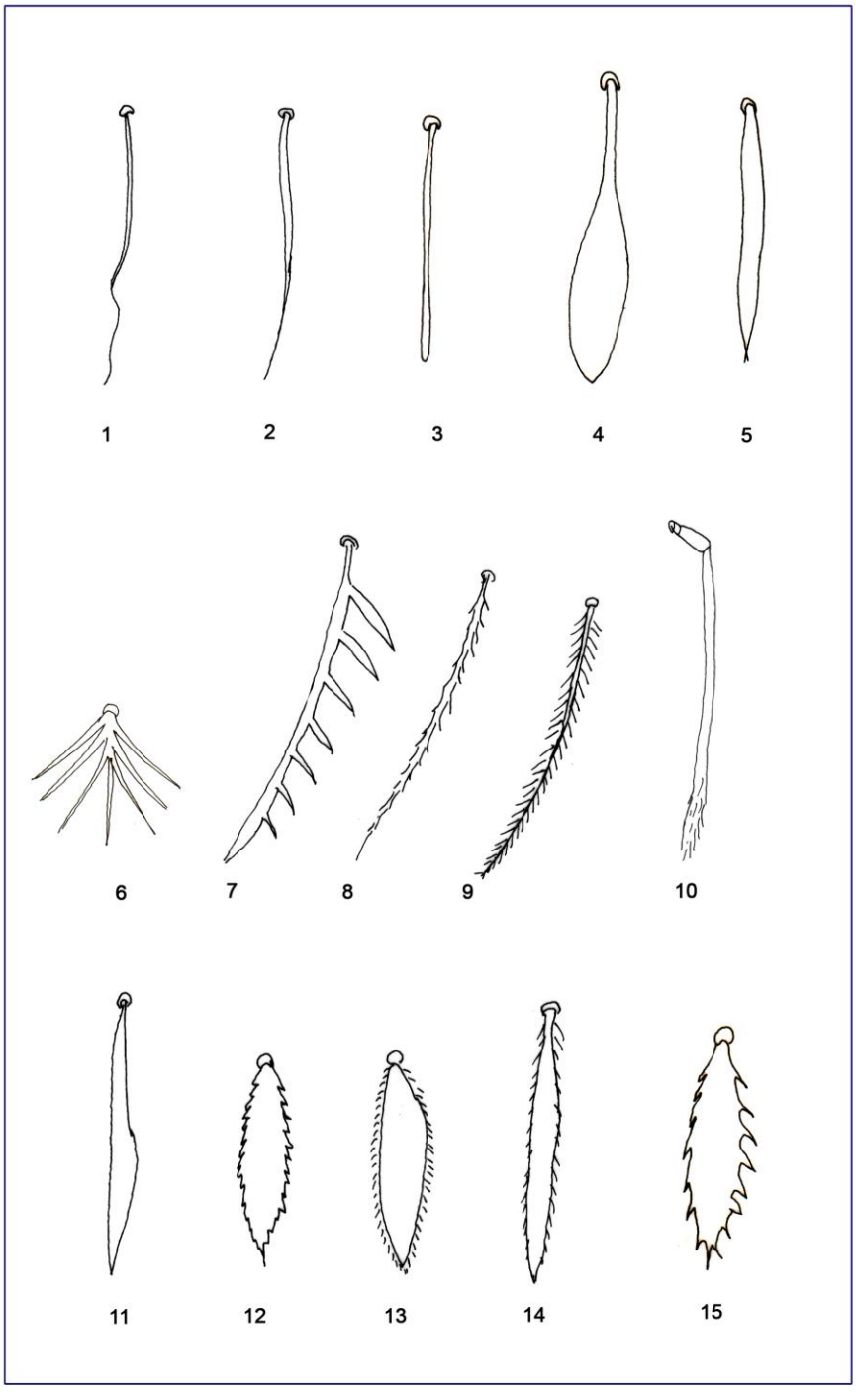

PLATE 4

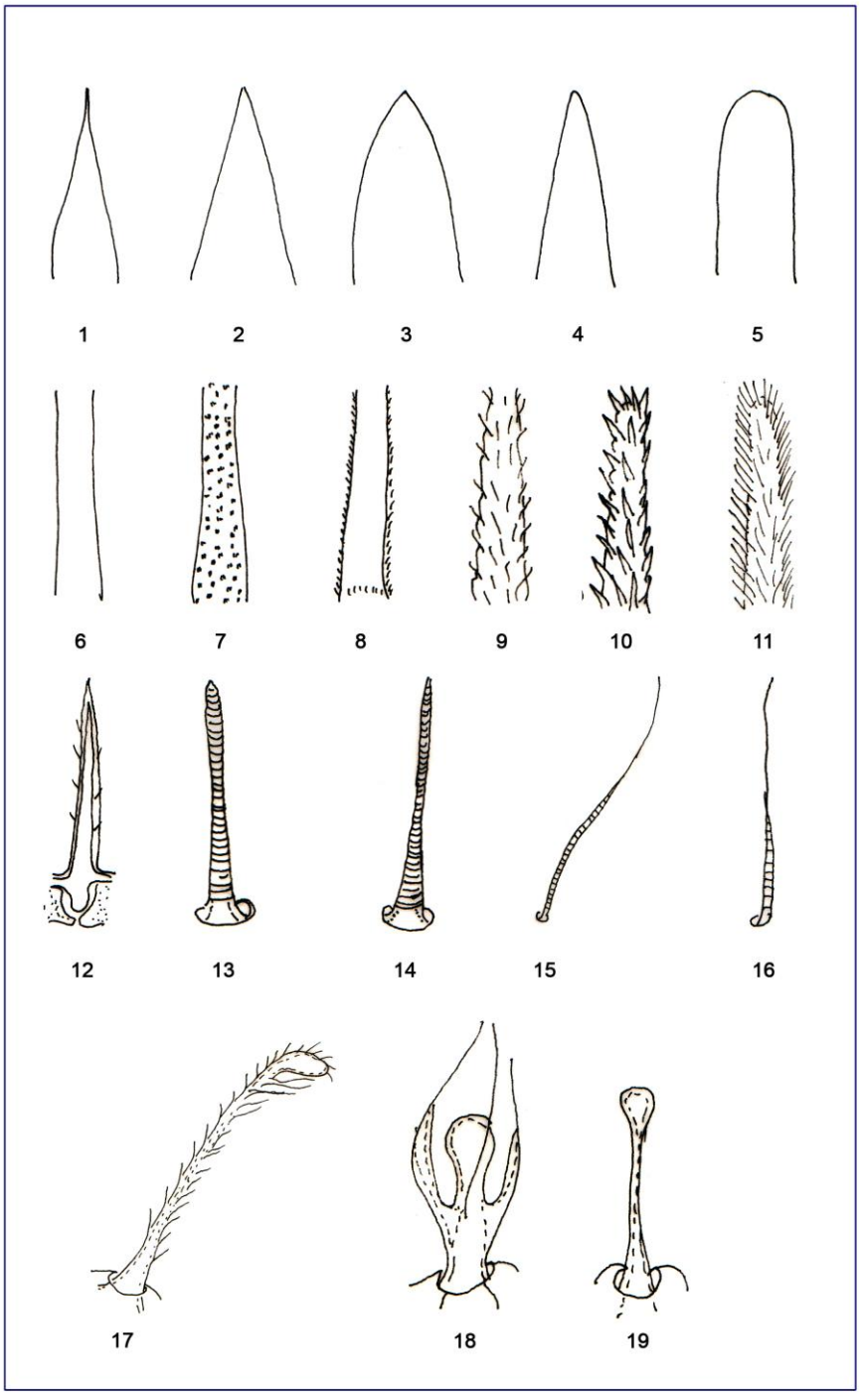

PLATE 5

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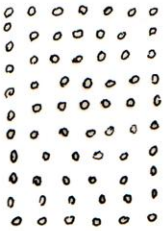

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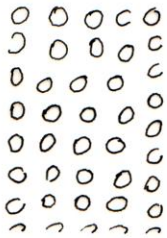

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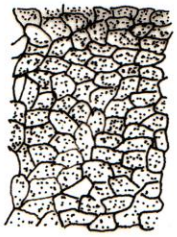

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PLATE 15

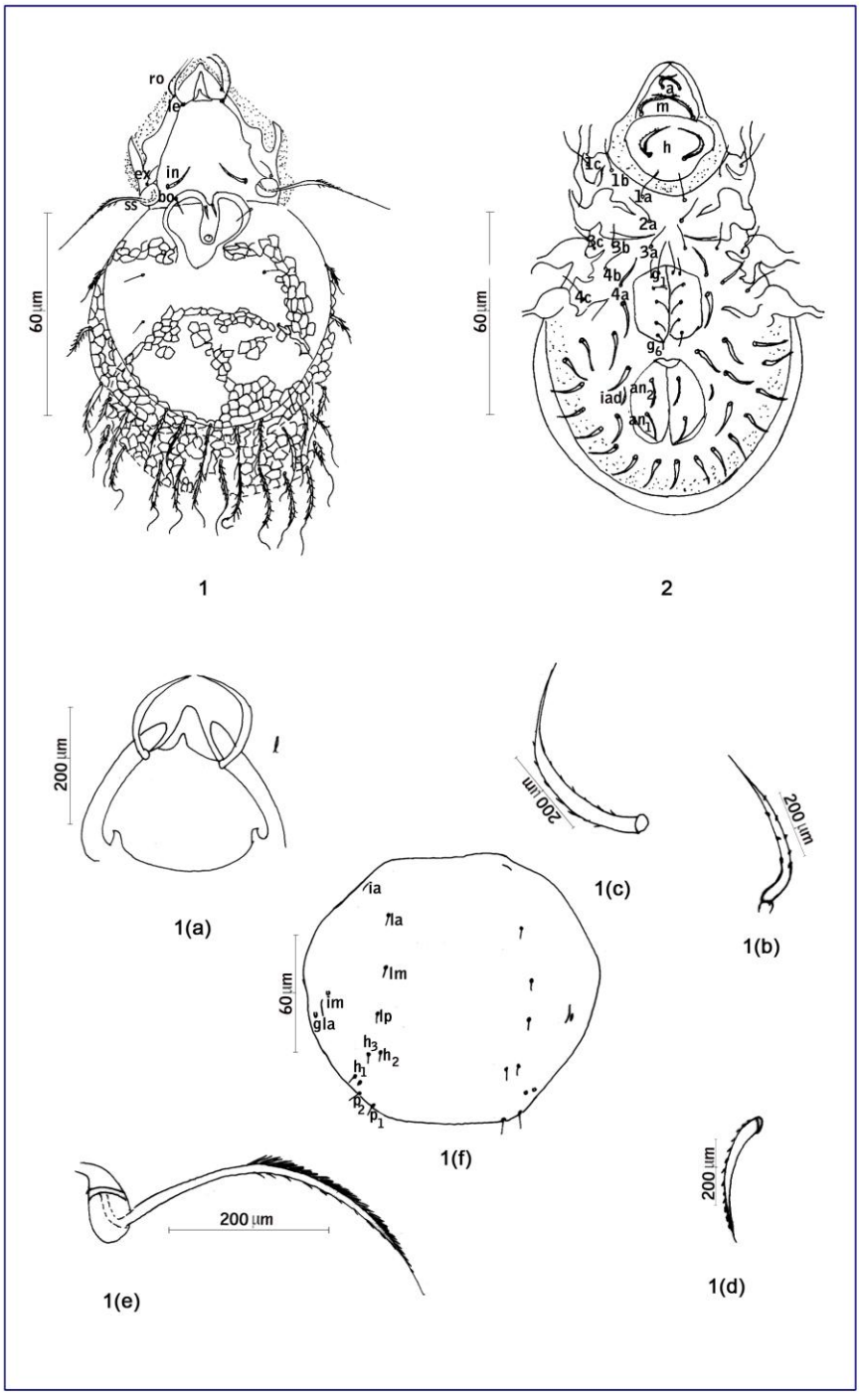
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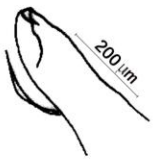
PLATE 16



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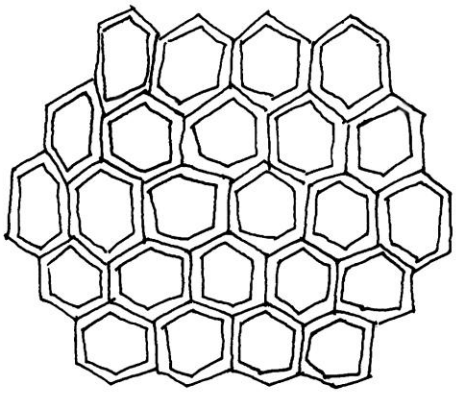

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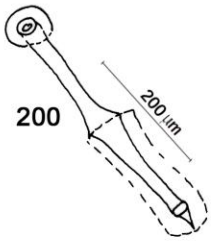

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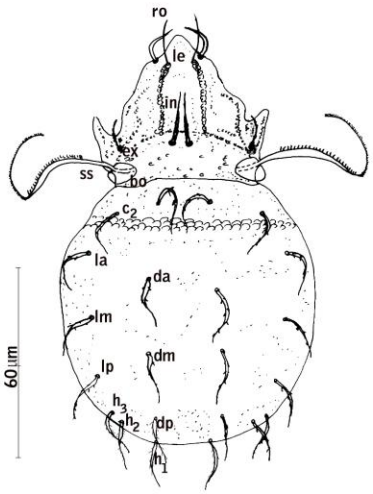
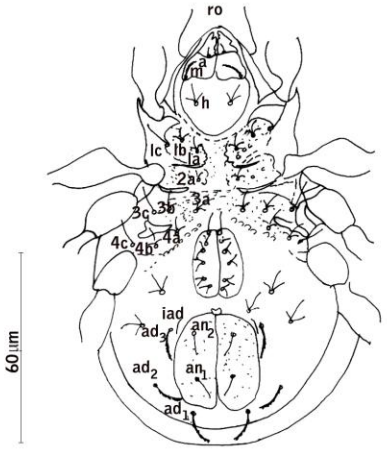
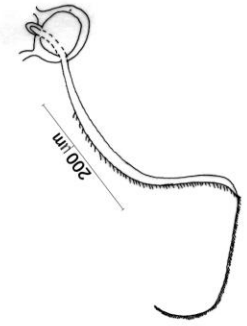
PLATE 17



1

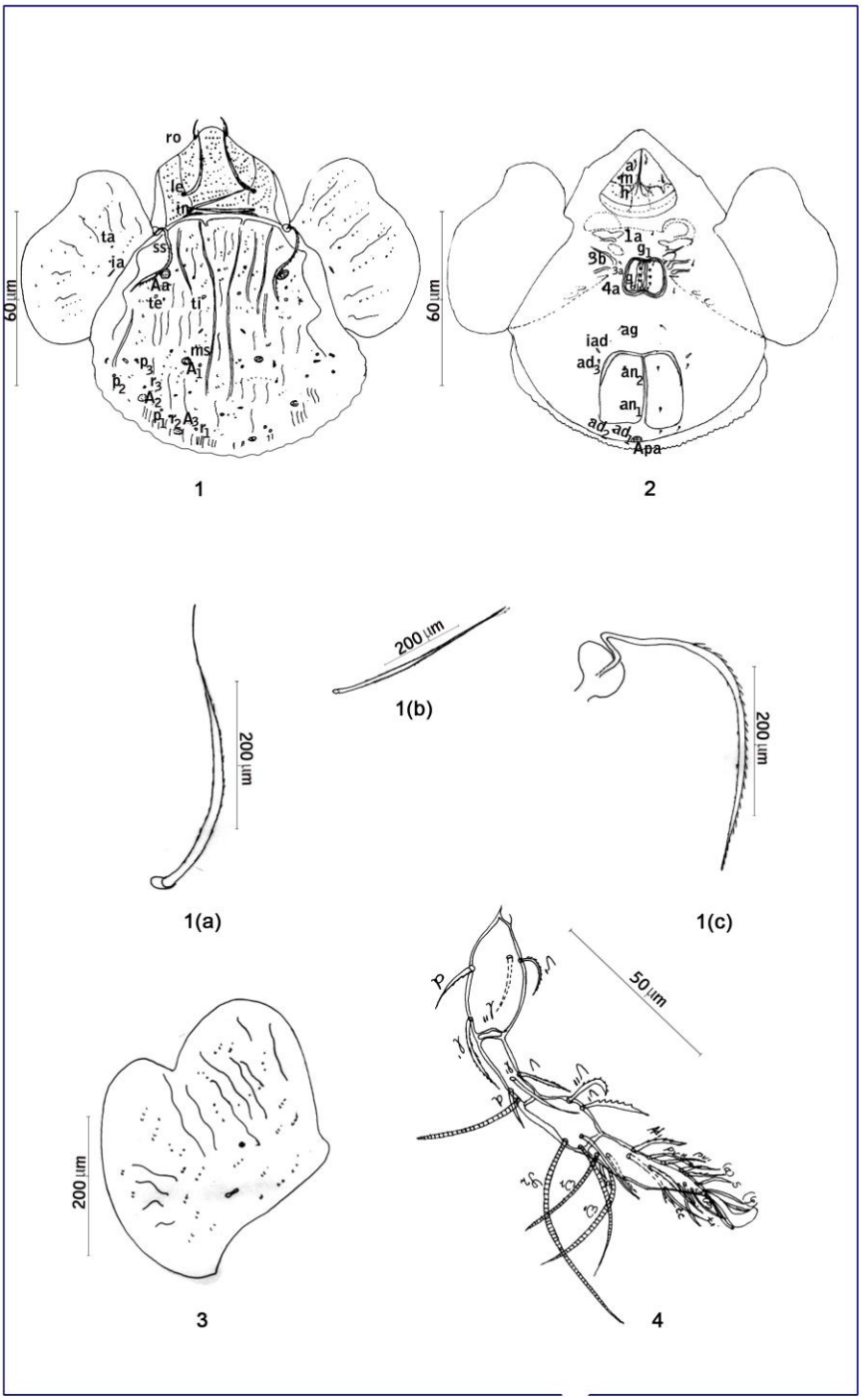


2



1(a)

PLATE 18


60 µm
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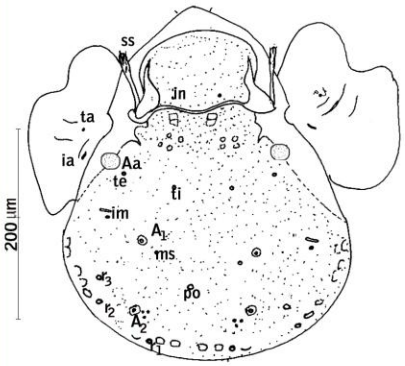
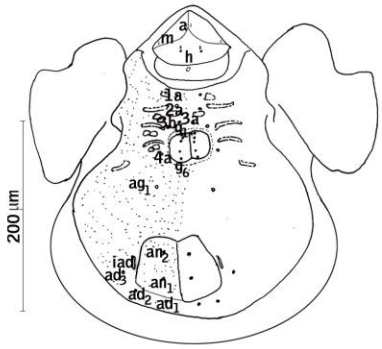
60 µm
1
2
200 µm
1(a)
200 µm
1(b)
200 µm
1(c)
200 µm
3
50 µm
4

PLATE 19



1



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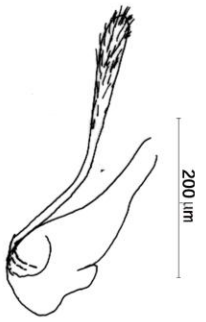
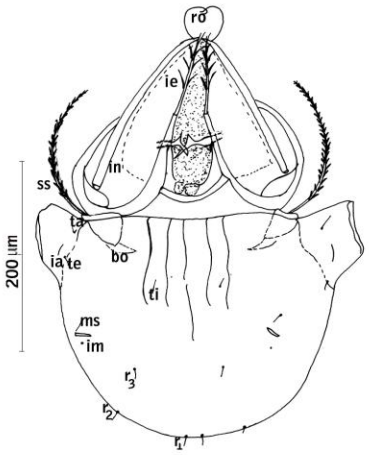
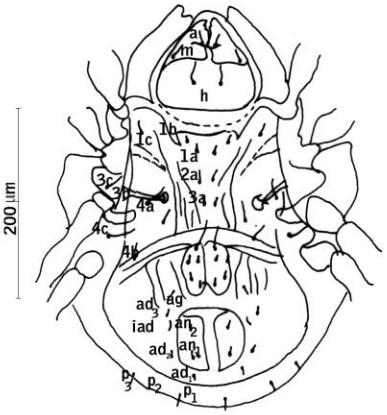


1(a)

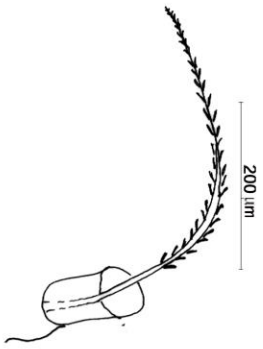
PLATE 20



1

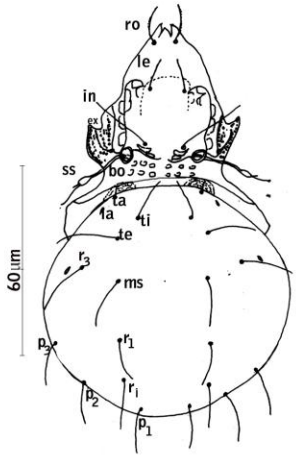


2

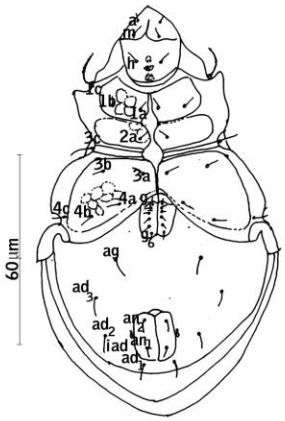


1(a)

PLATE 21



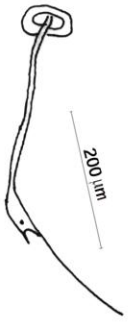
1



2

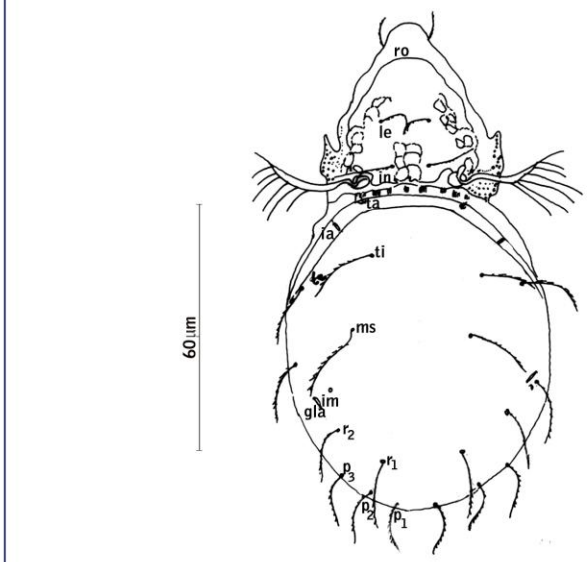
1(a)

1(b)



1(c)

PLATE 22


ro
le
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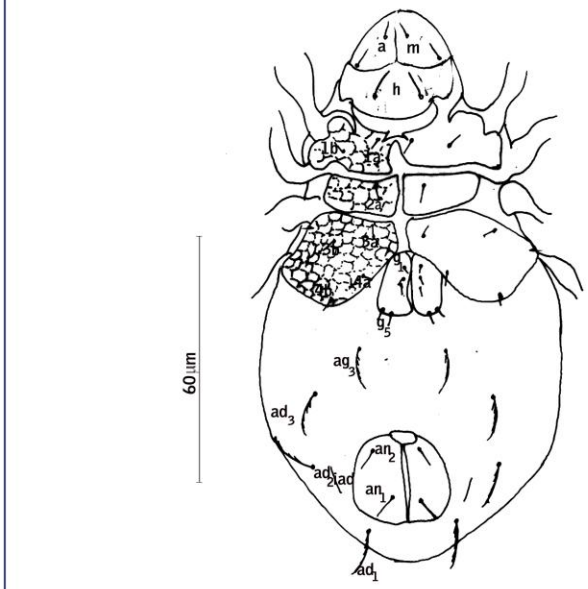
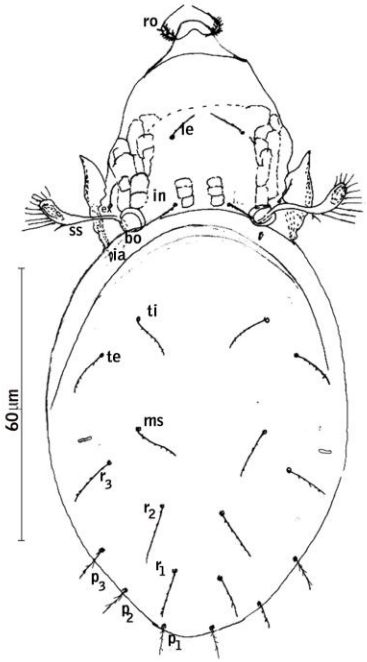
im
r_2
r_1
p_3
p_2
p_1
60 µm

1

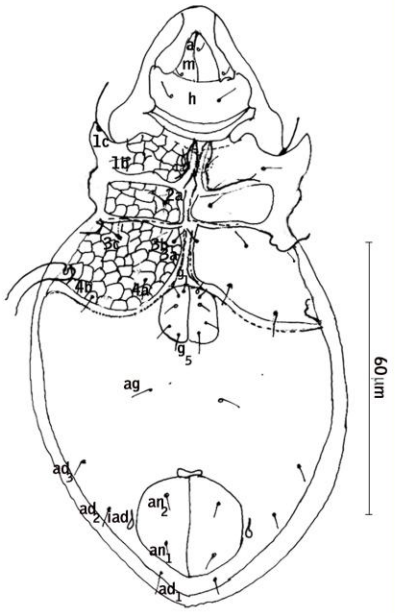

a
m
h
g_5
ag_3
ad_3
an_2
ad_2
ad_1
an_1
60 µm

2

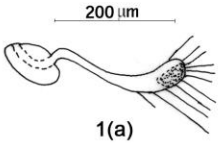
PLATE 23



1

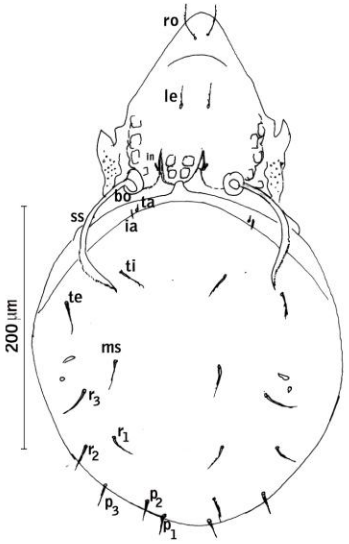


2

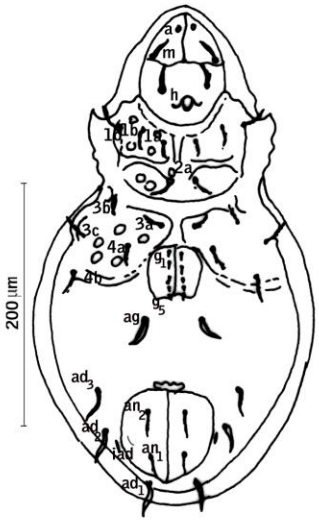


1(a)

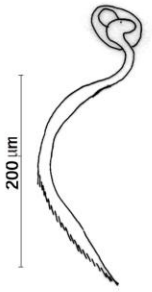
PLATE 24



1



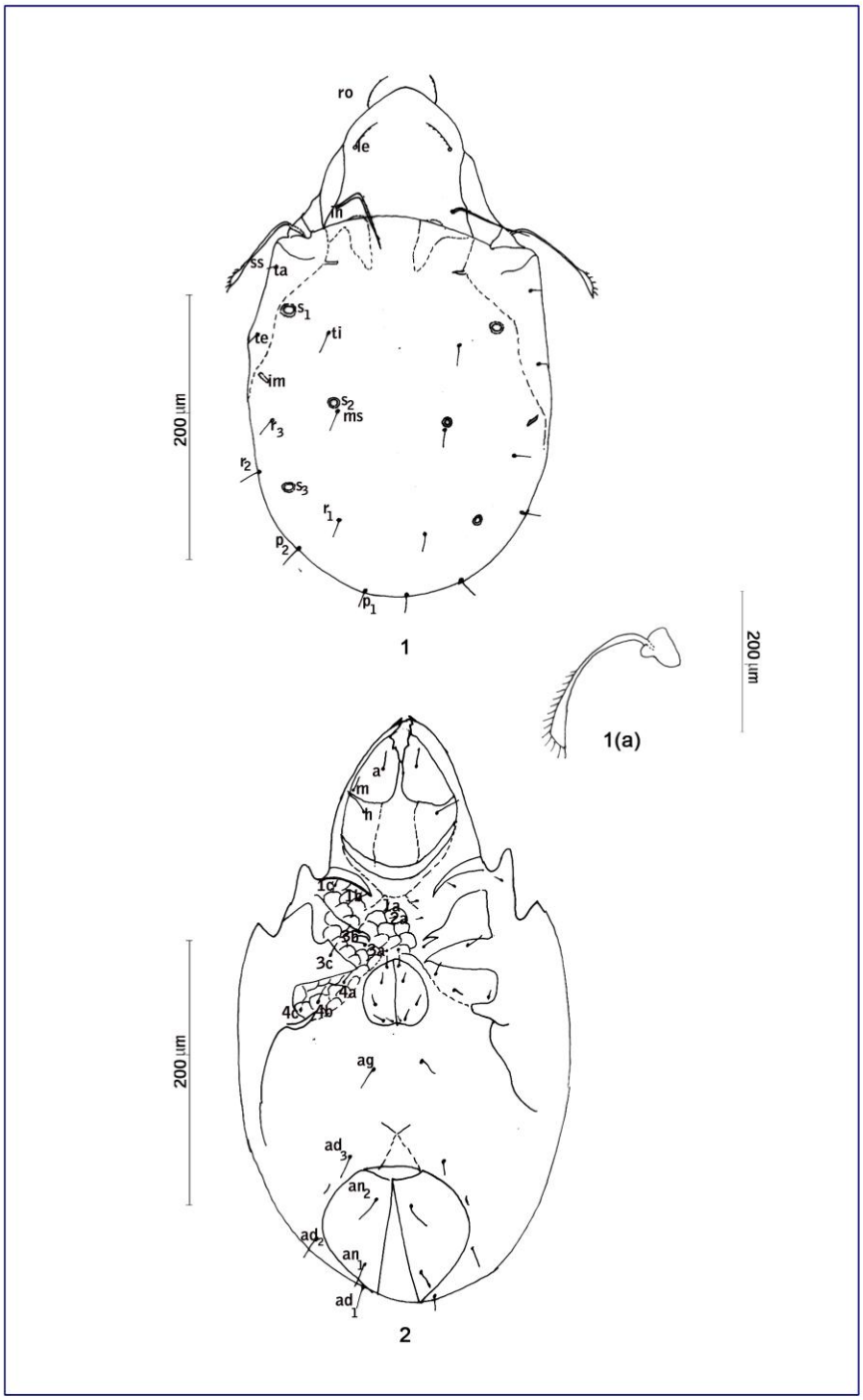
2



1(a)

1(b)

PLATE 25


ro
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s_1
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im
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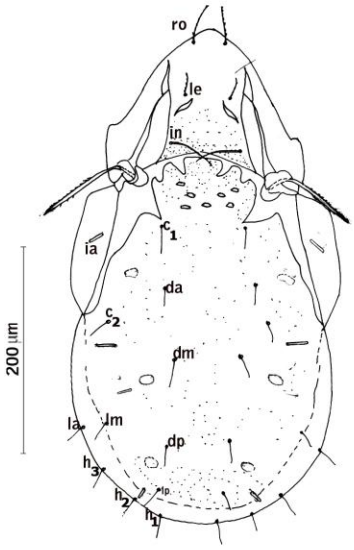
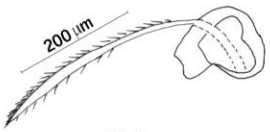
ms
r_3
r_2
s_3
r_1
p_2
p_1
200 µm
1
1(a)
200 µm
a
m
h
1c
1b
1a
2a
4b
3b
3c
3a
1d
4a
4c
4b
ag
ad_3
an_2
ad_2
an_1
ad_1
200 µm
2

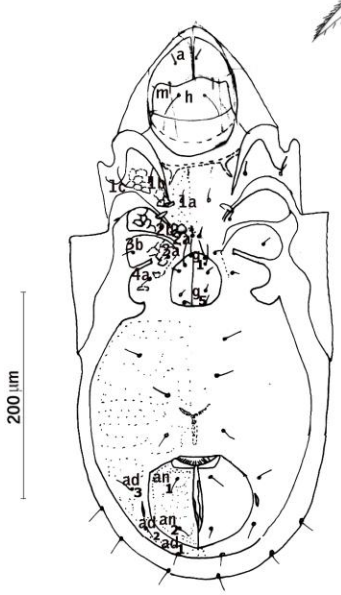
PLATE 26



1

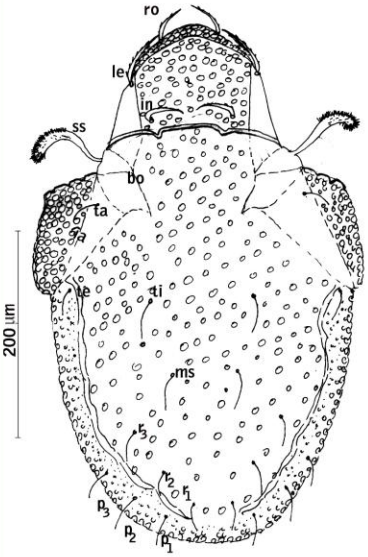


1(a)

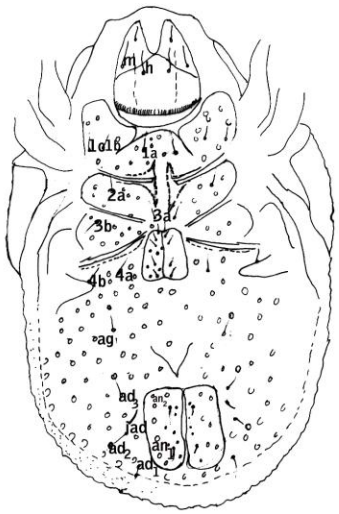


2

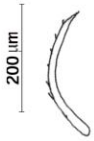
PLATE 27



1



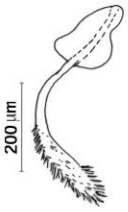
2



1(a)

1(b)

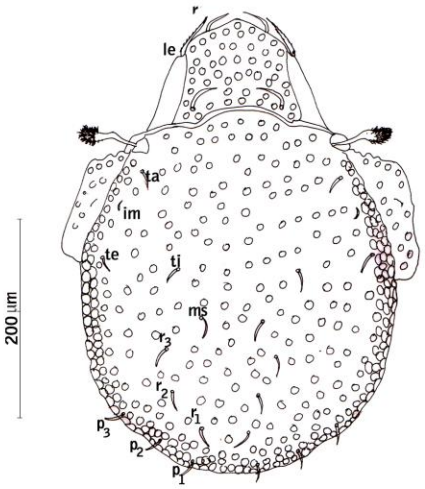
1(c)



1(d)

1(e)

PLATE 28


r
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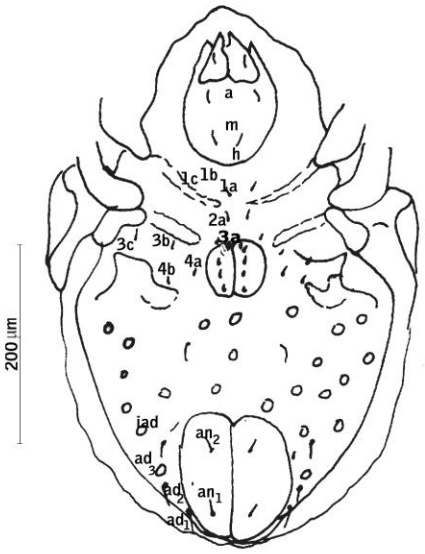
r_3
r_2
r_1
p_3
p_2
p_1
200 µm

1


a
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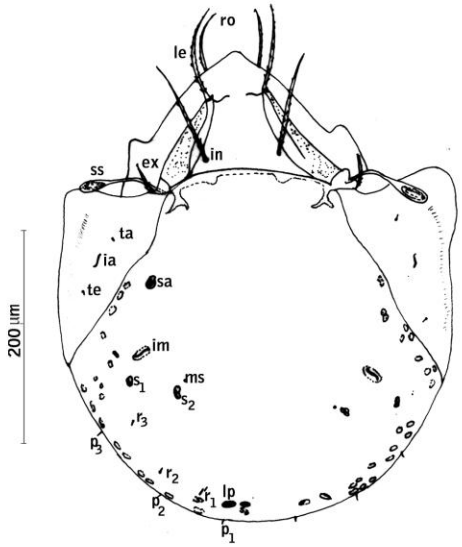
h
1c
1b
1a
2a
3a
3c
3b
4a
4b
200 µm
jad
an_2
ad
3d
ad
an_1
ad_1

2

PLATE 29


ro
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r_1
lp
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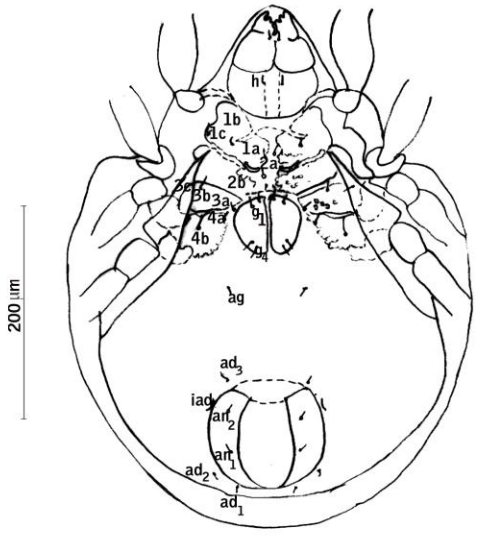
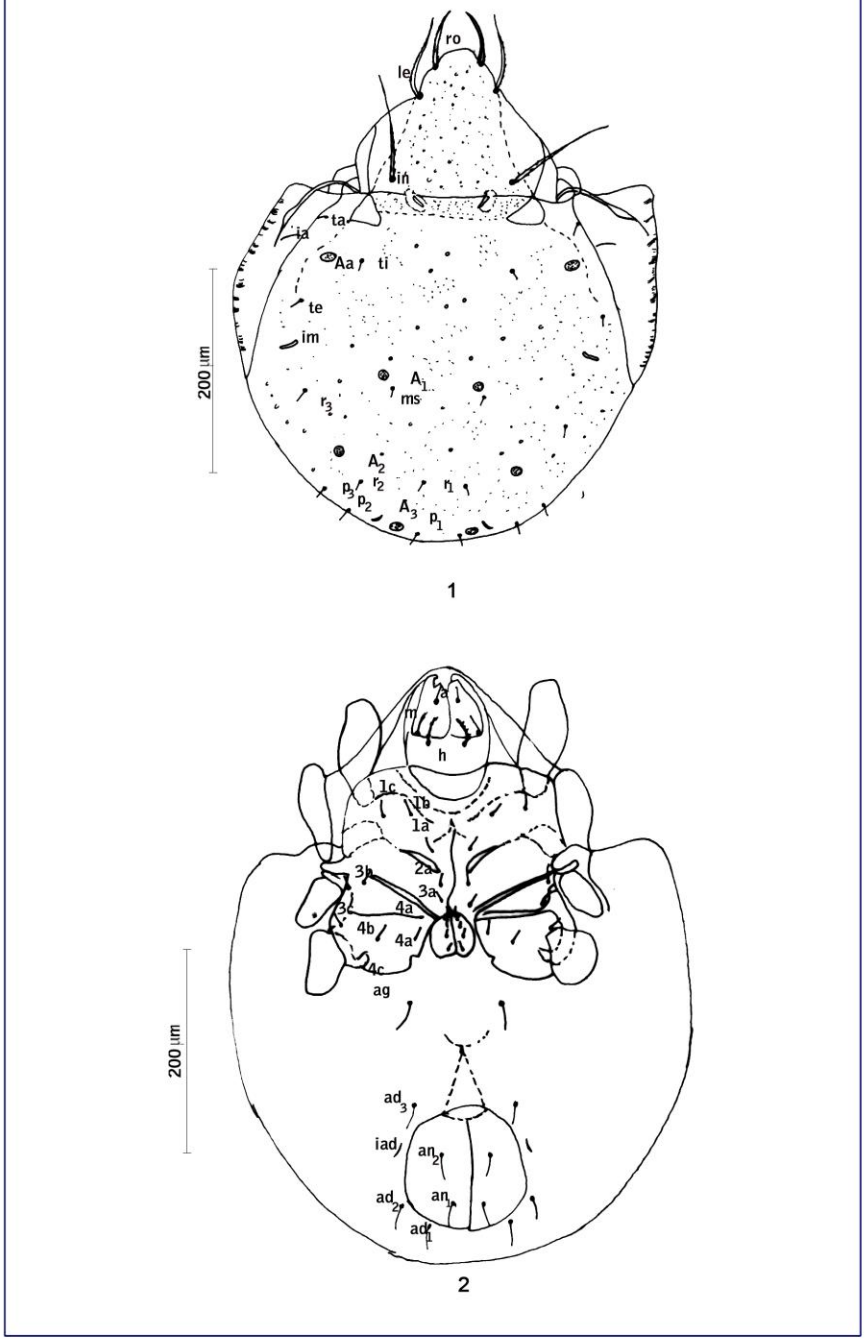
p_1
200 µm

1


h
1b
1c
1a
2a
2b
3c
3b
3a
4a
4b
g_1
g_4
ag
ad_3
iad
ar_2
ar_1
ad_2
ad_1
200 µm

2

PLATE 30


ro
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r_1
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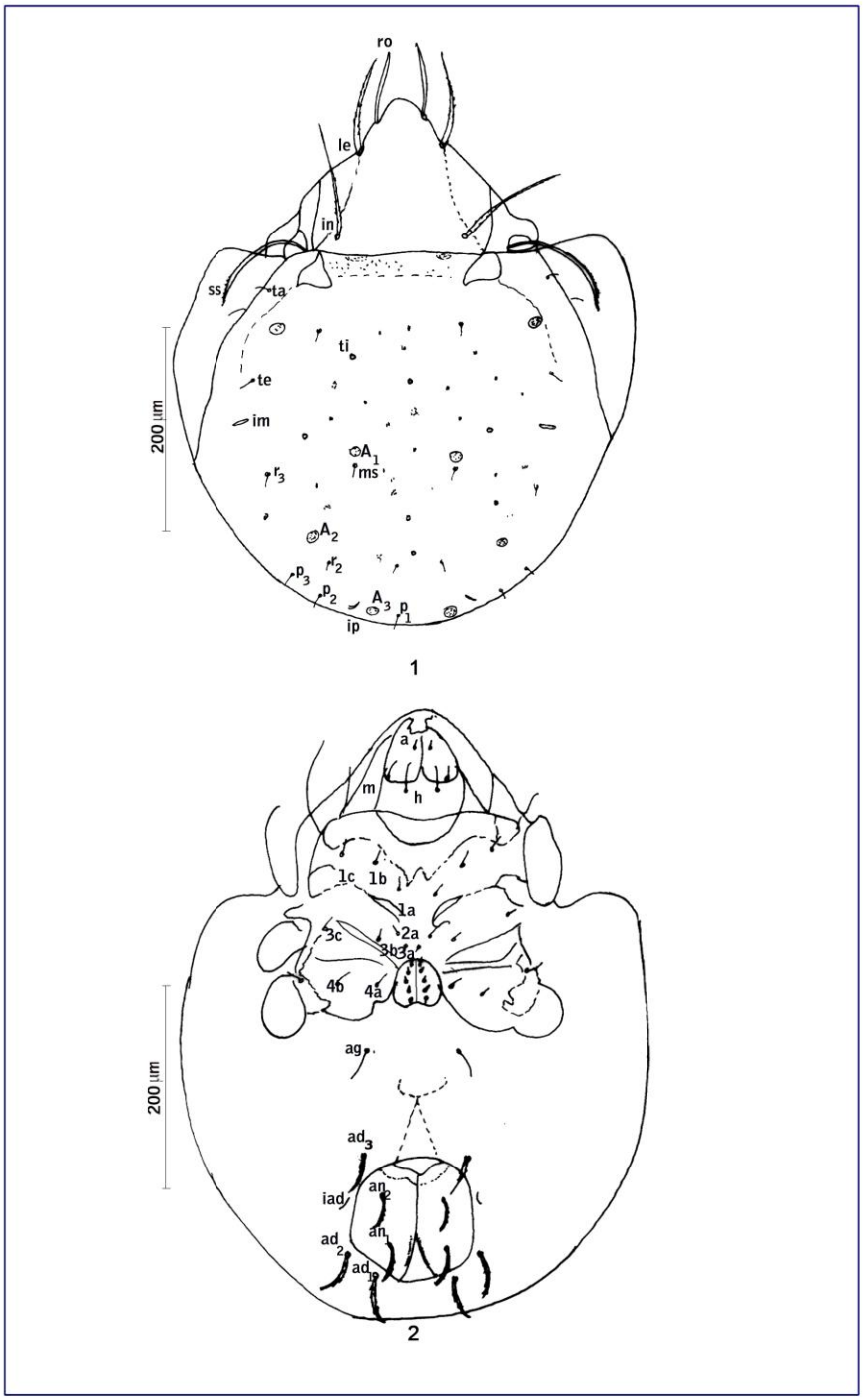
200 µm
1
h
1c
1b
1a
2a
3b
3a
3c
4a
4b
4a
4c
ag
200 µm
ad_3
iad
an_2
ad_2
an_1
ad_1
2

PLATE 31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A1
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A2
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p3
p2
A3
p1
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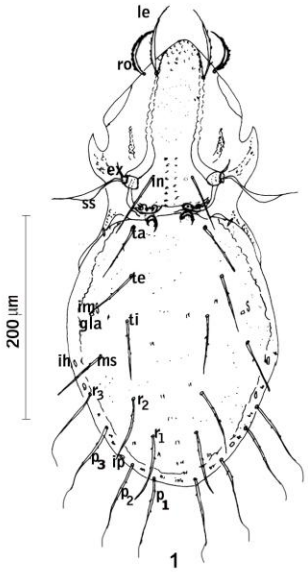
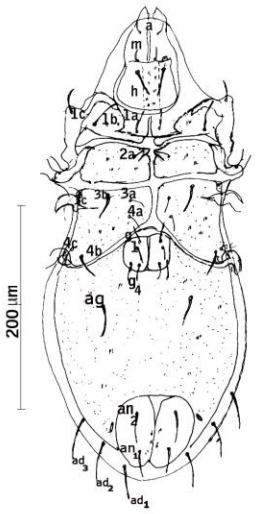
1b
1a
2a
3c
3b
3a
4b
4a
ag
200 µm
ad3
iad
an2
an1
ad2
ad1
2

PLATE 32



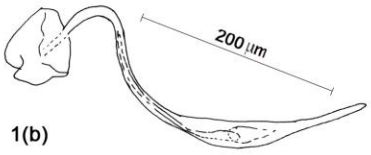
1



2

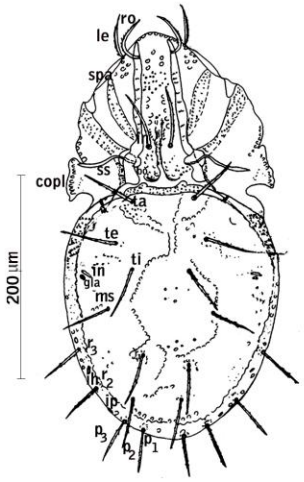
1(a)

1(c)

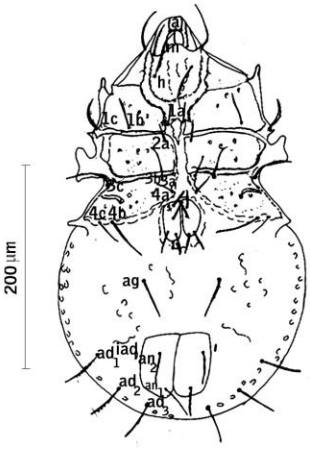


1(b)

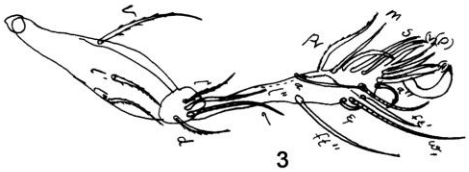
PLATE 33



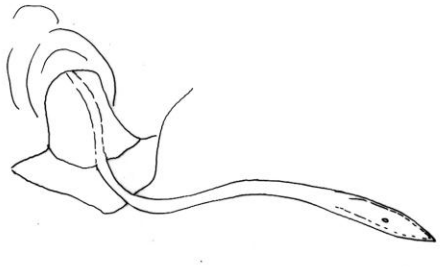
1



2

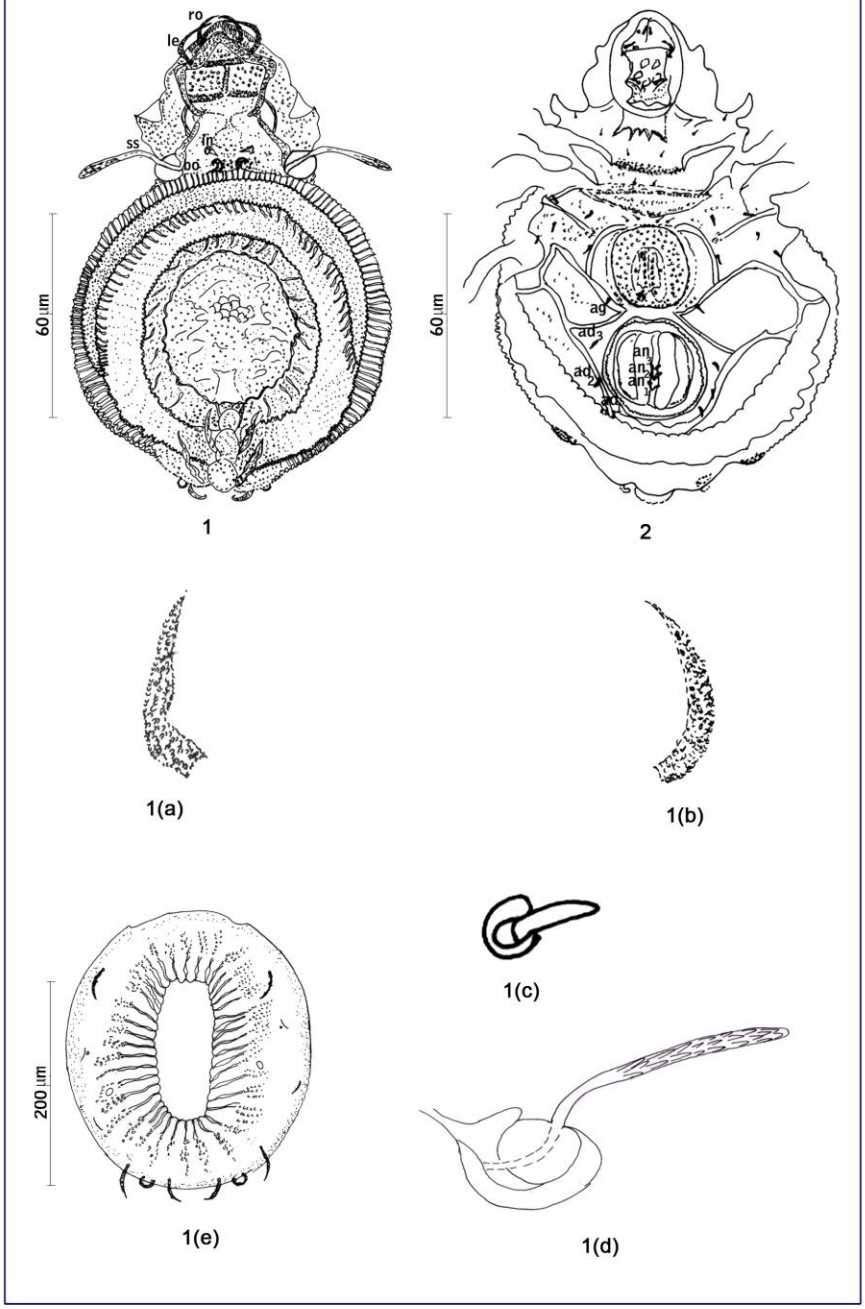


3



1(a)

PLATE 34


ro
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60 µm
1
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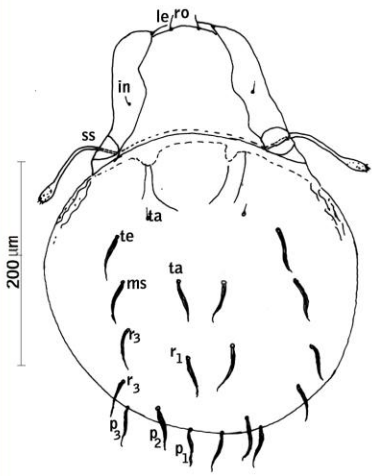
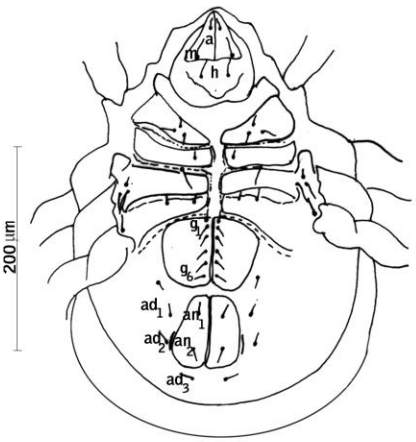
1(a)
1(b)
1(c)
200 µm
1(e)
1(d)

PLATE 35



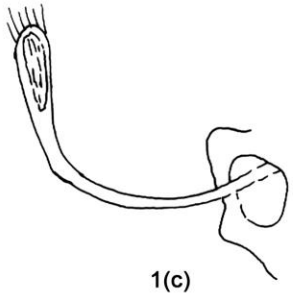
1



2

1(a)

1(b)



1(c)

PLATE 41

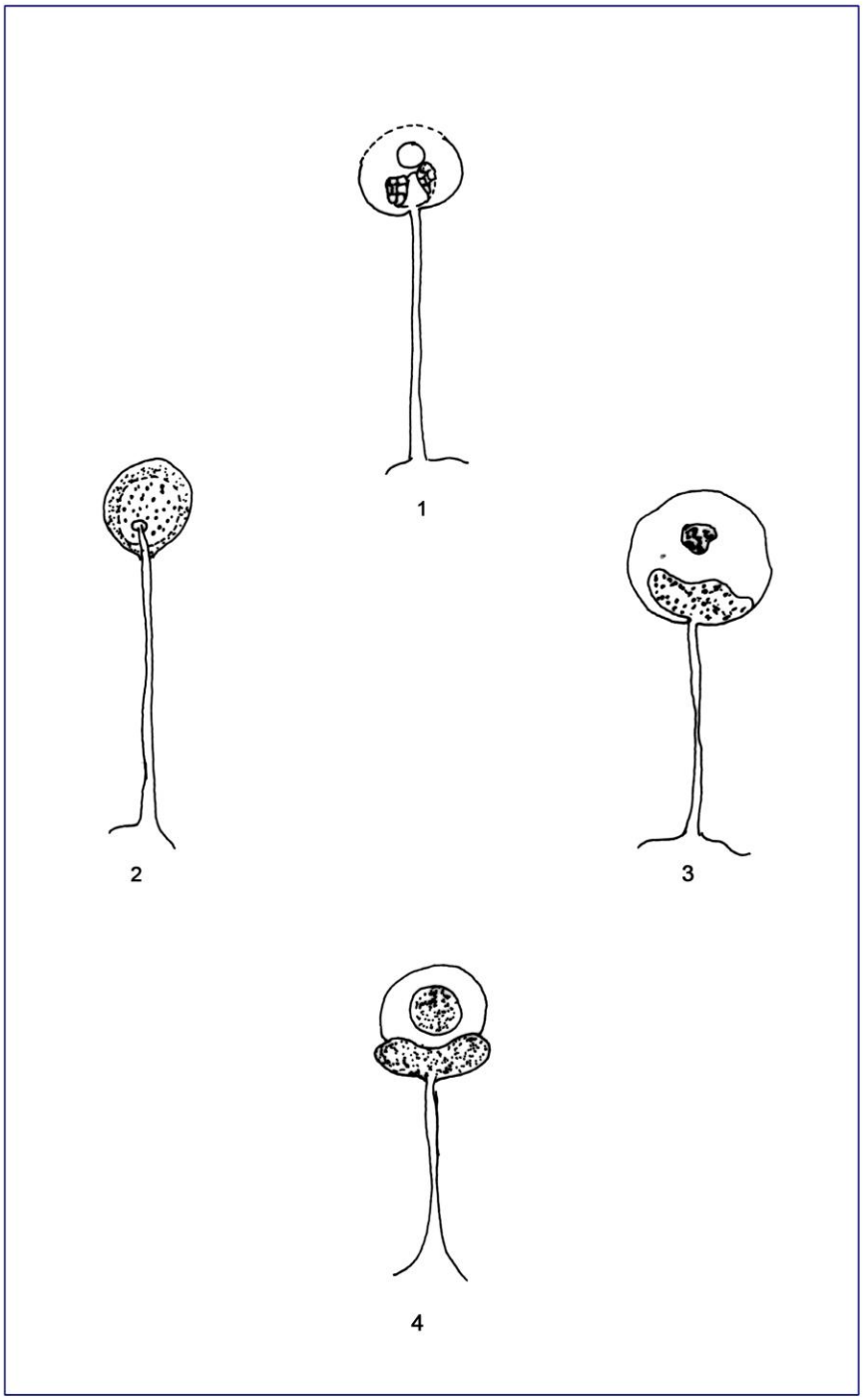


PLATE 42

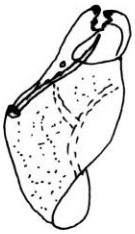
1(a)

1(b)

2(a)

2(b)

3(a)

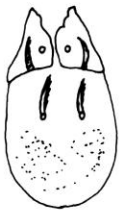


3(b)

4(a)

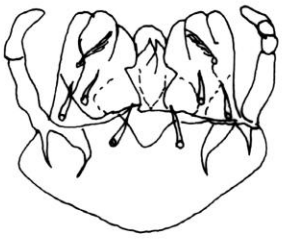
4(b)

PLATE 43



5a

5b

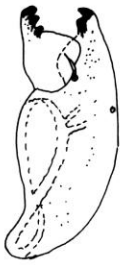


6a

6b

7a

7b



8

9

10

PLATE 49

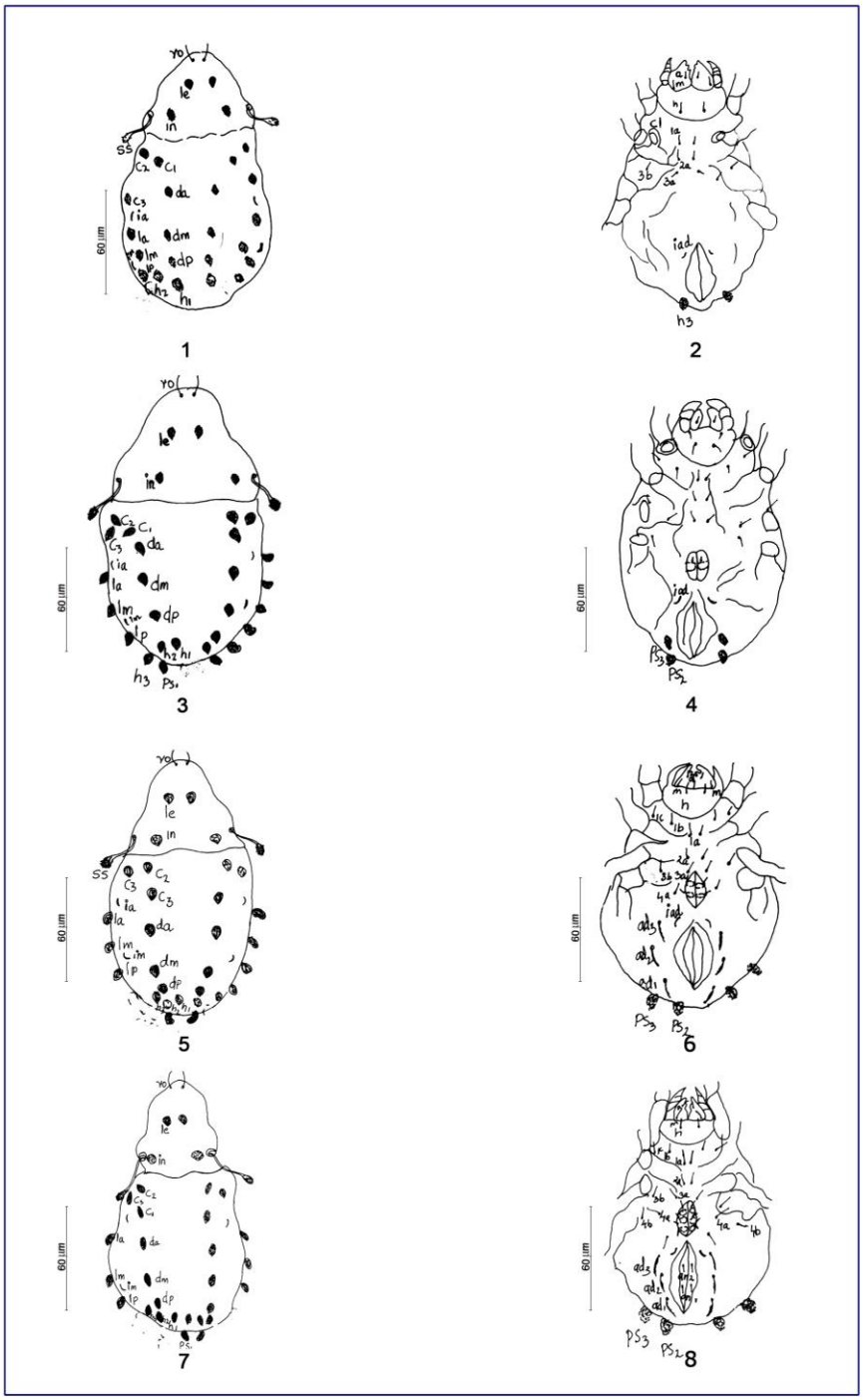


PLATE 51

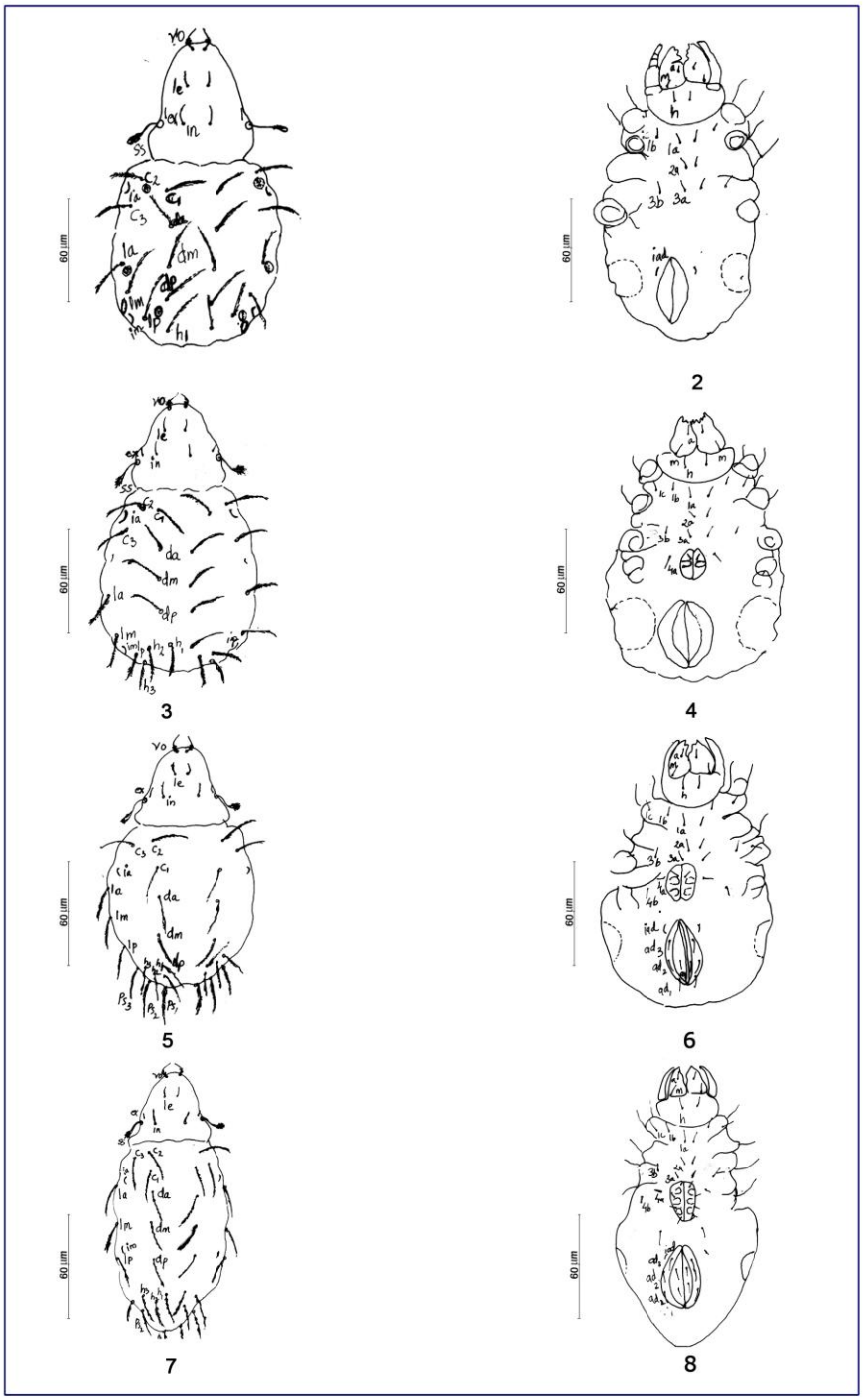


PLATE 53

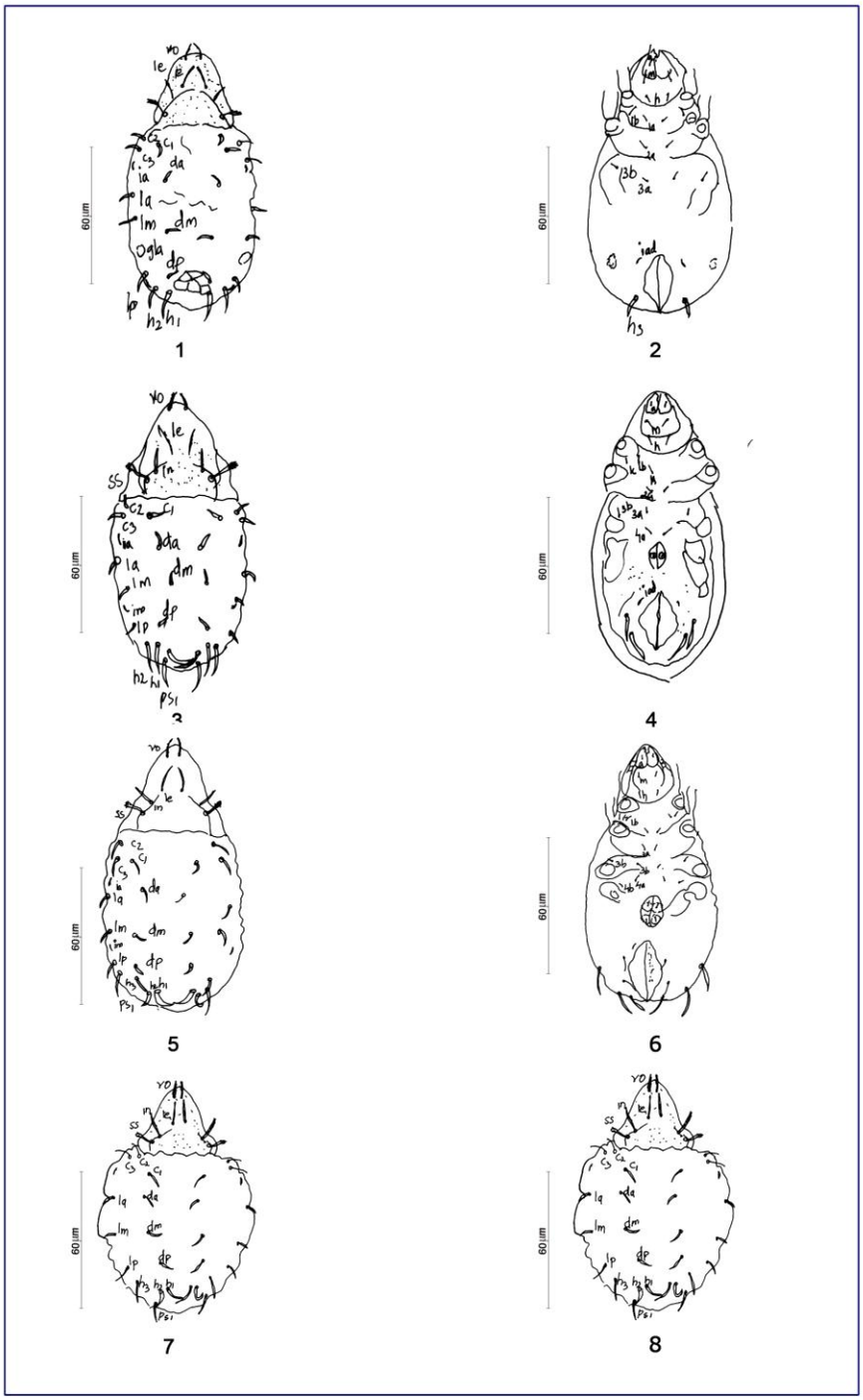


PLATE 55

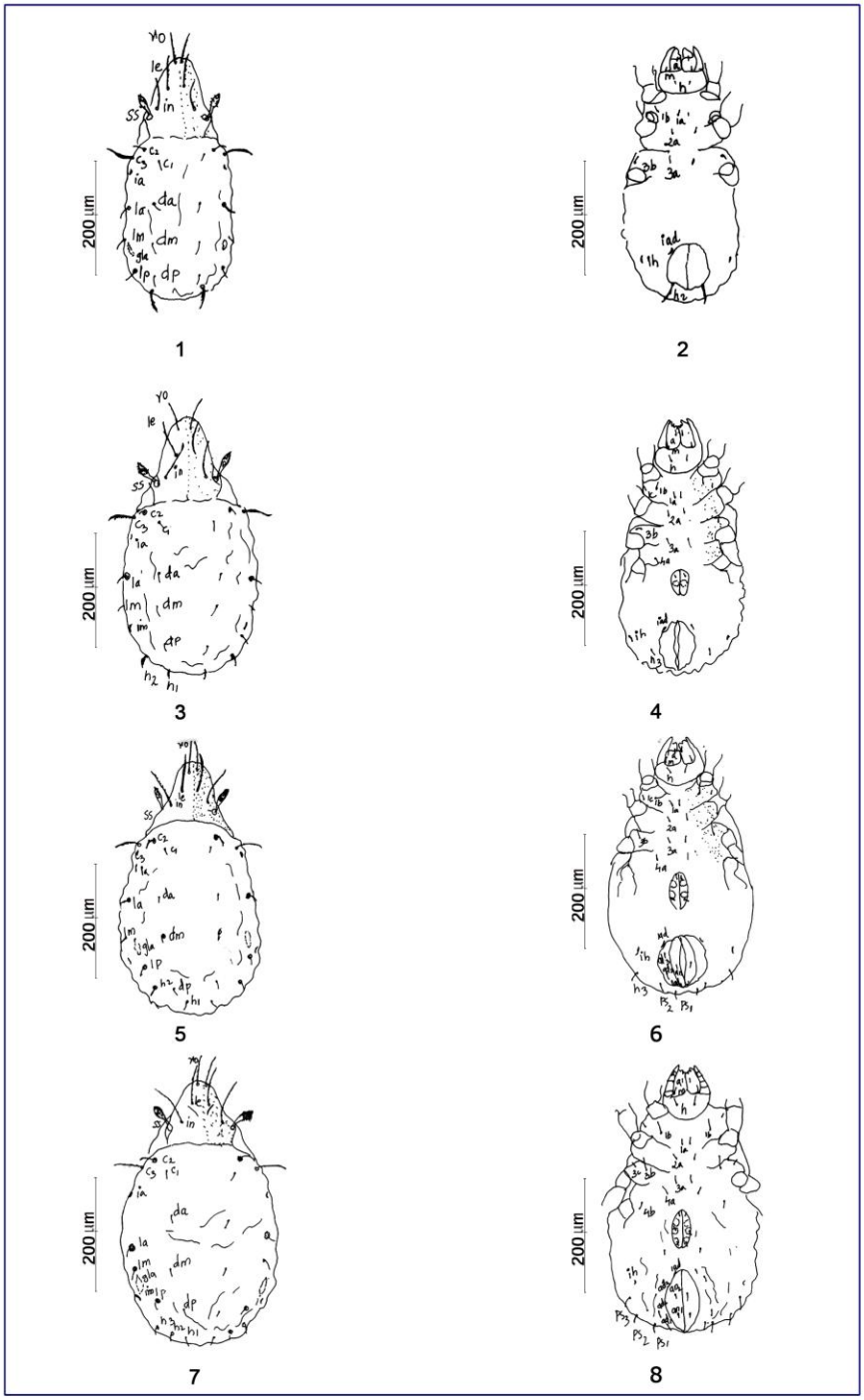


PLATE 57

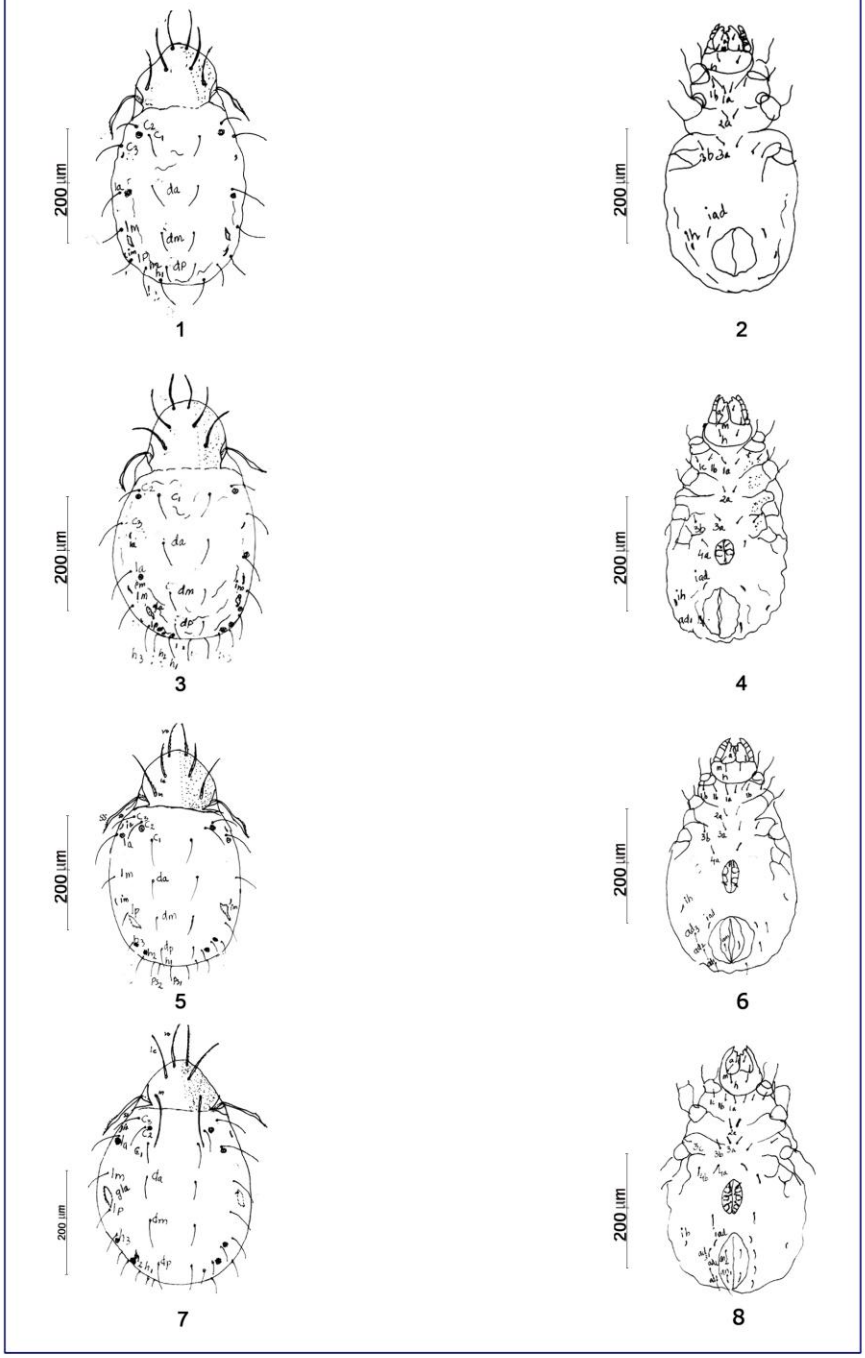


TABLE 1

Sites Surveyed

Site	District	Site locality	Vegetational geographic pecularities	Type of litter	Soil Texture	Soil Temperature	Humidity
1	Wayanad	Malankara, Kalpetta	*Coffea arabica*	High	Brown	23^0C	70%
2	,,	Santhigiri Ashram, Sultan Battery	*Camellia sinensis*	Low	Brown	24^0C	72
3	,,	Muthanga Reserve Forest	*Bambusa arundinacea, Mimusops elengi*	High	Black	19	56%
4	,,	,,	Waterlogged area bordered by *Artocarpus hirsutus*	Low	Ash	19	80%
5	,,	,,	*Artocarpus hirsutus, Muraya exotica*	High	Black	21	56%
6	,,	,,	*Artocarpus hirsutus Ficus racemosa*	Medium	Brown	23	56%
7	,,	,,	*Mimusops elengi*	High	Black	23	56%
8	,,	,,	*Tectona grandis*	Low	Pale brown	19	80%
9	‘‘	,,	*Bambusa arundinacea*	Medium	Dark brown	19	65%
10	,,	,,	Fully waterlogged area margined with *Bambusa arundinacea*	Low	Pale brown	19	80%
11	‘‘	,,	Water logged area		Ash	21	80%

12	Kozhikode	Kizhekumpadam palam near the Beypore river	Mangrove vegetation *Avicennia officinalis* L, *Acanthus ilicifolius, grasses* like, *Paspalam* sp and *Mariscus javanicus*, pith	High	Ash	21	75%
13	,,	Padipadam, Feroke near Kadalundi river	Retting ground bordered by *Cocos nucifera*, *Avicennia officinalis* L, *Acanthus ilicifolius*, pith	High	Brown	20	80%
14	,,	Mankavu near Kallai river	*Avicennia officinalis* L *Acanthus ilicifolius*	Low	Ash	22	76%
15	,,	Chaliyar Kadavu near Chaliyar river	*Saccharium officinarium*	Low	Ash	21	78%
16	,,	Kottakadavu near Kadalundi river	*Avicennia officinalis, Acanthus ilicifolis, Excorcavia agallocha* L	Medium	Pale Yellowish brown	21	77%
17	Malappuram	Hilly area at Kizhisserry	*Xylia xylocarpa, Mimusops elengi,, Dalbergia lanceoloria, Mangifera indica Semecarpus anacardium*	High	Black	24	66%
18	,,	Home yard at Kizhisserry	*Emblica officinalis Tamarindus indica*	Low	Brown	25	68%
19	,,	Vazhakkad near Chaliyar river	Water logged area bordered by *Bambusa arundinacea*	Low	Ash	21	80%

20	,,	Edavannappara	*Pandanus odoratissimus* bordering the paddy field which is semi water logged area.	Low	Yellowish brown	22	72%
21	Thrissur	Punkunnam	*Artocarus heterophyllus*	Low	Pale brown	25	58%
22	Idukki	Thovala,Mannakudy	*Hevea brasiliensis*	Medium	Brown	23	60
23	Thiruvananthapuram	Santhigiri Herbal Garden	*Ficus racemosa, Justicia beddomei, Alpinia galangal, Vitex negundo, Eclipta prostrata, Azadiracta indica, Ipomoea mauritiana, Hemidesmus indicus, Vernonia cineria, Saraca asoca*	Santhigiri Herbal garden	Black	22	72%
24	,,	Santhigiri Herbal garden	Biowaste accumulation	Black	High	23	74%
25	,,	Santhigiri Ashram Premises	*Artocarpus hirsutus, Asparagus racemosus, Pongamia glabra, Erythrina varigeta*	Brown	Medium	22	73%

TABLE 2

Systematic Position of the Oribatid Species Collected During the Study:

Based on Subias 2007 World Oribatid Catalogue

Site	Superfamily	Family	Genus	Subgenus	Species
1	Amerobelboidea Grandjean, 1954	Basilobelbidae Balogh, 1961	*Basilobelba* Balogh, 1958		*Basilobelba indica* Bhaduri, Chakrabarti & Rayachaudhuri, 1974
2	"	"	*Xiphobelba* Csiszar, 1961		*Xiphobelba santhigiriensis* sp. nov.
3	"	Eremulidae Grandjean, 1965	*Eremulus* Berlese, 1908		*Eremulus avenifer* Berlese, 1913
4	"	"	"		*E. curviseta* Hammer,1971
5	"	"	"		*E. flagellifera* Berlese, 1908
6	"	"	"		*E. truncatus* Hammer, 1971
7	"	"	*Pseuderemulus* Balogh & Mahunka, 1968		*Pseuderemulus gladiator* Balogh & Mahunka, 1968
8	Carabodoidea Koch, 1837	Carabodidae Koch, 1835	*Austrocarabodes* Hammer,1966	*Austrocarabodes* (*Austrocarabodes*) Hammer, 1966	*Austrocarabodes elegans* Hammer, 1966
9	"	"	*Carabodes* Mahunka,1979	*Carabodes* (*Klapperiches*) Mahunka, 1979	*Carabodes* (*Klapperiches*) *nigrosetosus* (Mahunka, 1979)

Site	Superfamily	Family	Genus	Subgenus	Species
10	Galumnoidea Jacot, 1925	Galumnidae Jacot, 1925	*Galumna* Von Heyden, 1826	*Galumna* (*Galumna*) Von Heyden, 1826	*Galumna flabellifera* Hammer, 1958
11	"	"	"	"	*G .discifera Balogh, 1960*
12	"	"	"	"	*G. flabellifera orientalis* Aoki,1965
13	"	"	"	"	*G. chujoi* Aoki, *1966*
14	"	"	"	*G.* (*Indogalumna*) Balakrishnan, 1985	*G. (Indogalumna) intermedius* sp. nov
15	"	"	*Allogalumna* Grandjean, 1936		*Allogalumna pellucida* Wallwork, 1965
16	"	"	*Pergalumna* Grandjean,1936		*Pergalumna bimaculata* Hammer, 1973
17	"	"	"		*P. intermedia* Aoki, 1963
18	Gustavioidea Oudemans, 1900	Astegistidae Balogh, 1961	*Cultroribula* Berlese, 1908		*Cultroribula lata* Aoki, 1961
19	Licneremaeoidea Grandjean, 1931	Scutoverticidae Grandjean, 1954	*Scutovertex* Michael, 1879		*Scutovertex sculptus* Michael, 1879
20	Microzetoidea Grandjean, 1936	Microzetidae Grandjean, 1936	*Berlesezetes* Mahunka, 1980		*Berlesezetes brazilozetoides* Balogh and Mahunka,1981
21	Oppioidea Sellnick, 1937	Oppiidae Sellnick, 1937	*Arcoppia* Hammer, 1977		*Arcoppia spotus* sp. nov.

Site	Superfamily	Family	Genus	Subgenus	Species
22	"	"	*Brachioppia* Hammer, 1961		*Brachioppia cajamarcensis* Hammer, 1961
23	"	"	"		*B. cuscensis* Hammer, 1961
24	"	"	*Lanceoppia* Hammer, 1962	*Lanceoppia (Lanceoppia)* Hammer, 1962	*Lanceoppia lancearia* (Balogh & Mahunka, 1975)
25	"	"	*Oppia* Koch,1936		*Oppia kuehnelti* Csizar,1961
26	"	"	*Ramusella* Hammer, 1962	*Ramusella (Ramusella)* Hammer, 1962	*Ramusella philippinensis* (Mahunka, 1982)
27	"	"	*Corynoppia* Balogh, 1983		*Corynoppia ajaii* sp. nov.
28	Oripodoidea Jacot, 1925	Caloppiidae Balogh, 1960	*Chaunoproctus* Pearce, 1906		*Chaunoproctus abalai* Bhaduri, Bhattacharya & Chakrabarti, 1975
29	"	Haplozetidae Grandjean, 1936	*Indoribate*s Jacot, 1929		*Indoribates philippinensis*, CorpuzRaros, 1979.
30	"	"	*Magyaria* Balogh, 1963		*Magyaria ornata* Balogh 1963
31	"	"	*Peloribates* Berlese, 1908	*Peloribates (Peloribates)* Berlese, 1908	*Peloribates asejugalis* (Pandit & Bhattacharya, 1999)
32	"	"	*Pilobatella* Balogh& Mahunka,1967		*Pilobatella genitae* sp. nov.

Site	Superfamily	Family	Genus	Subgenus	Species
33	“	“	*Trachyoribates* Berlese, 1908	*Trachyoribates (Rostrozetes)* Sellnick, 1925	*Trachyoribates (Rostrozetes) striata* sp. nov.
34	“	“	“	“	*T.(Rostrozetes) foveolatus* Sellnick, 1925
35	“	Scheloribatidae Jacot, 1935	*Scheloribates* Berlese, 1908	*Scheloribates* (*Scheloribates*) (Berlese, 1908)	*Scheloribates praeincisus interruptus* Berlese, 1916
36	“	“			*S.praeincisus* Berlese, 1910
37	“	“			*S. praeincisus rotundiclava* Perez indigo &Baggio, 1986
38	“	“			*S. praeincisus fijiensis* Hammer, 1971
39	“	“			*S. thermophilus* Hammer, 19
40	“	“			*S. decarinatus* Aoki, 1984
41	“	“			*S. rectus* Hammer, 1958
42	“	Scheloribatidae	*Perscheloribates* Hammer, 1973	*Perscheloribates* (*Perscheloribates*) Hammer, 1973	*Perscheloribates clavatus* Hammer, 1973
43	“	“	*Ischeloribates* Corpuz-Raros, 1980		*Ischeloribates lanceolatus* Aoki, 1984
44	“	“	“		*I. cavernicolus* Corpuz-Raros, 1980
45	“	Protoribatidae Balogh &Balogh,1984	*Protoribates* Berlese,1908		*Protoribates triangularis* Hammer, 1971

Site	Superfamily	Family	Genus	Subgenus	Species
46	“	“	“		*P.bisculpturatus* Mahunka, 1988
47	“	“	“	“	*P .punctata* Grobler,1991
48	“	“	“	“	*P.seminudus* Hammer, 1978
49	“	Tetracondylidae Aoki, 1961	*Dolicheremaeus* Jacot, 1938		*Dolicheremaeus indicus* Haq, 1978
50	“	“	“		*D.fijiensis* Hammer, 1973
51	Otocepheoidea Balogh, 1961	Otocepheidae Balogh, 1961	*Megalotocepheus* Aoki,1965		*Megalotocepheus kizhisseriensis* sp. nov.
52	Phenopelopoidea Petrunkevitch, 1955	Phenopelopidae Petrunkevitch, 1955	*Eupelops* Ewing, 1917		*Eupelops tahitiensis* Hammer, 1972
53	Plateremaeoidea Tragardh, 1926	Pheroliodidae Paschoal, 1987	*Pheroliodes* Grandjean, 1931		*Pheroliodes ciliata* sp. nov
54	Tectocepheoidea Grandjean, 1954	Tectocepheidae Grandjean, 1954	*Tectocepheus* Berlese, 1896		*Tectocepheus velatus* Michael, 1880
55	“	Tegeocranellidae P. Balogh, 1987	*Tegeocranellus* Berlese, 1913		*Tegeocranellus laevis* Berlese, 1905
56	Trizetoidea Ewing, 1917	Suctobelbidae Jacot, 1938	*Suctobelbella* Jacot, 1937	*Suctobelbella* (*Ussuribata*) Rajabinin, 1975	*Suctobelbella variosetosa* Hammer, 1961
57	Zetomotrichoidea Grandjean, 1934	Zetmotrichidae Grandjean, 1934	*Zetomotrichus* Grandjean, 1934	*Zetomotrichus (keralotrichus)* Mahunka,1985	*Zetomotrichus plumosus* Mahunka, 1985

TABLE 3
Relative distribution of the various oribatid species in the study sites

Sl. NO.	Species	Wayanad											Kozhikode					Malappuram				Thrisur	Idukki	Thiruvananthapuram		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	*Basilobelba indica* Bhaduri, Chakrabarti & Rayachaudhuri, 1974	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++++	+++	-	-	-	+++		+++	++
2	*Xiphobelba santhigiriensis* sp. nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++++	++++	++
3	*Eremulus avenifer* Berlese, 1913	-	++++	-	-	-	-	++++	-	-	-	-	-	-	-	-	-	++++	+++	-	-	-	-	+++++	++++	+++
4	E.curviseta Hammer,1971	+++	-	++++	-	+++	-	+++	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	+++	-	++	-
5	*E. flagellifer* Berlese, 1908	-	+++	+++	-	-	+++	-	-	-	-	-	-	-	-	-	-	+++	-	-	-	-	-	-	-	++++
6	*E. truncatus* Hammer, 1971	++	-	++++	-	++++	-	-	-	++++	-	-	-	-	-	-	-	-	-	-	-	-	+++	-	-	-
7	*Pseuderemulus gladiator* Balogh & Mahunka, 1968	-	-	-	-	+++	-	-	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	*Cultroribula lata* Aoki, 1961	+++	-	++++	-	-	-	+++++	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	-	++
9	*Austrocarabodes elegans* Hammer, 1966	++	-	++++	-	+++	-	+++	-	++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	*Carabodes* (*Klapperiches*) *nigrosetosus* Mahunka, 1979	-	-	+++	-	++++	-	-	-	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	*Scutovertex sculptus* Michael, 1879	-	++++	-	-	++++	-	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++	-	-
12	*Berlesezetes*	+++	++	-	+++	-	-	-	-	-	-	-	-	+++	++	-	+++++	+++	+++	-	-	-	-	++++	+++	-

Sl. NO.	Species	Wayanad											Kozhikode					Malappuram				Thrisur	Idukki	Thiruvananthapuram		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	brazilozetoides Balogh and Mahunka,1981																									
13	*Arcoppia spotus* sp. nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	++	-	-	-	-	-	-	-
14	*Brachioppia cajamarcensis* Hammer, 1961	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++++	-	-	-	-	-	-	-	-
15	*B. cuscensis* Hammer, 1961	-	-	-	-	-	-	-	-	-	-	-	++++	-	-	-	++	-	-	-	-	++	-	-	-	-
16	*Lanceoppia lancearia* Balogh & Mahunka, 1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	+++	++
17	*Oppia kuehnelti* Csizar,1961	++++	-	+++++	-	+++	++++	-	-	+++	-	-	-	-	-	-	-	+++	++++	-	-	-	+++	-	+++	-
18	*Ramusella philippinensis* Mahunka, 1982	-	-	-	-	-	-	-	-	-	-	-	+++	++++	-	-	+++++	-	-	-	-	-	-	-	-	-
19	*Corynoppia ajiai* sp. nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++++	+++	++++
20	*Chaunoproctus abalai* Bhaduri, Bhattacharya & Chakrabarti, 1975	-	++++	-	-	-	-	-	-	+++	-	-	-	-	-	-	-	++	-	-	-	-	+++	++	-	-
21	*Indoribates philippinensis* Corpis-Raros, 1979.	-	-	-	-	-	-	-	-	-	-	-	++	-	-	+++++	+++++	-	-	++	-	-	-	-	-	-
22	*Magyaria ornata* Balogh 1963	-	-	+++	-	-	-	-	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++	-
23	*Peloribates asejugalis* Pandit & Bhattacharya, 1999	-	+++	+++	-	++++	-	+++	-	-	-	-	-	-	-	-	-	++++	-	-	-	-	+++	++++	++++	+++
24	*Pilobatella genitae*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++++	++++	++++

Sl. NO.	Species	Wayanad											Kozhikode					Malappuram				Thrisur	Idukki	Thiruvananthapuram		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	sp. nov																									
25	*T.(Rostrozetes) foveolatus* Sellnick, 1925	++++	++++	+++	-	-	-	++++	-	+++++	-	-	+++++	++++	++	-	++++	++++	+++	-	-	-	+++	+++	+++	++++
26	*T.(Rostrozetes) striata* sp. nov	-	-	-	-	-	-	-	-	-	-	-	++++	+++++	+++++	-	+++	-	-	-	-	-	-	-	-	-
27	*Scheloribates praeincisus interruptus* Berlese, 1916	+++	+++	-	-	-	-	+++++	-	-	-	-	++++	++++	-	-	+++	+++++	+++	-	-	+++	-	+++	-	+++
28	*S.praeincisus* Berlese, 1910	-	+++	++++	-	+++	-	++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	+++	+++
29	*S. praeincisus rotundiclava* Perez indigo &Baggio, 1986	-	-	++++	-	+++	++++	-	+++	-	-	-	-	-	-	-	-	++++	+++	-	-	+++	-	++++	+++	-
30	*S. praeincisus fijiensis* Hammer, 1971	-	-	++	-	-	-	-	-	++++	-	-	-	-	-	-	-	-	-	-	-	++	-	-	++++	-
31	*S. thermophillus* Hammer, 1961	-	-	-	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	++++	+++
32	*S. decarinatus* Aoki, 1984	-	-	++++	-	-	-	-	-	+++	-	-	-	-	-	-	-	++++	+++	-	-	-	+++	-	-	-
33	*S. rectus* Hammer, 1958	-	-	-	-	++++	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	*Perscheloribates clavatus* Hammer, 1973	-	-	-	-	+++++	-	+++	-	+++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	*Ischeloribates lanceolatus* Aoki, 1984	-	-	+++	-	-	+++	-	-	++	-	-	-	-	-	-	-	-	-	-	-	-	-	+++	-	-
36	*I. cavernicolus*	-	-	+++	-	-	-	++++	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sl. NO.	Species	Wayanad											Kozhikode					Malappuram				Thrisur	Idukki	Thiruvananthapuram		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Corpuz-Raros, 1980																									
37	*Protoribates triangularis* Hammer,1971	-	-	+++++	-	-	+++	++	-	+++++	-	-	-	-	-	-	-	-	-	-	-	+++	-	+++	++++	-
38	*P.bisculpturatus* Mahunka,1988	-	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	++++	+++	+++
39	*P.punctata* Grobler,1991	-	-	+++++	-	-	-	-	-	-	-	-	+++++	++++	-	-	++++	++++	++++	-	-	-	+++	++++	+++++	-
40	*P.seminudus* Hammer, 1972	+++	++++	++++	-	+++++	-	+++++	-	-	-	-	-	-	-	-	++	+++	++	-	-	++	-	-	-	-
41	*Galumna flabellifera* Hammer, 1958	+++	-	++++	-	+++++	-	+++	-	+++	-	-	-	-	++	-	-	-	++	-	-	-	-	-	-	-
42	*G .discifera* Balogh, 1960	++	+++	-	-	-	-	++++	-	-	-	-	-	-	-	-	-	+++++	-	-	-	-	+++	+++	++++	-
43	*G.flabellifera orientalis* Aoki,1965	-	-	-	-	+++	-	++++	-	-	-	-	++++	-	-	-	+++	-	-	-	-	-	-	-	-	+++
44	*G.chujoi* Aoki, 1966	-	-	++++	-	+++	-	++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++	++++	-
45	*Indogalumna intermedius* sp. nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	-	-	-	-	-	-	-	-
46	*Allogalumna pellucida*, Wallwork, 1965	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	-	-	-	-	-	-	-	-
47	*Pergalumna bimaculata* Hammer, 1973	-	-	+++	+++	-	-	+++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-
48	*P. intermedia*	-	-	+++++	-	++++	-	-	-	-	-	-	-	-	-	-	-	+++	-	-	-	-	-	+++	++	-

Sl. NO.	Species	Wayanad											Kozhikode					Malappuram				Thrisur	Idukki	Thiruvananthapuram		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Aoki, 1963																									
49	*Eupelops tahitiensis* Hammer, 1972	-	-	++++	-	+++++	-	+++	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-
50	*Pheroliodes ciliata* sp. nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++++	-	-	-	-	-	-	-	-
51	*Tectocepheus velatus* (Michael, 1880)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	++	-	-	+++	++++	-
52	*Tegeocranellus laevis* Berlese, 1905	-	-	-	++++	-	-	-	-	-	-	++++	+++++	+++++	++	+++++	+++++	-	-	+++	+++++	-	-	-	-	-
53	*Suctobelba variosetosa* Hammer, 1961	-	++++	+++	-	-	-	+++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++	++++	-
54	*Zetomotrichus plumosus* Mahunka, 1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+++	+++	-	-	-	-	+++	++++	-
55	*Megalotocepheus kizhisseriensis* sp. nov	-	-	-	-	-	-	-	-	-	-	--	-	-	-	-	-	+++++	-	-	-	-	-	-	-	-
56	*Dolicheremaeus indicus* Haq,1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++++	-	-	-	-	-	++++	++++	-
57	*D.fijiensis* Hammer, 1973	-	-	+++++	-	-	-	+++	-	++++	-	-	-	-	-	-	-	+++	-	-	-	-	++++	+++	++++	-

'+' 5-10 individuals '++' 10-15 individuals '+++' 15-20 individuals '++++' 20-25 individuals '+++++' 25-30 individuals

Site 1: Malankara, Kalpetta **Site 2:** Santhigiri Ashram, Sultan Battery **Site 3-11:** Muthanga Reserve Forest (different vegetational/geographical peculiarities)
Site 12: Kizhekumpadam palam (near the Beypore River) **Site 13:** Pandipadam, Feroke (near Kadalundi River) **Site 14:** Mankavu (Near Kallai River)
Site 15: Chaliyar Kadavu (near Chaliyar River) **Site 16:** Kottakkadavu (near Kadalundi River) **Site 17:** Hilly area in Kizhissery
Site 18: Home yard at Kizhissery **Site 19:** Vazhakkad (near Chaliyar River) **Site 20:** Edavannappara **Site 21:** Punkunnam **Site 22:** Thovala, Mannakudy
Site 23: Santhigiri Herbal Garden **Site 24:** Santhigiri Herbal Garden (Biowaste Deposit) **Site 25:** Santhigiri Ashram premises

TABLE 4

Systematic Position of the Species Studied

Site	Species	Genus	Family	Superfamily
1	*Xiphobelba santhigiriensis*. sp. nov.	*Xiphobelba* Csiszar, 1961	Basilobelbidae Balogh, 1961	Amerobelboidea Grandjean, 1954
2	*Eremulus avenifer*, Berlese 1913	*Eremulus* Berlese, 1908	Eremulidae, Grandjean, 1965	Amerobelboidea Grandjean, 1954
3	*Arcoppia spotus* sp. nov.	*Arcoppia* Hammer 1977	Oppiidae Sellnick, 1937	Oppioidea Sellnick, 1937
4	*Brachioppia cajamarcensis* Hammer, 1961	*Brachioppia* Hammer, 1961	Oppiidae Sellnick, 1937	Oppioidea Sellnick, 1937
5	*Ramusella philippinensis* (Mahunka, 1982)	*Ramusella* Hammer, 1962	Oppiidae Sellnick, 1937	Oppioidea Sellnick, 1937
6	*Corynoppia ajaii* sp. nov.	*Corynoppia* Balogh, 1983	Oppiidae Sellnick, 1937	Oppioidea Sellnick, 1937
7	*Scheloribates praeincisus interruptus* (Berlese, 1916)	*Scheloribates* Berlese, 1908	Scheloribatidae Jacot, 1935	Oripodoidea Jacot, 1925
8	*Protoribates bisculpturatus* Mahunka, 1988	*Protoribates* Berlese,1908	Protoribatidae, Balogh &Balogh,1984	"
9	*P. punctate* Grobler, 1991	"	"	"
10	*Pilobatella genitae* sp. nov.	*Pilobatella* Balogh & Mahunka, 1967	Haplozetidae Grandjean, 1936	Oripodoidea Jacot, 1925

11	*Trachyoribates* (*Rostrozetes*) *striata* sp. nov.	*Trachyoribates (Rostrozetes) Sellnick, 1925*	Haplozetidae Grandjean, 1936	Oripodoidea Jacot, 1925
12	*T. (Rostrozetes) foveolatus*, Sellnick, 1925	*Trachyoribates (Rostrozetes)* Sellnick, 1925	Haplozetidae Grandjean, 1936	Oripodoidea Jacot, 1925
13	*Tegeocranellus laevis* (Berlese, 1905)	*Tegeocranellus* Berlese, 1913	Tegeocranellidae P. Balogh, 1987	Tectocepheoidea Grandjean, 1954
14	*Berlesezetes brazilozetoides* Balogh and Mahunka, 1981	*Berlesezetes* Mahunka, 1980	Microzetidae Grandjean, 1936	Microzetoidea Grandjean, 1936
15	*Megalotocepheus kizhisseriensis* sp. nov.	*Megalotocepheus* Aoki, 1965	Otocepheidae Balogh, 1961	Otocepheoidea Balogh, 1961
16	*Dolicheremaeus indicus* Haq, 1978	*Dolicheremaeus* Jacot, 1938	Tetracondylidae Aoki, 1961	Otocepheoidea Balogh, 1961
17	*Pheroliodes ciliata* sp. nov	*Pheroliodes* Grandjean, 1931	Pheroliodidae Paschoal, 1987	Plateremaeoidea Tragardh, 1926
18	*Indoribates philippinensis* Corpuz-Raros, 1979	*Indoribate*s Jacot, 1929	Haplozetidae Grandjean, 1936	Oripodoidea Jacot, 1925
19	*Allogalumna pellucida* Wallwork, 1965	*Allogalumna* Grandjean, 1936	Galumnidae Jacot, 1925	Galumnoidea Jacot, 1925
20	*Galumna (Indogalumna) intermedius* sp. nov.	*Glaumna (Indogalumna)* Balakrishnan, 1985	Galuminidae Jacot, 1925	Galumnoidea Jacot, 1925

TABLE 5

Gut Content Analysis of Field Collected Oribatid Mites

	Mites selected	Mites dissected	Food boli/ Faecal Pellets analysed	1	2	3	4	5	6	7	Remarks
				FungaL hyphae/Conidia/spores	Algae	Moss	Leaf particles	Wood particles	Pollen grain	Unidentified/fully digested particles	
1	*Xiphobelba santhigiriensis* sp. nov.	10	17	+++	-	-	+	-	-	+	Panphytophage
2	*Eremulus avenifer*	15	21	+++	-	-	++	-	-	++	″
3	*Berlesezetes brazilozetoides*	15	10	+++	-	-	+	-	-	+	″
4	*Arcoppia spotus* sp. nov.	18	20	+++	-	+	+	-	-	+	″
5	*Brachioppia cajamarcensis*	20	22	+++	-	+	+	-	-	++	″
6	*Ramusella philippinensis*	23	20	++	+	-	+	-	-	++	″
7	*Corynoppia ajaii* sp. nov.	26	18	+++	-	-	+	-	-	+	″
8	*Indoribates philippinensis*	10	12	++	+	-	+	-	-	+	″
9	*Pilobatella genitae* sp. nov.	14	14	++	+	-	++	-	-	++	″
10	*Trachyoribates (Rostrozetes) foveolatus*	17	12	+++	-	-	+	-	-	+	″

11	*T. (Rostrozetes) striata* sp. nov.	15	10	+++	-	-	+++	++	-	++	″
12	*Scheloribates praeincisus interruptus*	25	17	+++	-	+	+++	+	+	++	″
13	*Protoribates bisculpturatus*	15	10	+++	-	+	++	+++	+	+++	″
14	*P. punctata*	16	12	+++	-	+	++	+++	+	+++	″
15	*Galumna (Indogalumna) intermedius* sp. nov.	12	10	+++	+	+	++	+++	+	++	″
16	*Allogalumna pellucida*	11	13	+++	+	+	+	+++	+	+	″
17	*Pheroliodes ciliata* sp. nov.	15	10	-	-	-	+++	+++	+	++	Macrophytophage
18	*Tegeocranellus laevis*	15	16	++	+	_	+	_	_	+	Panphytophage
19	*Megalotocepheus kizhisseriensis* sp. nov.	10	8	+++	-	-	++	+++	-	+	″
20	*Dolicheremaeus indicus*	12	15	+++	-	-	++	+++	-	+	″

+++ Indicate Presence of substance in more than 50% of mites examined

++ Indicate presence of substance in 25-50% of mites examined

\+ Indicate presence of substance in less than 2% of mites examined

\- absence of substances

TABLE 6

Results of Food Choice Test of Laboratory reared species of oribatd mites

	Oribatid Species	Fungi						Litter									Other Items				Remarks
		Trichoderma harzianum	*Trichoderma viridae*	*Altenaria alternata*	*Aspergillus niger*	*Curvularia geniculata*	*Phytophthora capscii*	*Dalbergia lanceolaria*	*Dalbergia lanceolaria*	*Artocarpus hirsutus*	*Anacardium occidentale*	*Xylia xylocarpa*	*Mimusops elenji*	*Emblica officinalis*	*Bambusa arundinacea*	*Acanthus ilicifolius*	Decayed pneumatophores	Cow dung	Coconut pith	Filter paper	
1	*Berlesezetes brasilozetoides*	$A^{++}E$	$A^{++}E$	$A^{++}E$	A	$A^{++}E^{1}$	A	A	A	A	A	A	A	A	A	A^{+}	A^{+}	A	A^{+}	A	Panphytopagy
2	*Corynoppia sp. nov.*	$A^{++}E^{2}$	$A^{++}E^{2}$	$A^{++}E^{1}$	$A^{++}E^{1}$	$A^{++}E^{2}$	$A^{++}E^{2}$	A E	AE	A	A	A	A	A	A	A	A	A	$A^{+}E^{1}$	$A^{+}E^{1}$	"
3	*Ramusella philippinensis*	$A^{++}E^{2}$	$A^{++}E^{1}$	$A^{++}E^{1}$	AE	$A^{++}E^{2}$	A E^{2}	A	A	AE	A	A	A	A	A	$A^{++}E^{2}$	$A^{++}E^{2}$	A	$A^{++}E^{2}$	$A^{+}E$	"
4	*Trachyoribates (Rostrozetes) foveolatus*	A+E	A+E	$A^{++}E^{2}$	A	$A^{++}E^{2}$	A	A	A	A	A	A+	A	A+	A	A^{+}	A	A	$A^{++}E$	A	"
5	*Scheloribates praeincisus interruptus*	$A^{++}E^{2}S^{2}$	$A^{++}E^{2}S^{2}$	$A^{++}E^{2}S^{2}$	AE	$A^{++}E^{2}S^{2}$	AE	$A^{++}E^{1}S^{1}$	$A^{++}E^{1}S^{1}$	$A^{+}ES$	$AE^{2}S^{2}$	AES	AES	$A^{+}E^{2}S^{2}$	AES	$A^{+}ES$	$A^{+}E$ S	$A^{++}E^{2}S^{2}$	$A^{++}E^{2}S$	AES	"
6	*Protoribates. punctata*	A	A	$A^{++}E^{2}S^{2}$	A	$A^{++}E^{2}S^{2}$	A	AES	$A^{++}E^{1}S^{1}$	$A^{+}E^{1}S^{1}$	$A^{++}E^{2}S^{2}$	$A^{++}E^{2}S^{2}$	$A^{+}ES$	$A^{++}E^{2}S^{2}$	$A^{+}ES$	$A^{+}ES$	$A^{++}ES$	$A^{++}E^{2}S^{2}$	$A^{++}E^{2}S^{2}$	$A^{++}E^{1}S^{1}$	"
7	*G.(Indogalumna) intermedius* sp. nov.	A E	A E	A+E	AE	AE	A	AE	$A^{+}E$	A^{+}	$A^{+}E$	$A^{+}E^{1}$	A	A	A	A	A	A	$A^{+}E$	$A^{++}E^{2}$	"
8	*Pheroliodes ciliata* sp. nov.	R	R	R	R	R	R	A	A^{++}	A^{+}	A^{++}	A^{++}	A	A^{+}	A	A	A	R	A	A	Macrophytophage
9	*Megalotocepheus kizhisseriensis* sp. nov.	R	R	$A^{++}S^{2}$	R	$A^{++}S^{2}$	R	A S	$A^{++}S^{2}$	A S	$A^{++}S^{2}$	$A^{++}S^{2}$	A	A	A	A	A	A	A	$A^{+}S^{2}$	Panphytophagy
10	*Dolicheremaeus indicus*	R	R	$A^{++}ES^{2}$	R	$A^{++}ES^{2}$	R	A S	$A^{++}S^{2}E$	A	$A^{++}S^{2}$	A^{+}	A	A	A	A	A	A	A	$A^{+}S^{2}E$	"

A^{++}- High Feeding A^{+}- Moderate Feeding A -Low Feeding R - Rejection E^{2}- High Deposition of Egg E^{1}-Moderate Deposition of Egg E - Low Deposition of Egg
S^{2} – High Deposition of Spermatophore S^{1} – Moderate Deposition of Spermatophore S – Low Moderate Deposition of spermatophore

TABLE 7: Quantitative Difference in Phosphorous Content in Soils Due to Oribatid Feeding at Various Sites (in ppm)

Site	Experimental sample		Control sample		t-value	p-value
	Mean	SD	Mean	SD		
3	139.00	0.5577	14.80	0.7881	79.213	0.000
13	39.54	0.67363	25.48	0.6713	46.751	0.000
16	10.530	0.37431	9.190	0.11005	10.861	0.000
17	11.4000	0.9428	10.200	0.9428	28.460	0.000
23	74.280	0.64429	45.120	0.77287	91.644	0.000
24	147.020	0.88919	108.180	0.58841	115.191	0.000

TABLE 8: Quantitative Difference in Potassium Content in Soils Due to Oribatid Feeding at Various Sites(in ppm)

Site	Experimental sample		Control sample		t-value	p-value
	Mean	SD	Mean	SD		
3	238.10	0.73786	182.80	0.91894	148.385	0.000
13	727.80	1.3165	156.60	1.646	856.80	0.000
16	141.90	0.87560	122.90	0.87560	48.522	0.000
17	210.00	0.81650	188.20	0.7881	60.722	0.000
23	248.70	0.94868	232.70	0.94868	37.712	0.000
24	783.00	1.333	613.00	1.33	285.099	0.00

TABLE 9: Quantitative Difference in the Nitrogen Content in Soils Due to Oribatid Feeding at Various Sites(in %)

Site	Experimental sample		Control sample		t-value	p-value
	Mean	SD	Mean	SD		
3	3.4160	0.00699	2.5140	0.00843	260.385	0.000
13	2.1820	0.00632	1.2820	0.00632	318.198	0.000
16	0.5710	0.01197	0.3940	0.00843	38.222	0.000
17	2.0440	0.00699	1.7330	0.00675	101.198	0.000
23	2.8800	0.00667	2.5630	0.01252	70.687	0.000
24	3.1990	0.0101	3.0110	0.00738	44.869	0.000

TABLE 10: Quantitative Difference in Nitrogen and Carbon Levels in Pith Samples Owing to Oribatid Feeding (in %)

Sl. No.	Nutrient	Experimental sample		Control sample		t-value	p-value
		Mean	SD	Mean	SD		
1	Nitrogen	0.2460	0.00699	0.1060	0.00699	44.772	0.000
2	Carbon	16.1520	0.00632	5.2520	0.00632	3853.732	0.000

TABLE 11: Quantitative Difference in Phosphorous and Potassium Levels in Pith Samples Owing to Oribatid Feeding

Sl. No.	Nutrient	Experimental sample		Control sample		t-value	p-value
		Mean	SD	Mean	SD		
1	Phosphorous	662.5500	0.47434	195.8800	0.10328	3039.911	0.000
2	Potassium	471.5800	0.36148	108.6800	0.61968	1599.646	0.000

TABLE 12

Duration of Development (in days) of

Life Stages of *C. ajaii* sp. nov. at 30^{0}C & 70% RH on *T.harzianum.*

Sl. No.	Egg	Larva	I Quiescence	Protonymph	II Quiescence	Deutonymph	III Quiescence	Tritonymph	IV Quiescence	Total durations
1	4	1	1	2	2	2	2	2	2	18
2	4	2	1	2	2	2	2	2	3	20
3	4	1	1	3	2	2	2	3	2	20
4	5	1	1	2	2	2	2	2	2	19
5	4	1	1	2	2	2	1	2	2	17
6	5	1	1	2	2	2	2	2	3	20
7	5	1	1	3	3	2	2	2	2	21
8	4	1	1	3	2	2	2	3	2	20
9	5	2	1	2	2	3	1	3	2	21
10	5	1	1	2	3	2	2	2	2	20
Range	4-5	1-2	1	2-3	2-3	2-3	1-2	2-3	2-3	17-21

TABLE 13

Measurements (in μm) of the Life Stages of *Corynoppia ajaii* sp. nov.

Sl. No.	Egg	Larva	Protonymph	Deutonymph	Tritonymph	Adult
1	139/62	152/78	188/86	212/105	236/126	275/147
2	127/59	156/79	186/82	216/103	247/135	279/146
3	136/59	158/76	188/98	219/105	238/132	275/147
4	139/62	156/74	192/90	229/109	236/128	276/150
5	135/58	150/82	190/96	217/101	238/126	277/149
6	137/62	156/77	188/82	212/105	248/135	279/151
7	135/57	158/82	192/86	209/103	246/130	276/146
8	128/59	152/81	187/82	220/109	247/131	279/146
9	129/60	158/77	186/87	222/106	238/128	277/147
10	134/62	158/92	188/92	219/103	246/135	279/151
Range	127-139/57-62	150-158/74-82	186-192/82-98	209-229/101-109	236-248/126-135	275-279/146-151

TABLE 14

Diagnostic Features of the Life Stages *Corynoppia ajaii* sp. nov.

Sl. No.	Life Stages	Notogastral Setae (in Pairs)	Epimeral Setal Formula	Genital Setae (in pairs)	Aggenital Setae (in pairs)	Anal Setae (in pairs)	Adanal Setae (in pairs)
1.	Larva	12	2-1-2	-	-	-	-
2.	Protonymph	15	3-1-2-1	1	-	-	-
3.	Deutonymph	15	3-0-2-1	2	-	-	3
4.	Tritonymph	15	3-1-2-2	4	1	2	3
5.	Adult	10	3-1-3-2	5	1	2	3

TABLE 15

Appearance of Epimeral Setae in the Life Stages of *Corynoppia ajaii* sp. nov.

Sl. No.	Life stages	Epimere				Setae appeared anew	Setae disappeared	Epimeral setal formula
		I	II	III	IV			
1	Larva	*1a 1b*	*2a*	*3a, 3b*	-	-	-	2-1-2
2	Protonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a*	*4a*	-	3-1-2-1
3	Deutonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a, 4b*	*4b*	-	3-1-2-2
4	Tritonymph	*1a 1b 1c*	*2a*	*3a, 3b*	*4a, 4b*	-	-	3-1-2-2
5	Adult	*1a 1b 1c*	*2a*	*3a, 3b*	*4a, 4b, 4c*	*4c*	-	3-1-2-3

TABLE 16

Appearance of Adanal Setae in the Life Stages of *Corynoppia ajaii* sp. nov.

Sl. No.	Life Stages	Adanal Setae	Total Number of Adanal Setae	Setae Appeared Anew
1	Larva	-	-	-
2	Protonymph	-	-	-
3	Deutonymph	ad_1, ad_2, ad_3	3	3
4	Tritonymph	ad_1, ad_2, ad_3	3	-
5	Adult	ad_1, ad_2, ad_3	3	-

TABLE 17

Appearance of Genital Setae in the Life Stages of *Corynoppia ajaii* sp. nov.

Sl. No.	Life Stages	Genital setae	Total number of genital setae	Seta appeared a new
1	Larva	-	-	-
2	Protonymph	g_1	1	g_1
3	Deutonymph	g_1, g_2	2	g_2
4	Tritonymph	g_1, g_2, g_3, g_4	4	g_3, g_4
5	Adult	g_1, g_2, g_3, g_4, g_5	5	g_5

TABLE 18

Appearance of Anal Setae in the Life Stages of *Corynoppia ajaii* sp. nov.

Sl. No.	Life Stages	Anal setae	Total number of anal setae	Setae appeared as new
1	Larva	-	-	-
2	Protonymph	-	-	-
3	Deutonymph	-	-	-
4	Tritonymph	an_1, an_2	2	an_1, an_2
5	Adult	an_1, an_2	2	-

TABLE 19

Duration of Development (in days) of

Life Stages of *R. philippinensis* at 30 &70% RH

Sl. No.	Egg	Larva	I Quiescence	Protonymph	II Quiescence	Deutonymph	III Quiescence	Tritonymph	IV Quiescence	Total duration
1	3	1.5	1	2	1.5	2	1	2	1	15
2	4	2	1	2.5	1.5	2	1	3	1	18
3	4	2	1	2	1.5	2	1.5	3	2	19
4	4	2	1	2	1	2	1	3	2	18
5	3	2	1	2.5	1	2.5	1	2	2	17
6	4	1.5	1	2	1	2	1	2	2	16.5
7	3	1.5	1	2	1	2	1	2	1	14.5
8	3	2	1	2.5	1	2	1.5	3	1	17
9	4	1.5	1	2	1	2.5	1	3	1	17
10	3	2	1	2	1.5	2	1.5	3	1	17
Range	3-4	1.5-2	1	2-2.5	1-1.5	2-2.5	1-1.5	2-3	1-2	14.5-19

TABLE 20

Measurements (in μm) of the Life Stages of *Ramusella philippinensis*

Sl. No.	Egg	Larva	Protonymph	Deutonymph	Tritonymph	Adult
1	128/56	144/67	158/77	168/99	220/106	261/200
2	119/52	148/65	159/80	169/96	212/128	268/198
3	115/48	146/64	162/79	167/95	218/132	266/197
4	117/47	148/67	154/82	166/94	216/105	265/196
5	118/46	150/68	155/76	165/90	218/127	263/199
6	119/50	144/66	154/174	164/92	217/119	265/196
7	128/51	146/67	156/73	165/96	220/106	268/198
8	119/52	149/68	159/72	164/99	219/112	267/199
9	126/48	150/66	162/71	162/93	217/110	268/198
10	125/47	144/64	158/70	161/99	216/109	260/200
Range	115-128/46-52	144-150/64-68	154-162/72-82	161-169/92-99	212-220/105-132	261-268/196-200

TABLE 21

Diagnostic Features of the Life Stages *Ramusella philippinensis*

Sl. No.	Life Stages	Notogastral Setae (in Pairs)	Epimeral Setal Formula	Genital Setae (in pairs)	Aggenital Setae (in pairs)	Anal Setae (in pairs)	Sp. nov. Adanal Setae (in pairs)
1.	Larva	10	2-1-2	-	-	-	-
2.	Protonymph	12	3-1-2-1	1	-	-	-
3.	Deutonymph	15	3-1-2-2	2	-	1	3
4.	Tritonymph	15	3-1-2-2	4	1	2	3
5.	Adult	9	3-1-2-3	5	1	2	3

TABLE 22

Appearance of Genital Setae in the Life Stages of *Ramusella philippinensis*

Sl. No.	Life Stages	Genital setae	Total number of genital setae	Seta appeared a new
1.	Larva	-	-	-
2.	Protonymph	g_1	1	g_1
3.	Deutonymph	g_1, g_2	2	g_2
4.	Tritonymph	g_1, g_2, g_3, g_4	4	g_3, g_4
5.	Adult	g_1, g_2, g_3, g_4, g_5	5	g_5

TABLE 23

Appearance of Adanal Setae in the life stages of *Ramusella philippinensis*

Sl. No.	Life Stages	Adanal Setae	Total Number of Adanal Setae	Setae Appeared Anew
1.	Larva	-	-	-
2.	Protonymph	-	-	-
3.	Deutonymph	ad_1, ad_2, ad_3	3	3
4.	Tritonymph	ad_1, ad_2, ad_3	3	-
5.	Adult	ad_1, ad_2, ad_3	3	-

TABLE 24

Appearance of Epimeral Setae in the Different Life Stages of *Ramusella philippinensis*

Sl. No.	Life stages	Epimere				Setae appeared anew	Setae disappeared	Epimeral setal formula
		I	II	III	IV			
1	Larva	*1a 1b*	*2a*	*3a, 3b*	-	-	-	2-1-2
2	Protonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a*	*4a*	-	3-1-2-1
3	Deutonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a, 4b*	*4b*	-	3-1-2-2
4	Tritonymph	*1a 1b 1c*	*2a*	*3a, 3b*	*4a, 4b*	-	-	3-1-3-2
5	Adult	*1a 1b 1c*	*2a*	*3a, 3b*	*4a, 4b, 4c*	*4c*	-	3-1-2-3

TABLE 25

Appearance of Anal Setae in the Different Life Stages of *Ramusella philippinensis*

Life Stages	Anal setae	Total number of anal setae	Setae appeared anew
Larva	-	-	-
Protonymph	-	-	-
Deutonymph	-	-	-
Tritonymph	an_1, an_2	2	an_1, an_2
Adult	an_1, an_2	2	an_1, an_2

TABLE 26

Duration of Development (in days) of

Life Stages of *T. (Roztrozetes) striata* sp. nov at 30^0C & 70% RH

Sl. No.	*Egg*	**Larva**	**I Quiescent**	**Protonymph**	**II Quiescent**	**Deutonymph**	**III Quiescent**	**Tritonymph**	**IV Quiescent**	**Total durations**
1	14	5	2	4	5	4	7	10	8	59
2	14	5	2	4	4	4	7	10	8	58
3	10	5	2	3	4	4	7	9	8	52
4	12	3	2	4	4	6	4	10	10	55
5	12	3	3	3	5	6	4	7	10	53
6	16	5	2	3	5	6	4	4	10	55
7	10	3	2	3	5	6	4	7	10	50
8	15	3	3	4	4	6	5	7	10	57
9	11	3	3	4	4	4	5	8	9	51
10	11	5	3	3	4	4	7	7	10	54
Range	10-16	3-5	2-3	3-4	4-5	4-6	4-7	7-10	8-10	51-59

TABLE 27

Measurements (in μm) of the Life Stages of *Trachyoribates (Rostrozetes) striata*

Sl. No	Egg	Larva	Protonymph	Deutonymph	Tritonymph	Adult
1	169/92	232/118	258/157	298/182	316/196	382/225
2	147/79	236/117	266/148	283/179	305/194	380/222
3	146/79	248/106	266/149	295/169	297/189	382/225
4	169/92	248/122	247/147	285/156	306/179	383/225
5	155/86	236/117	258/157	295/169	295/176	381/224
6	169/79	248/122	266/148	276/175	297/189	383/225
7	169/92	230/121	253/156	273/178	305/194	381/224
8	147/79	236/117	266/148	295/169	316/19	382/225
9	169/92	248/122	247/147	285/156	306/179	383/225
10	155/86	236/117	258/157	295/169	295/176	381/224
Range	146-169/79-92	230-248/106-122	247-266/147-157	273-298/156-182	297-316/176-196	381-383/222-225

TABLE 28

Diagnostic Features of the Life Stages *Trachyoribates (Rostrozetes) striata* sp. nov.

Sl. No.	Life Stages	Notogastral Setae (in Pairs)	Epimeral Setal Formula	Genital Setae (in pairs)	Aggenital Setae (in pairs)	Anal Setae (in pairs)	Adanal Setae (in pairs)
1.	Larva	12	2-1-2	-	0	0	0
2.	Protonymph	15	3-1-2-1	1	-	-	-
3.	Deutonymph	15	3-1-2-2	2	-	-	3
4.	Tritonymph	15	3-1-3-2	4	1	2	3
5.	Adult	10	3-1-2-2	5	1	2	3

TABLE 29

Appearance of Adanal Setae in the life stages of *Trachyoribates (Rostrozetes) striata* sp. nov.

Sl. No.	Life Stages	Adanal Setae	Total Number of Adanal Setae	Setae Appearing Anew
1.	Larva	0	0	0
2.	Protonymph	-	-	-
3.	Deutonymph	ad_1, ad_2, ad_3	3	3
4.	Tritonymph	ad_1, ad_2, ad_3	-	-
5.	Adult	ad_1, ad_2, ad_3	-	-

TABLE 30

Appearance of Epimeral Setae in the Life Stages of *Trachyoribates (Rostrozetes) striata* sp. nov.

Sl. No.	Life stages	Epimere				Setae appeared anew	Setae disappeared	Epimeral setal formula
		I	II	III	IV			
1.	Larva	*1a, 1b*	*2a*	*3a, 3b*	-	-	-	2-1-2
2.	Protonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a*	*1c, 4a*	-	3-1-2-1
3.	Deutonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a, 4b*	*4b*	-	3-1-2-2
4.	Tritonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b*	*3c*	-	3-1-3-2
5.	Adult	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a, 4b*	-	*3c*	3-1-2-2

TABLE 31

Appearance of Genital Setae in the Life Stages of *Trachyoribates (Rostrozetes) striata* sp. nov.

Sl. No.	Life Stages	Genital setae	Total number of genital setae	Seta appeared anew
1.	Larva	-	-	-
2.	Protonymph	g_1	1	g_1
3.	Deutonymph	g_1, g_2	2	g_1, g_2
4.	Tritonymph	g_1, g_2, g_3, g_4	4	g_3, g_4
5.	Adult	g_1, g_2, g_3, g_4, g_5	5	g_5

TABLE 32

Appearance of Anal Setae in the Life Stages of *Trachyoribates (Rostrozetes) striata* sp. nov.

Sl. No.	Life Stages	Anal setae	Total number of anal setae	Setae appeared anew
1.	Larva	-	0	0
2.	Protonymph	-	-	-
3.	Deutonymph	-	-	-
4.	Tritonymph	an_1, an_2	2	an_1, an_2
5.	Adult	an_1, an_2	5	an_1, an_2

TABLE 33

Duration of Development (in days) of Life

Stages of *S. praeincisus interrupts* on *T.viridae* at 30^0C & 70% RH

Sl. No.	Egg	Larva	I Quiescent	Protonymph	II Quiescent	Deutonymph	III Quiescent	Tritonymph	IV Quiescent	Total duration
1	4	3	2	4	2	5	2	5	2	29
2	4	3	2	4	2	5	2	5	2	29
3	4	3	1	4	2	5	2	5	3	29
4	4	3	2	3	2	4	2	5	2	27
5	5	3	1	4	2	4	2	6	2	29
6	5	3	1	3	1	5	2	5	3	28
7	4	4	2	4	2	4	1	6	3	30
8	4	4	2	4	1	4	1	6	3	29
9	5	4	2	4	2	5	1	6	2	31
10	5	3	2	3	1	4	2	5	3	28
Range	4-5	3-4	1-2	3-4	1-2	4-5	2-5	5-6	2-3	27-31

TABLE 34

Measurements (in μm) of the Life Stages of *Scheloribates praeincisus interruptus*

Sl. No.	Egg	Larva	Protonymph	Deutonymph	Tritonymph	Adult
1	171/85	190/124	209/147	459/266	601/398	677/424
2	162/80	181/126	205/149	456/254	594/396	670/420
3	160/81	182/125	221/146	457/254	587/392	672/422
4	162/72	190/124	217/146	453/267	596/396	692/444
5	147/85	189/129	205/142	458/255	587/398	670/420
6	147/85	189/126	209/140	457/257	594/396	692/444
7	160/81	182/126	221/149	454/266	596/392	688/443
8	162/72	189/129	205/149	459/254	546/392	672/422
9	162/80	190/125	205/142	455/253	601/396	670/420
10	147/85	187/126	221/147	459/254	594/392	692/444
Range	147-162/72-85	181-190/124-129	205-221/140-149	454-459/254-266	587-601/392-398	670-677/422-444

TABLE 35

Diagnostic Features of the Life Stages *Scheloribates praeincisus interruptus*

Sl. No.	Life Stages	Notogastral Setae (in Pairs)	Epimeral Setal Formula	Genital Suckers (in pairs)	Genital Setae (in pairs)	Aggenital Setae (in pairs)	Anal Setae (in pairs)	Adanal Setae (in pairs)
1.	Larva	11	2-1-2	-	-	-	-	-
2.	Protonymph	12	3-1-2-1	1	1	-	-	1
3.	Deutonymph	14	3-1-2-1	2	2	-	1	3
4.	Tritonymph	15	3-1-3-2	3	3	1	2	3
5.	Adult	10	3-2-3-2	3	4	1	2	3

TABLE 36

Appearance of Epimeral Setae in the Life Stages of *Scheloribates praeincisus interruptus*

Sl. No.	Life stages	Epimeres				Setae appeared anew	Epimeral setal formula
		I	II	III	IV		
1.	Larva	*1a, 1b*	*2a*	*3a, 3b*	-	-	2-1-2
2.	Protonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a*	*1c, 4a*	3-1-2-1
3.	Deutonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a*	*4b, 3c*	3-1-3-1
4.	Tritonymph	*1a, 1b, 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b*	*4b*	3-1-3-2
5.	Adult	*1a, 1b, 1c*	*2a, 2b*	*3a, 3b, 3c*	*4a, 4b*	*2b*	3-2-3-2

TABLE 37

Appearance of Genital Setae in the Life Stages of *Scheloribates praeincisus interruptus*

Sl. No.	Life Stages	Genital setae	Total number of genital setae	Setae appeared anew
1.	Larva	-	-	-
2.	Protonymph	g_1	1	g_1
3.	Deutonymph	g_1, g_2	2	g_2
4.	Tritonymph	$g_1, g_2, g_3,$	3	$g_3,$
5.	Adult	$g_1, g_2, g_3, g_4,$	4	G_4

TABLE 38

Appearance of Anal Setae in the different life stages of *Scheloribates praeincisus interruptus*

Sl. No.	Life Stages	Anal setae	Total number of anal setae	Setae appeared anew
1.	Larva	-	-	-
2.	Protonymph	-	-	-
3.	Deutonymph	an_1	1	an_1
4.	Tritonymph	an_1, an_2	2	an_2
5.	Adult	an_1, an_2	2	-

TABLE 39

Appearance of Adanal Setae in the life stages of *Scheloribates praeincisus interruptus*

Sl. No.	Life Stages	Adanal Setae	Total Number of Adanal Setae	Setae Appearing Anew
1.	Larva	-	-	-
2.	Protonymph	-	-	-
3.	Deutonymph	ad_1, ad_2, ad_3	3	ad_1, ad_2, ad_3
4.	Tritonymph	ad_1, ad_2, ad_3	3	-
5.	Adult	ad_1, ad_2, ad_3	3	-

TABLE 40

Duration of Development (in days) of

Life Stages of *P. punctatus* on Coir Pith at 30^0C & 70% RH

Sl. No.	Egg	Larva	I Quiescent	Protonymph	II Quiescent	Deutonymph	III Quiescent	Tritonymph	IV Quiescent	Total duration
1	5	3	2	3	2.5	5	4	5	3	32.5
2	6	2	2	4	2.5	5	4	5	3	33.5
3	6	2	2	4	2	3	4	6	3	32
4	5	3	3	3	2	4	3	4	4	31
5	6	3	2	4	2	4	4	4	4	33
6	5	3	3	4	2.5	3	3	4	4	31.5
7	6	2	3	3	2.5	3	3	4	3	29.5
8	6	2	2	4	2	4	3	5	4	32
9	6	2	3	4	2	4	4	6	3	34
10	5	3	3	4	2.5	4	4	4	4	33.5
Range	5-6	2-3	2-3	3-4	2-2.5	3-5	3-4	4-6	3-4	29.5-34

TABLE 41

Measurements (in μm) of the Life Stages of *Protoribates punctata*

Sl.No	Egg	Larva	Protonymph	Deutonymph	Tritonymph	Adult
1	192/95	290/189	307/246	558/367	702/498	892/544
2	182/90	281/182	309/249	559/354	694/496	876/524
3	187/96	289/176	321/246	553/354	687/492	870/520
4	187/95	282/183	321/247	557/367	696/496	872/522
5	180/90	290/174	305/242	559/354	687/498	892/544
6	182/92	287/178	309/240	559/354	694/496	870/520
7	187/95	290/183	309/240	554/366	696/493	878/544
8	194/89	289/181	321/249	557/385	697/492	878/543
9	197/95	281/180	317/246	558/355	702/495	872/522
10	187/95	282/189	307/249	557/357	696/492	870/520
Range	180-197/ 89-96	281-290/174-189	305-321/240-249	553-559/354-385	687-702/492-498	870-892/520-554

TABLE 42

Diagnostic Features of the Life Stages *Protoribates punctata*

Sl. No.	Life Stages	Notogastral Setae (in Pairs)	Epimeral Setal Formula	Genital Suckers (in pairs)	Genital Setae (in pairs)	Aggenital Setae (in pairs)	Anal Setae (in pairs)	Adanal Setae (in pairs)
1.	Larva	11	2-1-2	-		-	-	-
2.	Protonymph	12	3-1-2-1	1	1	-	-	1
3.	Deutonymph	14	3-1-2-1	2	2	-	1	3
4.	Tritonymph	15	3-1-3-2	3	3	1	2	3
5.	Adult	10	3-1-3-3	3	5	1	2	3

TABLE 43

Appearance of Epimeral Setae in the Life Stages of *Protoribates punctata*

Sl. No.	Life stages	Epimere				Setae appeared anew	Epimeral setal formula
		I	II	III	IV		
1	Larva	*1a, 1b*	*2a*	*3a, 3b*	-	-	2-1-3
2	Protonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a*	*1c, 4a*	3-1-2-1
3	Deutonymph	*1a, 1b, 1c*	*2a*	*3a, 3b*	*4a, 4b*	*4b*	3-1-2-2
4	Tritonymph	*1a 1b 1c*	*2a*	*3a, 3b, 3c*	*4a, 4b*	*3c*	3-1-3-2
5	Adult	*1a 1b 1c*	*2a*	*3a, 3b. 3c*	*4a, 4b, 4c*	*4c*	3-1-3-3

TABLE 44

Appearance of Genital Setae in the Life Stages of *Protoribates punctata*

Sl. No.	Life Stages	Genital setae	Total number of genital setae	Seta appeared anew
1.	Larva	-	-	-
2.	Protonymph	g_1	1	g_1
3.	Deutonymph	g_1, g_2	2	g_2
4.	Tritonymph	g_1, g_2, g_3	3	g_1, g_2, g_3
5.	Adult	g_1, g_2, g_3, g_4, g_5	4	g_4, g_5

TABLE 45

Appearance of Adanal Setae in the Life Stages of *Protoribates punctata*

Sl. No.	Life Stages	Adanal Setae	Total Number of Adanal Setae	Setae appeared anew
1	Larva	-	-	-
2	Protonymph	-	-	-
3	Deutonymph	ad_1, ad_2, ad_3	3	ad_1, ad_2, ad_3
4	Tritonymph	ad_1, ad_2, ad_3	3	-
5	Adult	ad_1, ad_2, ad_3	3	-

TABLE 46

Appearance of Anal Setae in the Life Stages of *Protoribates punctata*

Life Stages	Anal setae	Total number of anal setae	Setae appeared anew
Larva	-	-	-
Protonymph	-	-	-
Deutonymph	an_1	1	an_1
Tritonymph	an_1, an_2	2	an_2
Adult	an_1, an_2	2	-